Breastfeeding and Breast Milk – from Biochemistry to Impact

A Multidisciplinary Introduction

Published by
Family Larsson-Rosenquist Foundation

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Foreword

I was 4 years old when my parents started to work in the field of breast pumps, back in 1962. The breastfeeding world looked different then as there was a strong belief it is possible to replicate everything that nature does – breastfeeding was at its low and formula was considered the norm. Still, my parents believed in the importance of breastfeeding and the importance of breast pumps to support mothers in need.

This belief in the life-long benefits of breastfeeding and breast milk eventually led us to establish the Family Larsson-Rosenquist Foundation.

When I started to become involved in the family business in the 1980s, it was clear to me as a trained scientist that we needed a scientific approach to better understand lactation. The first studies I did myself involved looking at the suction curves of babies at the breast. Through those studies a whole new world opened, and I learnt about the two distinct phases when an infant suckles at the breast – a stimulation and an extraction phase. Hence, I worked with our engineers to introduce these two phases to our breast pumps. This 2-Phase expression technology has today become the standard. This was also the start for our first research collaboration with Peter Hartmann and his team at the University of Western Australia.

Over the years our scientific network grew, as did our questions. I had many discussions with experts from different research fields including biochemistry, physiology, psychology and physics about breastfeeding and human lactation. It struck me how little knowledge there was in this field at the time and many thought that they knew all there was to know. It was clear to me that investment was needed to move the field forward - thus began our journey not only in product related research, but also in basic research to enlarge the knowledge base. This then led to some astounding findings: a new understanding of the anatomy of the lactating breast (updating knowledge that was over 150 years old) and the amazing discovery of stem cells in human milk. These findings showed us it was just the beginning – there is still so much more to know and learn.

Over the years our scientific network grew. We met and talked with many experts and multidisciplinary researchers in the field of breastfeeding, human milk and lactation, and the substantial long-term health benefits of breastfeeding and human milk for infants became clear.

As more evidence emerged, and with the realisation that research is key to ensuring that breastfeeding becomes the norm, it became my family's vision to help enable a world in which every child is granted an optimum start in life through the benefits of breastfeeding and human milk. This motivation was the signal needed for my family to establish the Family Larsson-Rosenquist Foundation, where science would take centre stage. I had the honour to be the founding president.

The vision for this book came following a visit to China in September 2013. Formula was dominating the market and breastfeeding rates at 6 months were extremely low (20.8%). One stop during this visit was the teaching hospital of Zhejiang Province (which has more than 50 million inhabitants). The dominance of formula was a big concern for the head of nursing research who was keen to reverse this trend – research was key to doing this. Her passion was clear, but one of her difficulties was getting an overview of research in the field of breastfeeding and human lactation. An example she shared, was the transfer of medications into the milk and she wished to do some research into this topic. I sent her Tom Hales book about how drugs are transferred into mother's milk together with Hale & Hartmann's "Textbook of Human Lactation".

This is just one example of one hospital in a huge country that is facing an immense problem – formula dependence – with no practical solutions for change. I have found myself in many similar situations with would-be change-makers who are becoming increasingly interested in breastfeeding as the understanding of the health and economic benefits of human milk increases. The challenge they face is always the same: where and how can they access the research that will lead to solutions for change?

There are a lot of studies discussing the benefits of breastfeeding, but these mainly focus on the health issues and much of it is not standardised. Empowering individuals with the knowledge to make change, to increase interest at a local or even national level is key and I am therefore convinced that there is a growing need for a book which provides a multidisciplinary overview of breastfeeding and human milk. There are a lot of books written about 'how to' breastfeed, but the market lacks one that provides such diverse aspects. This book explores a plethora of key topics, and their practical implications. It is written by professionals who are experts within their respective fields and therefore provides a comprehensive, interdisciplinary view of the world of breastfeeding and human milk. It is designed to empower those interested in promoting the positive benefits of breastfeeding and human milk with the knowledge required to persuade decision-makers that this is the best option for improving short- and long-term health, decreasing health care-related spending and increasing productivity – the same values and goals my family stands for and which our foundation is pursuing on a daily base.

I hope that, one day soon, at home and when I travel, to find breastfeeding has again become the norm.

Zug (Switzerland), in July 2018
Michael Larsson

Preface

Authors from around the globe, each a specialist within their field have readily contributed to provide readers with a comprehensive overview of breastfeeding and human milk to encourage and empower interested parties to move breastfeeding higher up on the public health agenda.

There are many books available looking at "how to" breastfeed or focusing on a single topic within the field, others look at the biomedical aspects of milk, however none address a wide range of research disciplines to provide a truly multidisciplinary comprehensive overview: covering topics from physiology and psychology, culture, politics and economics to HIV and medications, NICU and human milk banking. The topics are varied, yet all relevant and important elements in the quest to increasing breastfeeding rates.

Multidisciplinary Introduction to Breastfeeding and Breast Milk – from Biochemistry to Impact is written for a wide and varied audience, ranging from nursing staff and lactation experts who have daily contact with mothers and babies, to health ministers who want to learn about how scaling up of breastfeeding can contribute to reducing their health care expenditure. It is also a key for doctors and researchers who have an interest in the topic yet are not fully aware of all the benefits that breastfed infants enjoy. Based on sound science but written in popular science style, ensuring an easy read, the book provides a comprehensive and solid foundation including sources and references. It also features a unique in-depth scientific glossary of lactation that provides definitions for a plethora of important terms of breastfeeding and human milk that are science based and reviewed by acknowledged experts in the field.

The book aims to provide a holistic overview, and is divided into four parts with individual introductions. As each chapter covers a topic in depth, it can be also be read independently. Furthermore, the book can be used as a Dip-In-and-Out book as each chapter provides a summary of the topics covered at the beginning as well as a list of key findings and messages at the end of the chapter. This allows the reader to quickly identify topics and peruse key findings to identify areas of specific interest and to read the book in a more targeted manner.

Overall this book provides a unique insight into a wide range of aspects of breastfeeding, human milk and lactation, empowering individuals with the knowledge to increase public interest and to work towards the goal of making breastfeeding the norm again.

Zug (Switzerland), in July 2018
Göran Larsson

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Setting the Scene

1 Introduction

Peter E. Hartmann, E/Prof, PhD, BRurSc

Historically, there were only two options for infant nutrition that were compatible with infant survival: a mother's milk or a wet nurse's milk. Agricultural developments and the resulting domestication of animals led to an alternative – animal milk. However, most babies fed animal milk did not survive. This was largely due to its inappropriate composition for humans (e.g. cow's milk has too much sodium and casein) and poor hygiene. Today, the World Health Organization (WHO) recommends infants be exclusively breastfed beginning one-to-two hours after birth and continuing up to six months of age, when they can be gradually weaned over the next 2 years and beyond.

The first section of this book sets the scene with background information that will help readers learn why breastfeeding is so vital. It explains how the human body works to produce such a complex bioliquid for nurturing infants. It also offers a glimpse into the world of data collection on breastfeeding and human milk.

Part I (see chapter 2) begins with a chapter from Leith Greenslade, CEO, JustActions LLC, New York. She provides insight into the importance of breastfeeding, and how producing breastmilk – an extraordinary protective and nutritional substance – for the health and development of their babies empowers mothers. She explores how breastfeeding is important for global health and sustainable development. Finally, Greenslade outlines the many issues surrounding breastfeeding, such as the lack of acceptance of breastfeeding's importance, the collective failures by society and science to respond to poor breastfeeding outcomes, and the dearth of investment in breastfeeding innovations to help women balance the needs of breastfeeding and returning to paid employment, all of which are yet to be resolved.

Information – data – is the key to understanding the myriad issues linked to breastfeeding and to developing the policies and interventions that will resolve them. Maria Quigley, Professor of Statistical Epidemiology at the National Perinatal Epidemiology Unit, University of Oxford, provides an overview on collecting breastfeeding-related data and how it is processed (see chapter 3). Such data is used to compare infant feeding patterns in different countries and settings, and also to track progress towards achieving longer-term global health targets. Without consistent and comparable statistical data, it would be impossible to formulate and assess interventions aimed at overcoming the barriers to breastfeeding. Precise data definitions are required to ensure this consistency for both surveys and epidemiological studies. Professor Quigley addresses questions about the type of data needed to evaluate the long-term effects of breastfeeding in both mothers and infants, the quality of reporting on exclusive breastfeeding, what data should be collected for matters of economics, policy formation, education and implementation, who collects the data and how is it collected. Finally, she indicates where appropriate, randomized controlled trials are required to confirm observational studies and provide consistent and comparable statistical data.

In chapter 4, Ms Melinda Boss, the team leader of a multidisciplinary group developing evidence-based protocols, and I discuss the issues associated with creating a common understanding of human lactation in relation to how breastfeeding actually works from an anatomical and physiological perspective. The authors also discuss the development of related research – until the beginning of this century, the only definitive research into the anatomy of the lactating human breast was conducted in 1840. They show how this absence of research has greatly impaired advancing understanding of the anatomy and physiology of human lactation, such as the fact that the lactating breast is a complex metabolic organ that accounts for approximately one third of a mother's daily resting energy output. Next, the authors outline the initial phase of the lactation cycle – an extended process beginning with conception, followed by distinct stages during pregnancy and the first three days after birth. This overview is followed by a summary of the established lactation phase, where milk synthesis is regulated by an autocrine, or local, control that responds to an infant's appetite. The cycle ends with weaning and the involution of the gland once milk removal has ceased.

Part I (see chapter 5) concludes with Professor Berthold Koletzko, Dr. of Haunerschen Children's Hospital and Kinderpoliklinik of the Ludwig-Maximilians-University, Munich, answering the question, "Why breastfeed?" He helps readers understand the evolution of lactation and the delicate balance between limiting energy costs to mothers while maximising infant survival. In this context, he touches on the considerable data supporting the health effects and benefits of breastfeeding for both mothers and infants. For example, women who breastfeed may benefit from enhanced regression of fat that accumulates during pregnancy and reduced risk of mammary and ovarian carcinomas. He explains how infants who are breastfed have reduced risk of infections such as acute otitis media and acute gastroenteritis, as well as disorders later in life, such as mammary and ovarian carcinomas. Furthermore, he discusses initial evidence of the small but important benefit breastfeeding can have on a child's later cognitive ability, which is associated with significant advantages connected to educational achievement and income generation. He also touches on breastfeeding's role in strengthening mother-infant bonding. Professor Koletzko concludes by explaining how such findings should prompt health care professionals around the world to support women's health before pregnancy, during pregnancy and throughout lactation as each phase has a direct impact on lactation outcomes.

2 Breast Milk, Global Health and Sustainable Development

Leith Greenslade, MPP, MBA

Expected Key Learning Outcomes

- Why breastfeeding is so important
- How breastfeeding can help reduce the inequalities in health
- The health and economic benefits from increasing breastfeeding rates
- Reasons why mothers do not breastfeed despite all the evidence from research demonstrating the benefits
- The required change of policy focus needed to support a global increase in breastfeeding rates

2.1 The Importance of Empowered Mothers

Nature has empowered mothers with control over the production and distribution of an extraordinarily protective substance for the health and development of their babies – breast milk. This evolutionary innovation provides all of the nutrition an infant needs for the first six months of life and affords protection from infectious diseases, reduces the risk of sickness and death, and contributes to healthy digestive and brain development well into early childhood.

Unlike the vast majority of health interventions, breast milk is wholly owned and operated by mothers who function as "doctors" administering their "medicine". To unleash the protective powers of breast milk, mothers must not only be knowledgeable about the benefits of breast milk. They must also be freely able to exercise their choice to breastfeed, unfettered by external barriers. If mothers cannot breastfeed due to sickness or absence, they should be able to ensure that their babies have access to their own breast milk and, where that is not possible, to donor breast milk from the newborn period onwards.

It is critical that development actors confront the reality that for almost all mothers – an estimated 140 million women give birth every year – breastfeeding is not always a choice. Depending on the severity of the barriers, a mother may be so constrained by forces beyond her control (e.g., lack of education, lack of family support, the need to earn an income) that she cannot exercise a preference to breastfeed. For many tens of millions of mothers, breastfeeding is not possible in the environments in which they live. For these women, reducing or removing the external constraints is what will ultimately lead to sustained increases in breastfeeding.

Women facing the most significant barriers to breastfeeding are also most likely to live in communities where the costs of not breastfeeding fall most heavily on children. These are the populations where very low breastfeeding rates coexist with very high rates of newborn and child sickness and death. Empowering mothers in these high-risk environments to exercise a real choice to breastfeed in supportive homes, workplaces, and public spaces should be the primary focus of development efforts to increase breastfeeding rates.

2.2 The Benefits of Breast Milk

In the past 15 years the health benefits of breastfeeding have become extremely well known and extensively promoted. There is consensus among the global health community that breast milk confers its powerful protective properties on children by providing all of the nutrients, vitamins, and minerals children need in the first six months of life, alongside antibodies that combat infectious diseases, especially diarrhoea and pneumonia [1],

[2], and enzymes for optimal digestion. There is now widespread acceptance that the health benefits of breastfeeding continue well into early childhood, and potentially beyond. The benefits of breastfeeding for women include reduced risk of pregnancy and potentially lower lifetime risks of certain cancers, obesity, diabetes, and heart disease [3].

Several *Lancet* series on maternal, newborn, and child health and nutrition have laid out the evidence for the benefits of breast milk. The Maternal and Child Undernutrition Series [4], the Maternal and Child Nutrition Series [5], the Childhood Pneumonia and Diarrhoea Series [6], the Every Newborn Series [7], and the Breastfeeding Series [8] all cite evidence that breastfed babies are much more likely to survive the first six months of life [9], that initiation of breastfeeding within 24 hours of birth could reduce the risk of newborn death by 43% of all newborn deaths [10], [11], [12] and that breastfeeding could prevent 823,000 child deaths and 20,000 breast cancer deaths annually [13]. Other sources accord with these findings, including the Born Too Soon Report, which stresses the importance of breast milk for preterm babies [14], and the Global Burden of Disease Study 2016, which ranks “suboptimal breastfeeding” as a leading behavioural risk factor in child death, especially across African and Asian countries [15]. According to this body of evidence, no other single intervention has the power to prevent newborn and child deaths at the scale of breast milk.

There is less consensus about the long-term health and related benefits of breastfeeding for both breastfeeding mothers and breastfed infants. The many studies that report adult health benefits including reductions in heart disease, diabetes, and cancers; cognitive improvements including higher IQ; and even economic gains including higher educational performance and income [16] all suffer from methodological weaknesses as they are based on cross-sectional retrospective studies rather than randomised control trials. A recent meta-analysis of these studies cautioned that these methodological challenges limit the ability to draw firm conclusions [17], [18].

The 2016 *Lancet* Breastfeeding Series quantified the impact of these health and development benefits on healthcare costs and economic growth, reporting that increases in breastfeeding rates could save US$400 million in healthcare costs in the US, UK, Brazil, and China alone, and inject US$300 billion into economies from more productive workforces [19].

2.3 Breastfeeding as an Equity Strategy

Children born to low income families in high-risk environments disproportionately benefit from the special protective properties of breast milk because they are more likely to be exposed to infections exacerbated by poor living conditions and less likely to access quality healthcare as formal health services so often fail to reach them. A recent study reported that a 10% increase in breastfeeding prevalence across all households resulted in a larger absolute reduction in child deaths in the poorest households [20]. The authors concluded that breastfeeding is better positioned to reduce wealth-related child health inequalities than other interventions.

Although breastfeeding is one of the few health interventions where the gaps in coverage between high and low income households are narrow in low income countries, early and exclusive breastfeeding rates among poor families remain very low [21]. Globally, just 40% of infants from the poorest households are exclusively breastfeed for the first six months of life, and in many countries with the highest child mortality breastfeeding rates are even lower [22]. For example, the ten countries with the highest child mortality rates all have exclusive breastfeeding rates below 50% (▸ **Table 1.1**), and several have rates below 20%. Further, eight of the ten countries with the largest numbers of child deaths have exclusive breastfeeding rates below 50% (▸ **Table 1.2**). These include India, Nigeria, Pakistan, China, Democratic Republic of Congo, Indonesia, Angola, and the Philippines.

Despite recent improvements in breastfeeding rates in some countries, the rate of progress overall has been slow over the last 25 years [23].

▸ **Tab. 1.1** Breastfeeding rates in countries with the highest child mortality rates, 2015.

Country	Child Mortality Rate 2016	% Early Breastfeeding (0–1 hour) 2008–2015	% Exclusive Breastfeeding (0–6 months) 2008–2015
Angola	157	55	No data
Somalia	133	26	5
Chad	127	29	3
Central African Republic	124	44	34
Sierra Leone	114	54	32
Mali	111	46	34
Nigeria	104	33	17
Benin	98	50	41
Democratic Republic of Congo	94	52	48
Cote d'Ivoire	92	53	23
Niger	91	53	23
Global Average	41	43	40
Source: World Bank and UNICEF, latest.			

▸ **Tab. 1.2** Breastfeeding rates in countries with the highest newborn and child deaths, 2015.

Country	Number Newborn Deaths (0–1 month, 2015)	Number Child Deaths (0–5 years, 2015)	% Early Breastfeeding (0–1 hour)	% Exclusive Breastfeeding (0–6 months)
India	696,000	1,201,000	41	62
Nigeria	240,000	750,000	33	17
Pakistan	245,000	432,000	18	38
China	93,000	182,000	41	28
Democratic Republic of Congo	94,000	305,000	52	48
Indonesia	74,000	147,000	49	42
Angola	53,000	169,000	55	No data
Sudan	39,000	89,000	73	55
Kenya	34,000	74,000	58	61
Philippines	30,000	66,000	50	27
Source: UNICEF, 2015 and World Bank, latest.				

Among the 33 countries with the slowest rates of reduction in child mortality, only four have exclusive breastfeeding rates above 50% – Burundi, Togo, Papua New Guinea, and Lesotho [24]. This lack of improvement in breastfeeding rates in countries struggling to prevent child deaths implies that there are considerable equity gains to be made in targeting their most vulnerable populations for breastfeeding improvements, particularly in the countries with very low vaccination rates [25]. To leverage the equity impact of breastfeeding in full both within and between countries, it is critical that the global development community prioritises breastfeeding support in the populations with the lowest absolute rates of breastfeeding and breastfeeding progress, the weakest health infrastructure, and the highest burdens of newborn and child death.

2.4 The Cost-Effectiveness of Breastfeeding

Like many prevention efforts, breastfeeding investments are highly cost-effective. The 2013 Lancet Maternal and Child Nutrition Series reports that breastfeeding promotion compares very favourably with other nutrition intervention packages and has the power to reduce hundreds of thousands of child deaths at an annual cost per life saved of $US175. Of ten single nutrition interventions assessed by The Lancet, only the management of severe acute malnutrition and preventive zinc supplementation saved more lives than breastfeeding promotion, and of four intervention packages modelled, only the management of acute malnutrition saved more lives at lower cost than breastfeeding promotion [26].

Further, the 2014 Lancet Newborn Series reported that the earlier breastfeeding support services reach mothers after birth, the greater the impact on newborn health and breastfeeding duration. The Series cited that education and counselling can improve exclusive breastfeeding rates by 43% the day after birth and by up to 30% in the first month after birth. Kangaroo mother care, a strategy that improves the health of babies born too small, also encourages breastfeeding, with studies showing a 27% increase in breastfeeding rates at one to four months after birth and an increased breastfeeding duration. This body of research estimates that where a specific population can achieve 90% coverage of breastfeeding promotion exclusive breastfeeding rates can increase by 15% in newborns and by 20% in children aged one to five months [27].

Yet despite the evidence of the cost-effectiveness of breastfeeding support programmes, international development spending on breastfeeding programmes has never been high. Indeed, it has been declining since the 1990s and is now at historically low levels relative to other health prevention areas, most notably vaccines and insecticide-treated bed nets [28]. The relatively high level of investment in vaccines and in malaria prevention is one of the reasons why they are responsible for preventing such a large proportion of child deaths since 1990 in so many countries [29]. The fact that breastfeeding contributed so little to the 50% reduction in child deaths achieved over the life of the Millennium Development Goals begs a critical question: Could we have actually achieved the 66% reduction in child deaths required to achieve Goal 4 with greater investments in breastfeeding promotion and support?

2.5 Breastfeeding's Poor Performance

Despite the significant health and equity benefits of breastfeeding, and the cost-effectiveness of breastfeeding support services, rates of breastfeeding in most countries fall below the World Health Organization's (WHO) recommendations (early initiation of breastfeeding within one hour of birth, exclusive breastfeeding until 6 months of age, and continued breastfeeding until 2 years of age or older), and the World Health Assembly's target of at least 50% exclusive breastfeeding [14]. Globally, just 40% of babies are breastfed exclusively for the first 6 months and 43% in the first hour after birth, far below the coverage rates achieved by other child survival interventions such as vaccines (86%), Vitamin A (72%), and skilled birth attendance (78%). Currently, only 32 countries have achieved the 50% exclusive breastfeeding target and many countries struggling with high burdens of newborn and child mortality have rates far below 50%.

Progress in closing the high breastfeeding coverage gaps has also lagged other areas of global health. According to the Countdown to 2015 Final

Report, exclusive breastfeeding rates are increasing by just one percentage point a year and in most Countdown countries the proportion of children who are still breastfed at ages of 12 to 15 months and of 20 to 23 months is actually falling. As a result, just 13% of the breastfeeding coverage gap has been closed, putting breastfeeding well behind vaccination, malaria prevention and treatment, safe drinking water, and reproductive health advances.

An important new analysis of breastfeeding progress appears in the 2015 Global Nutrition Report [30] and finds that only 32 of 78 countries with sufficient data on breastfeeding are on-course to meet the 50% coverage target. Ten countries are off-course but making progress, 30 are off-course and making no progress, and six countries show large reversals in rates (Cuba, Egypt, Mongolia, Nepal, Turkey, and Kyrgyzstan). Of great concern is that some of the countries with the largest burdens of child death are among those off-course (e.g., Nigeria, Pakistan, Ethiopia, Bangladesh, Tanzania, Mozambique, Malawi, Cameroon, and Ivory Coast). The Report decries the lack of progress on breastfeeding rates and calls for urgent action to prioritise the collection of breastfeeding data in the 115 countries where it is lacking.

On a more promising note, the Global Nutrition Report also draws attention to countries that have made strong breastfeeding progress in recent years, especially India, which has doubled its exclusive breastfeeding rate (from 34% to 62%) over an eight-year period. The United Nations International Children's Fund (UNICEF) and the World Breastfeeding Trends Initiative also highlight several countries for their recent breastfeeding progress, although some of their high performers are now in the off-course category, according to the Global Nutrition Report [31]. The wide variation in exclusive breastfeeding rates (ranging from 0% in Chad to 87% in Rwanda) is also cause for optimism as it shows that even in the most challenging environments, breastfeeding advances are possible.

2.6 Barriers to Breastfeeding

Poor breastfeeding performance in a majority of countries coexists with generally high levels of awareness about the benefits of breastfeeding, especially among mothers. Surveys repeatedly show that women know 'breast is best' and self-report a strong preference to breastfeed. The wide gaps between women's preferences to breastfeed and breastfeeding rates suggest the existence of a significant 'know-do' gap and imply that women face steep barriers to breastfeeding in most countries. Understanding the nature of these barriers, how they operate in specific contexts, and how to neutralise them is one of the most critical challenges in child health and development.

Individual country surveys and the few multi-country surveys of women's attitudes to breastfeeding that exist attest to the 'know-do' gap in breastfeeding behaviour. A 2011 seven-country survey by the Philips Center for Health and Well-being found that although more than nine in ten of the 4,000 mothers surveyed wanted to breastfeed, only a minority were able to do so exclusively for six months [32]. A range of barriers from perceived breast milk insufficiency, to pain and discomfort, to transition to work, and fear of breastfeeding in public were cited. A 2014 nine-country study by Lansinoh found that most of the 13,000 mothers surveyed wanted to breastfeed exclusively but did not, citing pain and discomfort, lack of time, the difficulty of pumping at work, and public embarrassment as major reasons [33]. In addition, studies from several low income countries point to cultural beliefs about the importance of non-breast milk feeding for spiritual 'protection' and other purposes as significant barriers to exclusive breastfeeding [34].

Many non-survey based studies postulate other barriers to breastfeeding that focus on the marketing and availability of breast milk substitutes, especially infant formula [35]. These studies, many of them conducted by civil society organisations, point to lax implementation of the WHO Code of Marketing of Breast-milk Substitutes as a major barrier, arguing that aggressive marketing practices encourage mothers to use infant formula as a partial or complete substitute for breastfeeding.

They assume that if the companies that manufacture infant formula are prevented from marketing it, demand for infant formula would fall and breastfeeding would rise. However, the fact that so many of the 39 countries that have fully adopted the WHO Code have low exclusive breastfeeding rates suggests that the marketing of infant formula is not a major barrier to breastfeeding on its own, and full Code implementation does not reduce the underlying demand for breast milk substitutes.

A recent analysis of the implementation of the Code points to four countries that have strengthened Code implementation as best practice – Armenia, Botswana, India, and Vietnam [36]. However, only one of these countries (Vietnam) is described as on course with respect to breastfeeding progress in the Global Nutrition Report. The Access to Nutrition Index [37] offered the first independent assessment of Code compliance by five companies (Danone, FrieslandCampina, Groupe Lactalis, Heinz, and Nestlé) in 2016. It concluded that significant progress could be made if WHO were to clarify further its definition of products covered by the Code, and set out clearer definitions of some of the terms used in the Code as they were not all interpreted consistently by stakeholders.

It is likely that demand for alternatives to breast milk is driven more by the range of barriers identified in the consumer survey data than by the availability of infant formula. Further, it is even possible that restricting access to infant formula without addressing these underlying barriers could result in greater use of other substitutes (e.g., water, animal milk, tea, and foods) or reduced infant feeding entirely. If a number of powerful forces (e.g., rising female labour force participation and gender equality) are placing downward pressure on breastfeeding rates and these forces become even stronger as countries develop, unlike most other health indicators, breastfeeding rates will decline as countries develop regardless of special intervention. Most of the top ten countries in the Human Development Index have very low exclusive breastfeeding rates [38].

2.7 A Collective Failure to Respond

Despite a plethora of policy reports advocating the benefits of breastfeeding, and several special initiatives launched since the Innocenti Declaration on the Protection, Promotion and Support of Breastfeeding was signed by 30 governments and several UN agencies in 1990 [39], few programmes have systematically targeted the range of breastfeeding barriers faced by women. This is especially so in populations where breastfeeding could contribute significantly to newborn and child survival. An independent analysis conducted for UNICEF culminated in a landmark report, Breastfeeding on the Worldwide Agenda, that categorised the breastfeeding landscape as “policy-rich and implementation-poor” and called for urgent action to “transform the token attention breast-feeding often receives into a non-negotiable commitment to deliver a comprehensive package of health and nutrition interventions at scale” [40].

The few large-scale investments in breastfeeding programmes, especially the US Agency for International Development (USAID)-funded LINKAGES Project (1996–2006) [41] and the Bill & Melinda Gates-funded Alive & Thrive programme (2009–2015) [42], have demonstrated that dramatic increases in exclusive breastfeeding rates are possible when several barriers to breastfeeding are targeted simultaneously. Of special note are the results from the Alive & Thrive programme in Bangladesh and Vietnam where exclusive breastfeeding rates rose from 49% to 86% and from 19% to 63%, respectively, among populations of millions of women. Whether these impressive increases can be sustained over time remains to be seen and the subsequent decline in the exclusive breastfeeding rates in several of the LINKAGES sites after the programme ended urges caution. However, the results of these programmes are an endorsement of the “Breastfeeding Gear” model, which argues that successful breastfeeding programmes should function like a “well-oiled engine” with several factors working in synchrony and coordination [43].

The results of successful programmes like Alive & Thrive suggest that development agencies need to go beyond breastfeeding promotion and single-barrier focused initiatives to impact breastfeeding rates substantially. With a raft of new breastfeeding supportive policies and advocacy platforms that now includes the Every Newborn Action Plan [44], the new Global Strategy for Women's, Children's and Adolescents' Health [45], the Scaling Up Nutrition (SUN) movement, and the new Global Breastfeeding Collective, supported by UNICEF and the WHO with funding from the Bill & Melinda Gates Foundation, the time is ripe for large, multi-country investments that translate these policies and mobilise these platforms to action. It will be especially important to target breastfeeding action to newborns as they have been poorly served by existing breastfeeding initiatives despite the evidence that increases in early initiation have the potential to prevent hundreds of thousands of newborn deaths each year [46]. It is particularly tragic that the babies who could benefit most from breast milk, i.e., sick and vulnerable newborns, have never been the subject of special efforts by development actors to increase their access to their mother's milk or to donor milk through human milk banks. The WHO Baby Friendly Hospital Initiative has never targeted sick and vulnerable newborns.

The widespread failure of all development actors – governments, business, and civil society – to invest adequately in removing or reducing the full range of barriers to breastfeeding experienced by mothers is now a contributing factor in the downward pressure on breastfeeding rates in most countries. With several substantial funding platforms now available for large-scale nutrition investments, including the Global Financing Facility in Support of Every Woman, Every Child, the Power of Nutrition Fund, and the 2016 Nutrition for Growth Summit, a critical challenge for the breastfeeding community will be to attract a fair share of this investment for high impact breastfeeding initiatives.

2.8 Investments in Breastfeeding Innovations

Identifying compelling investment opportunities with the potential to increase early and exclusive breastfeeding rates in countries where gains will directly translate into newborn and child survival, reduced healthcare costs, and economic gains is now an urgent priority. The most promising solutions will be able to neutralise one or more of the barriers to breastfeeding and lower the rising costs women face as countries develop. The most investment-worthy innovations will have a proven capacity to: (a) increase breastfeeding initiation within an hour for both home and hospital births, (b) ensure even the most vulnerable newborns have access to human milk, (c) improve women's self-confidence about the adequacy of their milk supplies, (d) reduce breastfeeding pain and discomfort and improve technique, (e) reduce breastfeeding time constraints, especially by extending paid parential leave, and (f) create breastfeeding-friendly workplaces, homes, and public spaces.

Examples of specific innovations in each of these categories include cash and non-cash incentives for early initiation at home and at hospitals in the form of direct payments to mothers and/or facilities for high early initiation rates. Widespread access to donor breast milk for vulnerable newborns could be provided through a network of regulated human milk banks located at facilities and in the community [47]. New individual measures of breast milk supply could be developed, with mothers receiving a medical assessment of their supply to build their confidence in the early weeks and months that substitutes are unnecessary [48]. If substitutes are necessary, donor breast milk could be provided through human milk banks. Immediate access to lactation consultants in the home via phone apps could help with technique and pain challenges. Access to new generations of affordable, easy-to-use breast pumps specially designed for low resource settings could reduce the time constraints many women experience, and new methods of pasteurisation in the absence of refrigeration could lengthen the shelf-life of pumped breast milk.

A new system of employer incentives and disincentives could standardise the availability of regular breastfeeding breaks alongside specially equipped rooms to pump and store breast milk at work [49]. On-site infant care where mothers can actually breastfeed their babies during work may be even more effective. Public spaces could be transformed by government-funded breastfeeding rooms or “pods” attached to public buildings (e.g., schools, transport hubs, and libraries). Social business franchises could offer women a private place to breastfeed throughout the day, even for a small fee, similar to the way sanitation facilities are being provided in many urban areas in Africa and South Asia [50]. Where these workplace innovations occur alongside expansions in the duration of paid parental leave, the impact on breastfeeding rates could be transformative.

In 2015, the Breastfeeding Innovations Team was formed to strengthen the pipeline for breastfeeding innovations. The Team comprises a global network of more than 200 organisations and individuals committed to accelerating the development and adoption of innovations with the greatest potential to increase access to breast milk for babies, especially the most vulnerable. It works in support of the UN Secretary-General’s Every Woman, Every Child movement, the Every Newborn Action Plan, and the Global Breastfeeding Advocacy Initiative. More groups like these with the capacity to crowd in a community of breast milk innovators and mobilise support from investors will be critical.

2.9 Breaking Breastfeeding Barriers: a Call to Action

To achieve the greatest increases in breastfeeding rates, innovations will need to benefit mothers living in high-risk environments disproportionately. This is especially relevant to the populations in sub-Saharan Africa and South Asia where breastfeeding increases have the potential to close newborn and child survival gaps. As the specific barriers to breastfeeding differ across populations, innovations will need to be very sensitive to context. Accordingly, development actors should join forces with the agencies able to develop the necessary innovations in a new multi-stakeholder partnership with a singular aim: to increase early and exclusive breastfeeding rates dramatically in populations where breastfeeding gains can contribute the most to national child health goals.

As such, the Breaking the Barriers to Breastfeeding Partnership would enlist all UN agencies, civil society, and corporate actors with the capacity to contribute to population-wide breastfeeding increases in the following 15 countries: India, Nigeria, Pakistan, China, Democratic Republic of Congo, Indonesia, Cote d’Ivoire, Sudan, Kenya, the Philippines, Chad, Somalia, Central African Republic, Sierra Leone, and Mali. These agencies would work with national, state, and local governments to assess the major barriers to breastfeeding among the sub-national populations suffering the greatest burdens of newborn and child deaths, and then develop integrated strategies to reduce or remove the barriers systematically over a ten-year period. The Partnership would make full use of the mechanisms available to governments (legislation, tax and transfer systems, and direct service delivery), to business (marketing, employment policies, product design, and direct service delivery) and to civil society (advocacy, direct service delivery, and social mobilisation) as levers to neutralise specific barriers to breastfeeding.

The Partnership would be financed collaboratively with contributions from governments, UN agencies, business, and civil society with support from high-profile platforms like the Global Financing Facility. High-profile advocacy platforms such as the UN Secretary-General’s Every Woman, Every Child movement would champion the initiative. It would build on the lessons learned from the most successful breastfeeding programmes, especially Alive & Thrive, and on engagement of groups like SUN which have already rallied many partners, including a strong group of companies, to support breastfeeding improvements [29].

2.10 Breastfeeding and the Sustainable Development Goals

In September 2015, the global policy environment for public health profoundly changed with endorsement of the Sustainable Development Goals at the United Nations General Assembly. At this historic gathering, 194 governments pledged to achieve, by 2030, 17 of the most ambitious development goals ever contemplated, including two goals directly related to breastfeeding [51]:

- Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
- Goal 3: Ensure healthy lives and promote well-being for all at all ages.

It is of great concern that the current World Health Assembly target for breastfeeding — achieving 50% coverage of exclusive breastfeeding by 2025 — does not match the ambition of the Sustainable Development Goals and falls far below coverage targets for other lifesaving interventions. Not only will the 50% target fail to inspire further gains in the 34 countries with exclusive breastfeeding rates above 50%, but it will not drive breastfeeding to the levels required for maximum impact on newborn and child survival in underperforming countries.

The world needs ambitious goals for interventions with the greatest potential impact on newborn and child health and development, including breastfeeding. The evidence justifies a target of 100% coverage for early initiation of breastfeeding and 80% for exclusive breastfeeding in the first six months in countries with the highest child mortality. Specific indicators tracking both of these targets are also needed so that governments and development actors are accountable for breastfeeding progress. In the absence of ambitious breastfeeding targets and indicators, the world risks continued underachievement of increasing breastfeeding rates and of maximising breastfeeding's contribution to attain global health goals.

With more ambitious targets, new strategies will be needed to drive breastfeeding rates to historically high levels, certainly since the industrial era. In this new environment, solutions will invariably come from new actors, and impact will be determined by the ability of governments, the UN, business, and civil society to work in broad partnerships based on shared value and collective impact. The ultimate goal of all parties should be to create a world where breastfeeding mothers have the freedom to breastfeed, where breastfeeding progress is unlocked through mother empowerment, and where there is a systematic breakdown of the barriers to breastfeeding through continuous innovation. This is ultimately what will make breastfeeding gains sustainable, when women everywhere can enjoy the freedom to exercise their preference for their babies to be fed breast milk.

Key points

- Breastmilk provides all of the nutrition infants needs for the first six months of life, significantly reducing the risks of sickness and death in infancy, and contributing to healthy development well into early childhood and beyond.
- Breastfeeding is one of the most under-leveraged equity strategies in child health. No other single health intervention has the potential to reduce the inequalities in health and to prevent newborn and child deaths at the scale of breastfeeding.
- Breastfeeding is a cost-effective investment in child health and development and at an estimated cost of US$175 per life saved, promotion of breastfeeding compares favourably with other nutrition intervention packages.
- There is a significant "know-do" gap in breastfeeding – women seem to be well aware of the benefits of breastfeeding but often face significant barriers, such as perceived breast milk insufficiency, pain and discomfort, transition to work, and fear of breastfeeding in public.
- To achieve an increase in breastfeeding rates, the focus of breastfeeding promotion needs to shift from isolated efforts to multi-country, multi-stakeholder partnerships.
- Current global targets for breastfeeding rates do not match the ambition of the UN Sustainable Development Goals

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3 Data Collection on Infant Feeding

Maria Quigley, Prof, MSc, BA

Expected Key Learning Outcomes
- **The source and importance of data collection**
- **The main data collection methods**
- **The main considerations when collecting data**

3.1 Data Collection on Infant Feeding

3.1.1 What Data Need to be Collected

The World Health Organization (WHO) recommends that infants are breastfed within one hour of birth and breastfed exclusively for the first six months after birth, and that breastfeeding is continued alongside complementary foods for up to two years of age or beyond. The WHO has developed population-level indicators of infant and young child feeding practices [1]. These are used to compare infant feeding patterns between different countries and to describe trends over time. They are also used to monitor progress in achieving goals. The indicators related to breastfeeding are associated with the following practices:
- Early initiation of breastfeeding
- Duration of breastfeeding
- Duration of exclusive breastfeeding
- Ever breastfed

The remainder of this chapter discusses how data on breastfeeding practices are collected and the potential problems with data collection.

3.1.2 Who Collects Data and How

Data collection on breastfeeding occurs in a variety of formats, which can be broadly grouped into surveys of breastfeeding, and epidemiological studies and trials. These are described below.

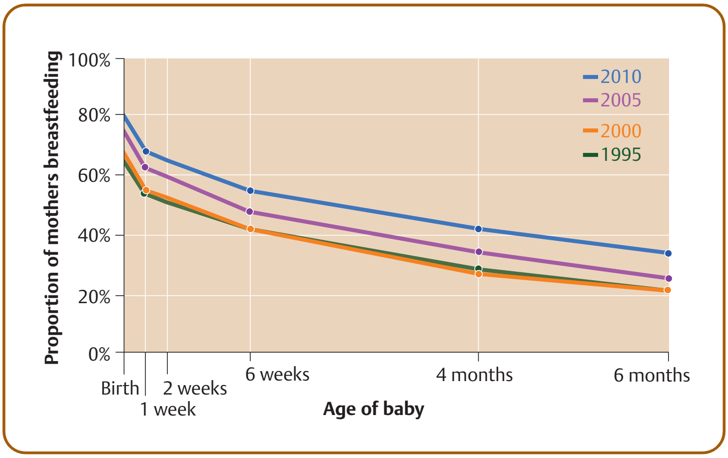
Surveys of breastfeeding practices

An important method of collecting reliable data on breastfeeding practices is a large-scale survey. National surveys with a focus on infant feeding have been conducted in many countries, including the UK (the Infant Feeding Surveys, which were conducted every five years from 1975 to 2010) and the US (Longitudinal studies of infant feeding practices, IFPS I and II, which were conducted in 1992–1993 and 2005). In 2010, Australia conducted its first national infant feeding survey. Some countries do not carry out surveys of infant feeding but rather include a module on infant feeding as part of another regular national survey. For example, the French National Perinatal Surveys (conducted in 1995, 1998, 2003, 2010, and 2016) and the annual Canadian Community Health Survey (CCHS) that began in 2000, include a component on infant feeding that enable breastfeeding practices to be monitored.

Many countries such as England, Scotland, and New Zealand collect maternity data from medical records and other routinely collected data sources. These data, which include information related to breastfeeding, are often collected over several years and thus enable trends in breastfeeding practices to be monitored over time.

Breastfeeding practice data are sometimes obtained using large, one-off studies such as national birth cohorts. For example, the Norwegian Mother and Child Cohort Study (MoBa) and the UK Millennium Cohort Study have been used to describe breastfeeding patterns at a particular point in time [2], [3].

All of the above data sources are used to describe national data on breastfeeding practices at certain infant ages, such as the proportion of babies who were ever breastfed, who were still being breastfed, or who were exclusively breastfed. When data are collected using a consistent methodology, then trends over time can be examined. For example, ▶ **Fig. 3.1** shows how in the UK Infant



▶ **Fig. 3.1** Prevalence of breastfeeding at ages up to six months by year (UK, 1995–2010). (Reproduced from McAndrew, et al. Infant Feeding Survey 2010. Leeds: Health and Social Care Information Centre)

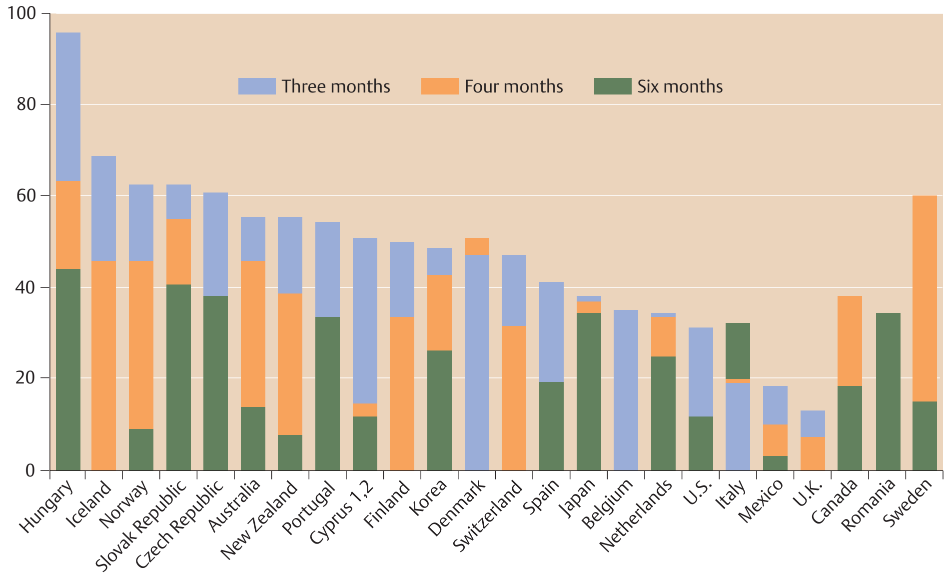
Feeding Survey, the proportion of infants being breastfed up to age six months has changed between 1995 and 2010 [4]. While the proportion of infants who began breastfeeding increased from 66% in 1995 to 81% in 2010, a similar pattern of reduction in the early weeks is seen across the same time period.

Data on breastfeeding from different national sources are often combined to form global datasets such as those described in the Organisation for Economic Co-operation and Development (OECD) Family Database and the Global Database on Infant and Young Child Feeding. The OECD Family Database analysed data on breastfeeding rates sourced from national health institutes or surveys [5]. The results showed that in the period around 2005 the proportion of infants who were ever breastfed varied widely across OECD countries, from less than 50% in Ireland to almost 100% in Norway, Denmark, and Sweden. Rates of exclusive breastfeeding were also compared across countries with available data. The proportion of infants who were exclusively breastfed was almost 50% at three months but less than 25% at six months although the variation between countries was high (▶ **Fig. 3.2**).

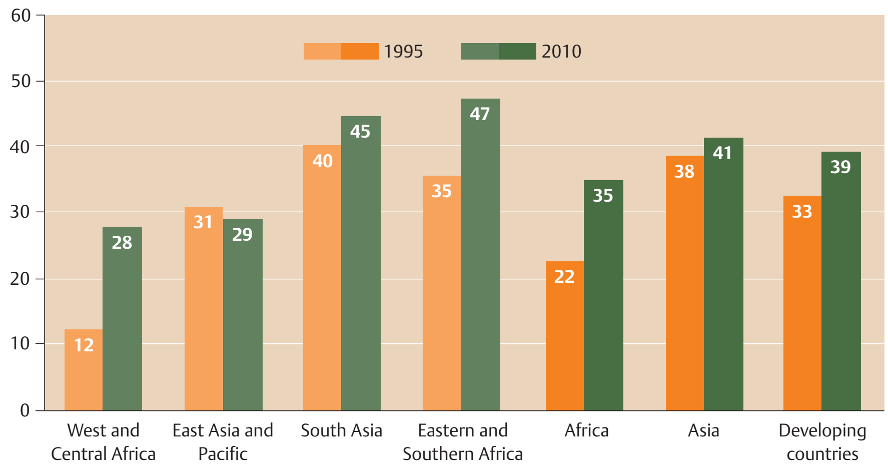
The Global Database on Infant and Young Child Feeding, which is maintained by UNICEF, contains data on 440 national household surveys for 140 countries. Data are updated annually and are used to compare breastfeeding rates across countries. The Global Breastfeeding Scorecard assesses how recently a country has collected globally comparable data on exclusive breastfeeding, based on reports to this Database. The Global Database has been used to estimate global and regional averages of the rate of exclusive breastfeeding in infants aged 0–5 months [6]. Findings showed that on average the rate of exclusive breastfeeding increased from 33% in 1995 to 39% in 2010, with the largest increase seen in West and Central Africa (▶ **Fig. 3.3**).

Importantly, these global databases provide the sources of their data, which is helpful for those who want to obtain more detailed information from a particular source.

Interpreting data from a given source or comparing different sources should be carried out with caution because of the differing definitions of breastfeeding indicators (described in the next section), and different inclusion and exclusion criteria between study populations. Many surveys and studies are often restricted to a particular geographical population such as a country or a large hospital. Thus, confirming who was eligible for inclusion in the study is of importance; for example, does the study include all births in a particular population only, or all mothers living in an area, or all mothers delivering in one hospital, or are the data restricted to certain groups such as singletons or infants born at term?



▸ **Fig. 3.2** Proportion of children who were exclusively breastfed at 3, 4, and 6 months, around year 2005. (Reproduced from OECD Family Database (http://www.oecd.org/els/family/database.htm))



▸ **Fig. 3.3** Trends in exclusive breastfeeding among infants younger than six months. (Reproduced from Cai X, Wardlaw T, Brown DW. 2012. Global trends in exclusive breastfeeding. Int Breastfeed J. 2012; 7: 12)

Epidemiological studies and trials with a focus on breastfeeding

Randomised controlled trials of breastfeeding interventions

Breastfeeding has been the subject of numerous randomised controlled trials. These studies typically collect prospective detailed data on infant feeding. They also enable breastfeeding patterns to be described in their study populations, for example, the cluster randomised trial of an intervention aimed at the promotion of breastfeeding in Belarus (PROBIT) [7]. This study yielded breastfeeding data on 16,491 mother-infant pairs and was able to compare the duration of breastfeeding, including exclusive breastfeeding, in the intervention and control arms. The cluster randomised trial of breastfeeding counselling by peer counsellors (PROMISE) was conducted in communities in Burkina Faso, Uganda, and South Africa [8]. This study obtained data on the prevalence of exclusive breastfeeding in 2,579 mother-infant pairs at 12 and 24 weeks across these three countries.

Epidemiological studies of breastfeeding

There is also a large body of literature on the association between breastfeeding and specific outcomes in the child or mother. Such studies are usually epidemiological studies (e.g., case-control, cross-sectional, or cohort studies), or reviews and meta-analyses of these studies.

The Western Australia Pregnancy Cohort Study is a prospective birth cohort that recruited 2,602 live-born infants in 1989–1992 [9]. This study investigated the association between the duration of breastfeeding and child outcomes in infancy and later in childhood. Parents were provided with a diary card at the time of birth and asked to complete the card daily, recording feeding history and illnesses throughout the first year. As such, breastfeeding data was recorded prospectively.

The UK Millennium Cohort Study is a nationally representative population-based cohort of 18,818 infants born in the UK in 2000–2001 [3]. Infants were recruited at around nine months of age and information was collected about breastfeeding, infant health, and other factors by parental interview, usually with the mother. Questions on infant feeding enabled the researchers to estimate the duration of both ‘any’ breastfeeding and exclusive breastfeeding, and data were studied in relation to infant outcomes and (from subsequent data collected on the same cohort) child outcomes.

The Norwegian Mother and Child Cohort Study (MoBa) is a national population-based pregnancy cohort [2]. Data on breastfeeding in 29,621 mothers were collected by questionnaire when infants born in 2002–2005 were aged six months. These study data have been used to describe breastfeeding patterns and factors that predict breastfeeding patterns.

Long-term effects of breastfeeding

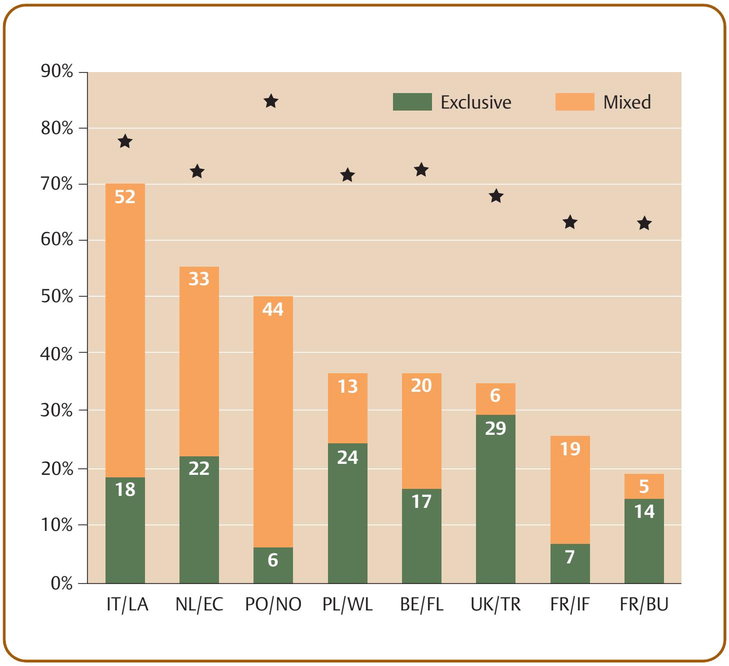
There have been many studies that have looked at the long-term effects of breastfeeding. A prospective, population-based birth cohort study followed infants born in 1982 in Pelotas, Brazil and assessed their IQ, educational attainment, and income when they were aged 30 years [10]. Data on breastfeeding duration were collected when the infants were on average aged 19 months.

Long-term effects of lactation in mothers

While the majority of studies of breastfeeding have focused on outcomes in the child, many studies have also explored outcomes in the mother. The association between breastfeeding and the risk of developing breast cancer later in life is an interesting example. One particular study analysed data from 47 epidemiological studies in 30 countries as part of an individual participant data meta-analysis [11]. The study included data on 50,302 women with invasive breast cancer and 96,973 controls who did not have breast cancer. The measure used was the woman’s total (lifetime) duration of breastfeeding; for example, if a woman had three children and breastfed each of them four months, her total duration of breastfeeding was 12 months. The information was therefore collected retrospectively, decades after the women had given birth to their children.

Special populations such as preterm infants and multiples

Infant feeding patterns in some groups of babies are more complex than that in babies more generally, and these groups need to be studied separately. The MOSAIC study is a population-based study of very preterm infants across ten regions in



▶ **Fig. 3.4** Rates of exclusive and mixed breastfeeding at discharge in very preterm infants in each study region, and overall national breastfeeding rates (black dots). (Reproduced from Bonet M, et al. Arch Dis Child Fetal Neonatal Ed. 2011; 96: F450–F452)

Europe [12]. Data on maternal and infant characteristics, including infant feeding, were collected from medical records using a common protocol. ▶ **Fig. 3.4** shows the rates of exclusive and mixed breastfeeding of very preterm infants at hospital discharge in each study region, and compares them to the region's national breastfeeding rate.

Data on breastfeeding in multiples is relatively scarce because many studies exclude multiples. In 2001–2004, a large study conducted in Nishinomiya City, Japan, used data from a nearly universal medical check-up of infants aged 3–6 months to compare breastfeeding rates in singletons, twins, and triplets [13]. Data were available on 14,963 singletons, 290 twins, and nine (0.1%) triplets, and breastfeeding rates at 3–6 months were compared between the three groups.

3.2 Problems with Data Collection

When interpreting data on breastfeeding from a given source, or comparing data from different sources, it is important to take into account the methods used for data collection, the breastfeeding definitions that have been used, and the study population.

Different breastfeeding data sources may also vary in terms of their inclusion and exclusion criteria in their study population. Common exclusion criteria for study populations include preterm and/or low birth weight infants and multiples. Some studies include multiples, but only include data on one of the multiples in a set.

Breastfeeding data are often collected retrospectively and therefore there is a risk of recall bias. Several studies have shown that the majority of mothers accurately report breastfeeding duration within one month, up to three years after the birth of their infant, although data on the introduction of solids (required for measuring the duration of exclusive breastfeeding) are less reliable [14]. A particular problem is rounding error; for example, if a mother stopped breastfeeding when her baby was six months, then this could be reported as either breastfeeding for six months or breastfeeding for less than six months.

Breastfeeding data may also be prone to reporting bias. In many settings, women may over-report their duration of breastfeeding because they perceive it as socially desirable to do so. This is likely to be more of a problem when interviewing women about breastfeeding, rather than allowing them to self-complete a questionnaire or fill in a diary.

Perhaps the most important problem with collecting data on breastfeeding is that of misclassification. Feeding patterns are complex and dynamic processes, and it is often difficult to capture accurate data on breastfeeding, particularly if it is measured using a limited number of questions at one point in time. Some of the more common problems are described below:

3.2.1 How Exclusive is Exclusive Breastfeeding?

A common discrepancy between data sources is the definition of exclusive breastfeeding [15]. This may be based on whether the infant was exclusively breastfed in the past 24 hours, or whether the infant had only received breast milk up until this point in time. Answers to this question may also vary depending on whether the definition includes expressed breast milk feeding or only direct feeding at the breast.

3.2.2 Does Breastfeeding Include Breast Milk Feeding?

Another common problem concerns the categorisation of expressed breast milk. When questioning whether the mother has ever breastfed her baby, or when the baby last breastfed, mothers who have fed their baby expressed breast milk, either alone or in combination with direct breastfeeding, may not know how to answer the question, and mothers with the same feeding patterns may give inconsistent answers. It is particularly important to capture accurate data when studying groups of mothers in which expressing is relatively common, such as those with preterm infants or who are returning to work.

3.2.3 How to Collect Complex Feeding Data: Preterm Infants, Multiples

Infants who are born very preterm tend to have complex feeding patterns. They can be fed expressed breast milk (mother's own or donor milk) and/or formula via a tube, cup or bottle, and they may also be breastfed directly. These feeding patterns may change (and recur) in a complex, dynamic process. Multiples are often born very preterm and have complex feeding patterns, which may vary across co-siblings. Many studies exclude multiples, or they include multiples but only include data on one of the twins or triplets. A limitation with this approach is that it does not allow infant feeding pattern to vary. While broad feeding patterns are usually similar within a set of twins or higher-order multiples, the exact feeding pattern may differ.

3.3 Conclusion

Data collection is important to monitor progress in achieving long-term global goals, such as the Sustainable Development Goals. It is important to observe trends and to reflect on the country deviations. However, it must be considered that the collection of accurate data is confounded by many factors including differing definitions of breastfeeding indicators, different inclusion and exclusion criteria and geographical restrictions. There are no global standards to aid in the accurate collection of data and the development of consistent methodology for data collection would certainly be of benefit for the long-term monitoring of breastfeeding statistics.

Key Points

- Data collection on infant feeding is mainly collected on a national basis and is available in various global databases. These datasets are not necessarily comparable, hence pooled analysis is difficult
- Data collection can be broadly grouped into a) surveys of infant feeding practices, which may be national or global, involving birth cohorts or use of maternity data from medical records; or b) epidemiological studies and trials, which investigate breastfeeding interventions, mother-child outcomes, and special infant populations (pre-term and multiples)
- When analysing the data it is important to consider the inconsistencies in terminology and data collection methods, this would be alleviated if standard procedures and terminologies were developed

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4 How Breastfeeding Works: Anatomy and Physiology of Human Lactation

Melinda Boss, MPS, B.Pharm, Senior Research Fellow; Peter E. Hartmann, E/Prof, PhD, BRurSc

Expected Key Learning Outcomes

- **The history of the understanding of the anatomy and physiology of lactation**
- **The processes of lactation**
- **The production and regulation of milk supply**
- **How the complexity of lactation benefits both mother and baby**

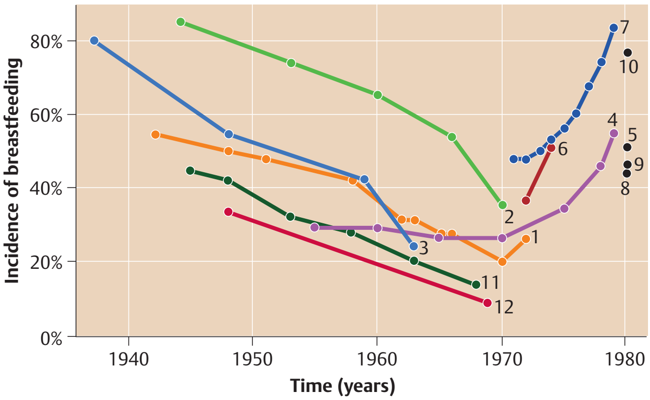
4.1 Introduction

In 1840, Astley Cooper published a book titled "On the Anatomy of the Breast". His anatomical dissections of the lactating breast are still used in textbooks to this day. This is in part due to the difficulty in obtaining specimens (lactating women rarely donate their bodies to science) and partly due to a lack of scientific interest in this fascinating organ. Thus, Cooper's work stands out as the exception and his book provides a sound foundation for the understanding of mammary anatomy and physiology. He rightly deserves to have the ligaments of the breast, Cooper's ligaments, named in his honour. This chapter addresses historical as well as current knowledge of lactation, including a detailed review of Cooper's work and how this developed our current understanding. His dissections remain the seminal work on the gross anatomy of the human breast and many of his preparations have been reproduced here to illustrate the structure of its parenchyma, together with its innervation, blood, and lymphatic supply.

In addition, the anatomy of the lactating breast forms the basis for a detailed consideration of the physiology of human lactation. The historical development of the current knowledge of the mechanisms involved in the synthesis and secretion of milk are considered in a functional context. The removal of milk from the mammary gland is also reviewed, including milk ejection and the infant suck-swallow-breathe reflex. This chapter covers changes occurring over the lactation cycle from conception, secretory differentiation during pregnancy, secretory activation after birth, the endocrine and autocrine regulation of lactation, and finally involution and the return of the mammary gland to its resting state.

4.2 Background

In 1758 Carolus Linnaeus, the "father of taxonomy", grouped into one class both aquatic and land animals with the capacity to produce milk for their young: Mammalia. The selection of this term was unusual because it was only directly applicable to half the animals in this class, namely females. Indeed, he ignored other biological traits (such as hair, sweat glands, and three ear bones) that are specific to all mammals. Wet nursing, the practice of mothers breastfeeding another mother's infant, was widely practiced at that time. Specifically, rich families paid poor mothers to breastfeed their babies. Diaries of rich mothers suggest that they reluctantly accepted this "cuckoo-like" behaviour because they had been convinced that it was best for their babies. Wet nursing was prevalent in the "better classes" in Sweden and other European countries. Linnaeus was strongly opposed to wet nursing. It is said that he chose the term, Mammalia, because he wanted to emphasize that young mammals should be suckled by their own mothers. Today, our current knowledge of the importance of breastfeeding to both the mother and her infant reinforces the wisdom of Linnaeus' choice of the term, Mammalia.



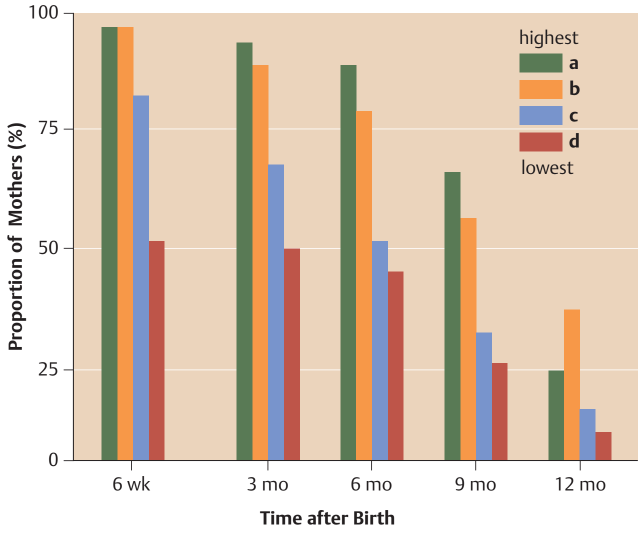
(1) at 3 months of age, Australia (from Wilmot, 1973)
(2) at 2 months of age, Sweden (from Hofvander & Sjolin, 1971)
(3) at 3 months of age, Poland (from Vahlquist, 1975)
(4) at 1 week of age, U.S.A. (from Martinez & Nalezienski, 1981)
(5) at 1 week of age, Canada (from M. E. Thomson & Brault-Dubuc, 1981)
(6) at 1 week of age, United Kingdom (from Sloper, Elsden & Baum, 1977)
(7) at 1 week of age, Australia (from Hartmann, Kulski, Rattigan, Prosser & Saint, 1981)
(8) at 3 months of age, Sweden (from WHO, 1981)
(9) at 3 months of age, Hungary (from WHO, 1981)
(10) at 3 months of age, Australia (from Hitchcock & Owles, 1980)
(11) at 2 months of age, Denmark (from Biering-Sørensen, Hilden & Biering-Sørensen, 1980)
(12) at 3 months of age, United Kingdom (from Vahlquist, 1975)

▶ **Fig. 4.1** Changes in the proportion of infants who were breastfed in high-income countries from 1938 to 1980. (Reproduced from Hartmann, P.E. et al. Human lactation: Back to nature. Physiological Strategies in Lactation. Symposia of the Zoological Society of London. 337–368, 1984)

The abandonment of breastfeeding in the 19th and 20th centuries seems to have been associated with the development of condensed cow's milk in 1853 and evaporated cow's milk in 1885. Pasteurisation and the home icebox also decreased the risk of contamination of infant formula with microbiological pathogens. By the 1920s and 1930s evaporated cow's milk was widely available at affordable prices and several clinical studies suggested that infants fed evaporated cow's milk formula thrived as well as those that had been breastfed. Importantly, these studies have not been supported by modern research. Indeed, Cowie, et al. concluded that 'We may also surmise that had cow's milk been tested by usual procedures that are now applied to new drugs it is unlikely, in view of its puzzling toxicity to infant rabbits, that it would have reached the stage of even a clinical trial in human infants!' [1]

The active marketing of "safe" infant formula under the erroneous belief that scientifically developed formula was either better or equivalent to breastmilk for the nourishment of babies, enabled the lower socioeconomic classes to use this "pocket wet nurse" and follow the example set by the richer classes. The decline in breastfeeding was arrested in 1972 in most high-income countries ▶ **Fig. 4.1** when for the first time in Western history affluent mothers began to breastfeed their own babies ▶ **Fig. 4.2**. This example has filtered down all social classes and currently almost all mothers in some Western countries choose to breastfeed their newborn infants.

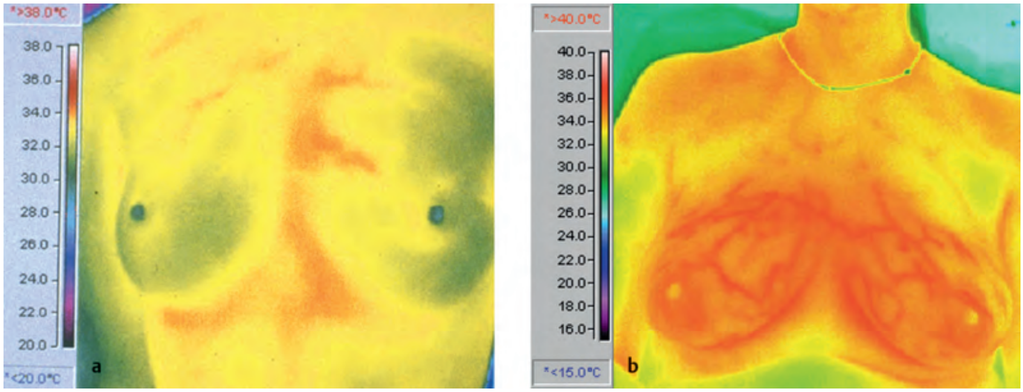
The breast is unusual in that lactation is characterised by periods of high secretory activity followed by periods of quiescence. Indeed, lactation is the final phase of the reproductive cycle in mammals. In all of the 4000 plus species of mammal, maternal milk is essential for the survival of



▶ **Fig. 4.2** Social rank of mothers and the proportion of mother's breastfeeding in Australia from 6 weeks to 12 months postpartum in 1983.

the young during early postnatal life. However, mammals are either hatched or born at very different stages of maturity. Species-specific lactation strategies and milk composition provide a unique environment for the maturation of each mammal's young [2]. Therefore, it is not surprising that the milk of one species is not suitable for optimum physiological growth and development of the young of another. Human lactation is no exception; for example, human infants grow extremely slowly compared to most other mammals. The time to double birth-weight extends many months for human infants but is only a few days in piglets. Indeed, human milk has a very low concentration of protein relative to its energy content and therefore cannot support rapid infant growth. The proportion of energy derived from protein is lower in infants than that recommended for adults. It follows that the proportion of essential amino acids in human milk must exactly match the infant's requirements. This is very difficult achieve with infant formula. To obtain the required intake of all essential amino acid(s), extra protein has been added to infant formula. Unfortunately, this higher protein intake is associated with adverse outcomes in infants such as obesity and increased renal solute load.

The evolution of a large brain (i.e., one that requires ~25% of the mothers daily resting energy intake) has given humans a significant competitive intellectual advantage over all animals, including other mammals. Consequently, unlike other mammals, extensive brain growth in human infants occurs in the first one to two years after birth. This rapid postnatal growth is facilitated by many components present in breastmilk. Furthermore, the lactating breast is a very active metabolic organ (▶ **Fig. 4.3**), with energy output in breastmilk representing ~30% of the daily resting energy requirements of the mother. It is also important to consider the duration of lactation. Other large primates breastfeed for years rather than months; for example, the orang-utan breastfeeds for 7 years. Therefore, it is also to be expected that women would breastfeed for a number of years and indeed rural Aboriginals in North Western Australia breastfed their babies into their 6th year of life. Modern traditional societies (i.e., those without access to manufactured contraceptives or prepared infant foods) usually wean between 2–3 years of age [3]. The World Health Organization recommends that all infants should receive breastmilk only (with no additional food, drink, or water) until 6 months after birth and then contin-



▶ **Fig. 4.3** Thermal images of the breasts of (a) non-lactating and (b) lactating women (red 38 °C, green 31 °C). (from Kent J.C., Hartmann, P.E. 1995 Unpublished data.)

ue to be breastfed with the introduction of first foods up to 2 years of age and beyond [4]. Currently, most infants in developed countries are weaned before one year of age [5], [6], [7].

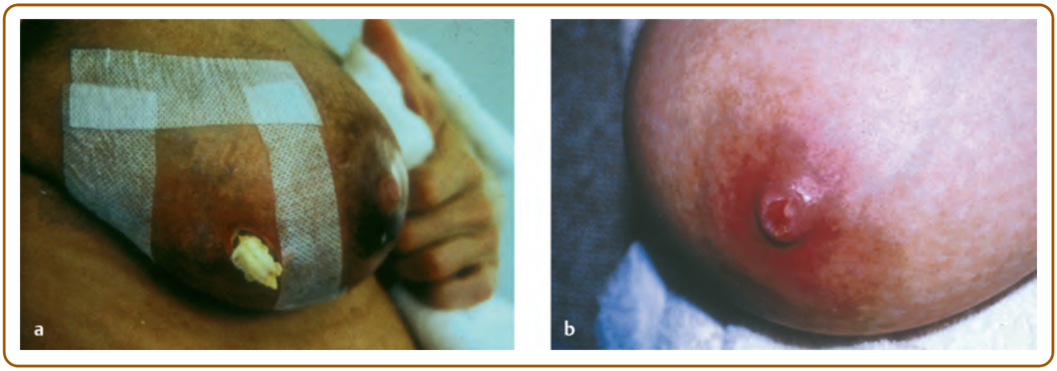
The promotion of breastfeeding by community groups and health professionals in countries like Australia has been excellent, and 96% of mothers now choose to breastfeed their babies compared to only 48% in 1972 [5], [8]. Indeed, facilitation of breastfeeding (e.g., in coffee shops) is now beginning to be seen as providing an economic dividend (▶ **Fig. 4.4**). Unfortunately, there is a rapid decline in breastfeeding with time after birth, with less than 16% of infants exclusively breastfed to 5 months and only 60% receiving any breastmilk at this time [5].

The commitment of such a large proportion of maternal energy intake to lactation over a long period of time (years), and the conservation of genes associated with lactation and milk composition strongly suggests that mothers are "hard-wired" to breastfeed. This conclusion is reinforced by the observation that mothers will endure hardships such as severe breast and nipple pain and still continue to breastfeed their infants. This begs the question, 'Why have women in high-income countries found it difficult to breastfeed?' Two reasons may be postulated. First, perhaps subtle uncertainties accumulate and diminish the mother's confidence in her ability to produce enough milk for her baby. Secondly, mothers experience unacceptably high incidences of conditions, such as breast engorgement, mastitis, and severe nipple pain, which challenge the resilience of even the most committed mothers (▶ **Fig. 4.5**).

Since there is only limited basic research on human lactation, evidence-based medical diagnosis and treatment of lactation dysfunction is very limited. For example, unlike other metabolically equivalent organs in the body, there are no clinical tests to assess the normal function of the lactating breast and no reference ranges for either milk production or milk composition. Consequently, family doctors do not have objective tests to assist with the diagnosis and treatment of mothers who experience breastfeeding difficulties. There are no clinical tests to measure 24-hour milk production, yet perceived low milk supply is one of the major causes of mothers ceasing to breastfeed.

Conventional medical care (that is, the availability of a lactology medical specialist to whom the family doctor can refer patients if necessary) does not exist and this is probably responsible for much of the current decline in breastfeeding with time after birth. This is appalling considering that the lactating breast requires a higher proportion of daily resting energy than the brain. Attention to this situation was succinctly stated in TIME magazine,

▸ **Fig. 4.4** A coffee shop advertisement in Perth, Western Australia featuring a mother breastfeeding her 6 month old baby and inviting other breastfeeding mothers to frequent the coffee shop in 2011. (STM 2011, Sunday Times Magazine, January 2016)



▶ **Fig. 4.5** Lactating mothers with (a) breast abscess and (b) mastitis. Both mothers breastfed their babies during the breast trauma and for several months after recovery. (from Hartmann, P.E. 1985. Unpublished data.)

> *'... lactation is probably the only bodily function for which modern medicine has almost no training, protocol or knowledge. When women have trouble breast-feeding, they're either prodded to try harder by well-meaning lactation consultants or told to give up by doctors. They're almost never told, "Perhaps there's an underlying medical problem – let's do some tests"'[9].*

Obviously a much deeper understanding of the anatomy and physiology of the human breast are required so that appropriate medical care can be provided for lactation.

4.3 Gross Anatomy

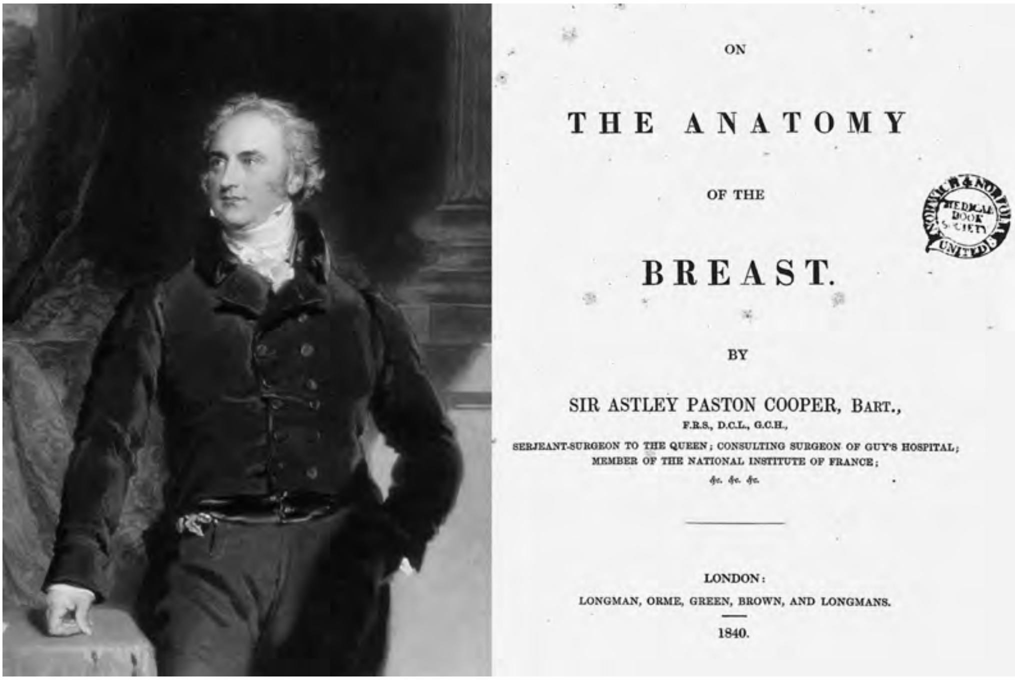
4.3.1 History

Any consideration of the anatomy of the non-lactating and lactating human breast is not complete without acknowledgment of the contribution of the brilliant Sir Astley Paston Cooper in 1840 [10] (▶ **Fig. 4.6**). He was the greatest surgeon of his time and was much loved in the medical world [11]. His patients knew him for his sweetness of manner and courtesy. Against the practice of the time, Cooper always removed his top hat on entering the wards. He also took good care of his students; for example, he found accommodation for the poet Keats when he was a medical student. Cooper's careful observations and meticulous dissections set the foundation for current knowledge of the gross anatomy of the lactating human breast. His findings have, in the main, stood the test of time.

> *'My rule has been to publish that only which I could show to those who were sceptical, and were yet desirous of arriving at the truth.'*

Subsequently, few scientists have followed his example and investigated this extremely interesting organ, the human mammary gland. Very few papers investigating the anatomy of the lactating human breast were published for the remainder of the 19th century and the entire 20th century. Thus, anatomical diagrams and descriptions of the gross anatomy of the lactating breast have changed little over the past 165 years.

Cooper obtained lactating breasts from the bodies of cadavers who were most likely provided by gangs of "resurrection men". The bodies were from women in established lactation. The breasts from mothers who died soon after giving birth (presumably from puerperal fever) were decomposing from virulent septicaemia and unsuitable for his anatomical studies. Cooper studied the gross anatomy of the lactating breast including the ductal system, innervation, blood vessels, lymphatic system, fatty tissue, and the ligamenta suspensoria. These ligamenta suspensoria are now commonly referred to as "Cooper's ligaments" in recognition of his contribution to the understand-


ON

THE ANATOMY

OF THE

BREAST.

BY

SIR ASTLEY PASTON COOPER, BART.,

F.R.S., D.C.L., G.C.H.,

SERJEANT-SURGEON TO THE QUEEN; CONSULTING SURGEON OF GUY'S HOSPITAL;
MEMBER OF THE NATIONAL INSTITUTE OF FRANCE;
&c. &c. &c.

LONDON:

LONGMAN, ORME, GREEN, BROWN, AND LONGMANS.

1840.

▶ **Fig. 4.6** Sir Astley Cooper, author of the seminal book "On the Anatomy of the Breast", published in 1840. (Cooper, AP 1840. On the Anatomy of the Breast, Longman.)

ing of the anatomy of the lactating breast and in particular for being the first to provide a detailed description of these ligaments (▶ **Fig. 4.7**). Cooper's ligaments support the breast in its normal position. Cooper noted that without the internal support provided by these ligaments the breast tissue (which is heavier than the surrounding fat) would sag under its own weight, losing its normal shape and contour.

> *'The uses of the ligamenta suspensoria are to connect the nipple to the breast, the breast to the skin and to fold up the gland to increase the secretory organ, without spreading it more widely over the surface of the chest. They also enclose the adipose matter of the breast.'*

Errors in interpretation of Cooper's work have persisted over time and this suggests that few authors actually quoted from his original work.

4.3.2 Foetal and Pubertal Development

The normal growth and functional development of the breast may be either reduced or even abolished by trauma such as from cosmetic surgery. Therefore, the anatomy and physiology of lactation is concerned not only with breastmilk and the function of the breast during lactation, but also with development. Development must encompass maturation of the breast from foetal stages to sexual maturity, together with development to a secretory state during pregnancy and after birth.

The mammary ridge (milk line) appears as a raised portion of ectoderm on either side of the midline by the time the human embryo has attained a length of 4–6 mm (4^{th} week of gestation). Regression of the mammary ridge occurs except for the pectoral region (2^{nd} to 6^{th} rib), which forms the mammary buds that lead to the development of breasts. In 2–6% of women, mammary buds may develop anywhere along the mammary ridge

▶ **Fig. 4.7** (a) Section of the mammary gland through the nipple, showing ducts over a bristle, unravelled, and proceeding to the posterior part of the gland. (b) A preparation made to show the ligamenta suspensoria supporting the folds of the breast to the inner side of the skin. (c) A view of the gland, dissected and unravelled, to show the ducts over bristles, lobuli, and glandules. (Cooper, AP 1840. On the Anatomy of the Breast, Longman. Plate IV fig 1.)

and may either mature into accessary breasts (polymastia) or remain as accessory nipples (polythelia).

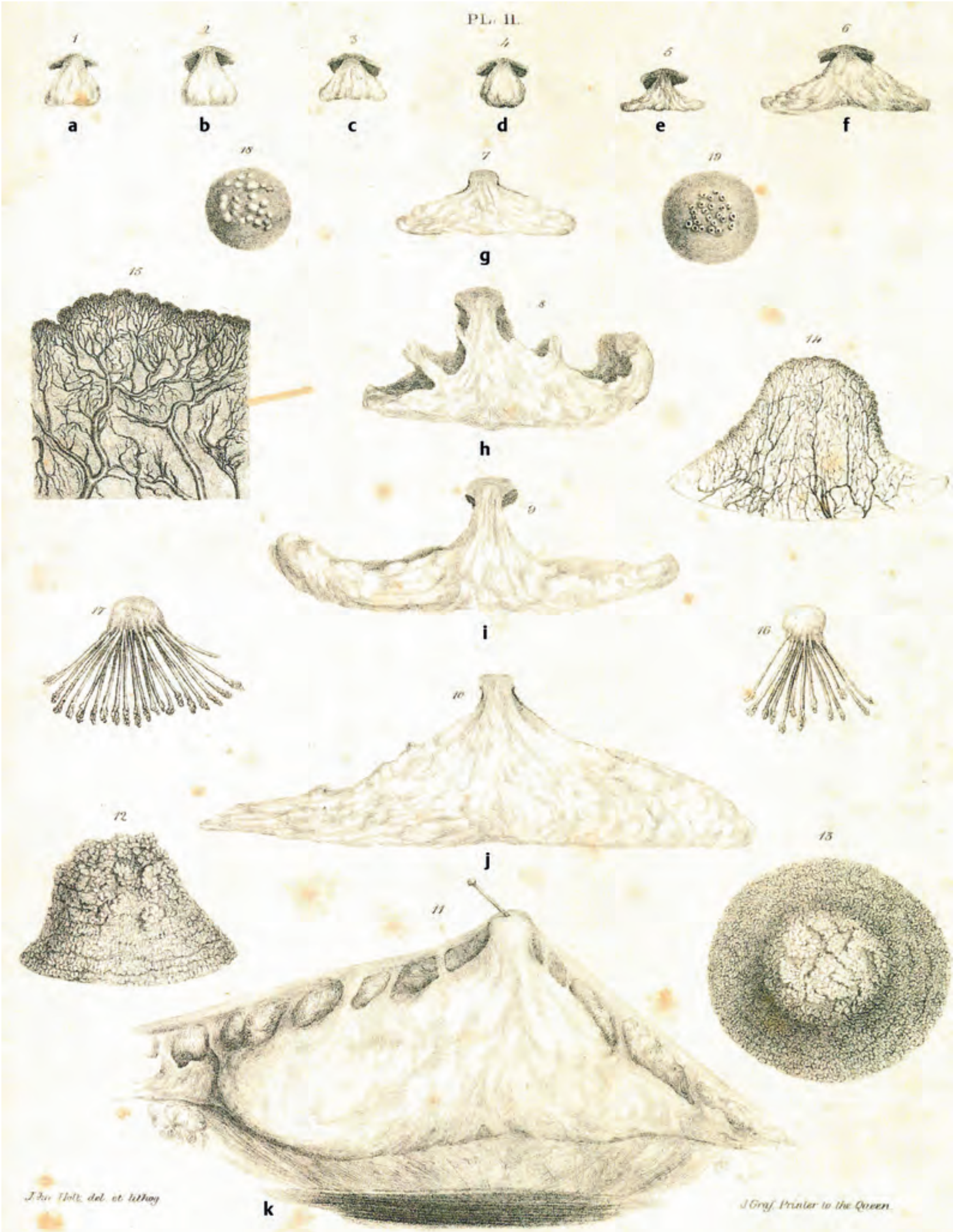
By the end of gestation, epithelial cells in the mammary buds have elongated microvilli on the luminal surface, the cytoplasm is rich in organelles, and the rough endoplasmic reticulum has dilated cisternae containing fine granular material. The Golgi vesicles in these epithelial cells contain dense, dark granules and fat droplets that are discharged into the alveolar lumen. Therefore, by the end of gestation, the cells of the breast of the human foetus have reached a high degree of differentiation and are secreting in response to the foetal hormonal milieu of late pregnancy.

The newborn breast consists only of rudimentary ducts that have small club-like ends, which regress soon after birth. Neonatal galactorrhoea, commonly referred to as witch's milk, is a fluid secreted from the breasts of newborn infants. Indeed, witch's milk is one of the few pre-scientific terms still in current medical usage. It was thought that the witches possessed infants that secreted such milk and these infants were not favoured. However, this physiological occurrence is found in 100% of term infants less than 3 weeks of age and is usually resolved before the infant reaches 4 months of age [6]. Witch's milk is similar in composition to colostrum and when compared with extracellular fluid, the concentration of sodium is low. Thus, the ionic composition of the mammary secretion of the newborn infant can be used to distinguish between true neonatal galactorrhoea with low sodium and bacterial infection that has high sodium content. Bacterial infection increases the permeability of the breast epithelium and the ionic content of the secretion from the infant nipple under these circumstances tends to equilibrate with the higher sodium content of the extracellular fluid [12].

Throughout childhood only isometric growth of the breast occurs and the rudimentary breasts remain quiescent. Allometric growth of the human breast occurs at puberty and continues during the luteal phase of the menstrual cycle until maximum development is achieved between 20–30 years of age. During this period there is accelerated growth of the nipple and the development of sub-areolar tissue, leading to elevation of the areola and nipple. In the adult, the areola is a circular pigmented area of skin about 40 mm in diameter, but the size of both the areola and nipple can vary greatly between women and with time (▶ **Fig. 4.8**).

4.3.3 Non-Lactating Adult Breast

The non-lactating breast is composed of glandular and adipose tissue and is supported by a loose network of fibrous connective tissue (Cooper's ligaments). Ultrasound imaging has identified an average of nine ductal openings (nipple pores) at the nipple. This is in close agreement with Cooper's observations from his dissections of seven to ten functional ductal openings on the nipple. Larger numbers (15–20) are usually quoted in textbooks based on Cooper's work. Careful reading of



▸ **Fig. 4.8** Size of the breast from 11 months to 20 years of age. (a) 11 months, (b) 3yr, (c) 4yr, (d) 6yr, (e) 9yr, (f) 11yr, (g) 12yr, (h) 13yr, (i) 14yr, (j) 16yr, and (k) 20yr. (Cooper, AP 1840. On the Anatomy of the Breast, Longman. Plate II.)

his work shows that he only observed a maximum of 12 functional ducts opening at the nipple. 'The greatest number of lactiferous tubes I have been able to inject, has been twelve, and more frequently from seven to ten.' However he did note up to 22 openings on the nipple but concluded that a number of these were just follicles and not open ducts.

Although prior to pregnancy the adult breast is in an inactive state, changes do occur in the breast during the menstrual cycle. In the proliferative phase of the menstrual cycle (when follicles are primed for ovulation) there is increased cell division. During the luteal phase (when follicles produce progesterone to prepare the uterus for the fertilised egg), the ducts become somewhat dilated and the alveolar cells contain some lipid droplets. From 3–4 days before the onset of menstruation, increased turgescence and tenderness are observed. Breast volume normally increases by 15–30 mL but in some women this increase can be up to 300–400 mL. Towards the end of menstruation the secretory tissue begins to regress and breast oedema decreases to reach a minimum breast volume by 5–7 days after menstruation.

During the non-lactating state the lobules consist of either tubules or ducts lined with epithelial cells and embedded in connective tissue. They are widely separated, with connective and adipose tissues predominating. At this stage of development there is only a small contribution from the glandular tissue. A few bud-like sacculations (terminal end buds) arise from the ducts, but the gland consists predominantly of interlobar and interlobular ducts. The few alveoli present consist of simple cuboidal epithelial cells without distinctive structural features. The milk ducts branch under the areola, are quite superficial, and are easily occluded with the application of light pressure. Differences in the morphology (external appearance) of the breast exist, even between different ethnic groups, but the internal structure of the glandular and supporting tissues is similar in practically all species of mammal [1].

The distribution of adipose tissue in the human breast is highly variable. It is situated beneath the skin (subcutaneous), between the glandular tissue (intra-glandular) and beneath the breast (retromammary fat pad). Unlike other mammals, women have significant amounts of intra-glandular adipose tissue. In other species studied, the mammary glands contain subcutaneous and retromammary adipose tissue but no intra-glandular adipose tissue. The variable amount of intra-mammary adipose tissue may be, in part, the reason why breast size does not correlate with milk production. As Cooper observed,

> *'The quantity of milk which a woman is capable of secreting, cannot be estimated by the size of her breast, as it often is large and hard rather than secretory, or it is loaded with adeps, and produces but little milk.'*

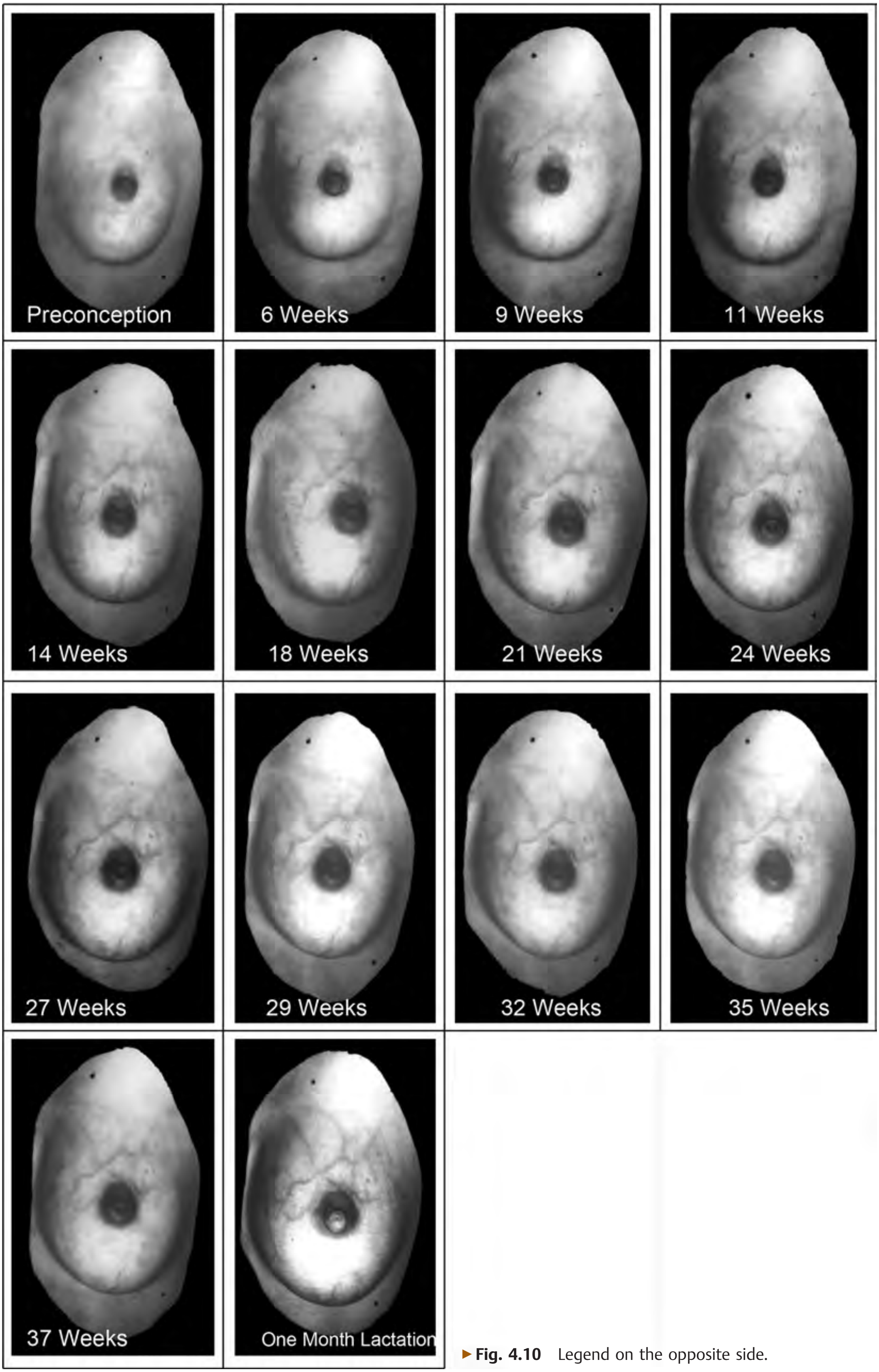
Knowledge of the innervation of the breast is relatively limited compared to that of other major organs in the body. Investigation of the innervation and sensitivity of the breast has predominantly focused on women who have undergone breast surgery such as reduction mammoplasty. Cooper showed that the 2nd to 6th intercostal nerves supply the breast (▶ **Fig. 4.9**). These nerves divide into two branches. The deep branch supplies the glandular tissue and the other branch takes a relatively superficial course within the gland, supplying the nipple and areola. The areola also contains a dense intradermal nerve plexus supplying numerous sensory end organs, including Meissner's corpuscles and Merkel's discs (mechanoreceptors). This ensures it is receptive to mechanical stimuli, such as suckling.

Innervation of the larger ducts has been observed but no nerves have been associated with the smaller ducts, and a lack of sensitivity of the epidermis of the nipple has been noted. Clinically, women recognise the overall fullness and distension of their breast as well as pain associated with some abnormalities, but are often unable to accurately localise either sensation.

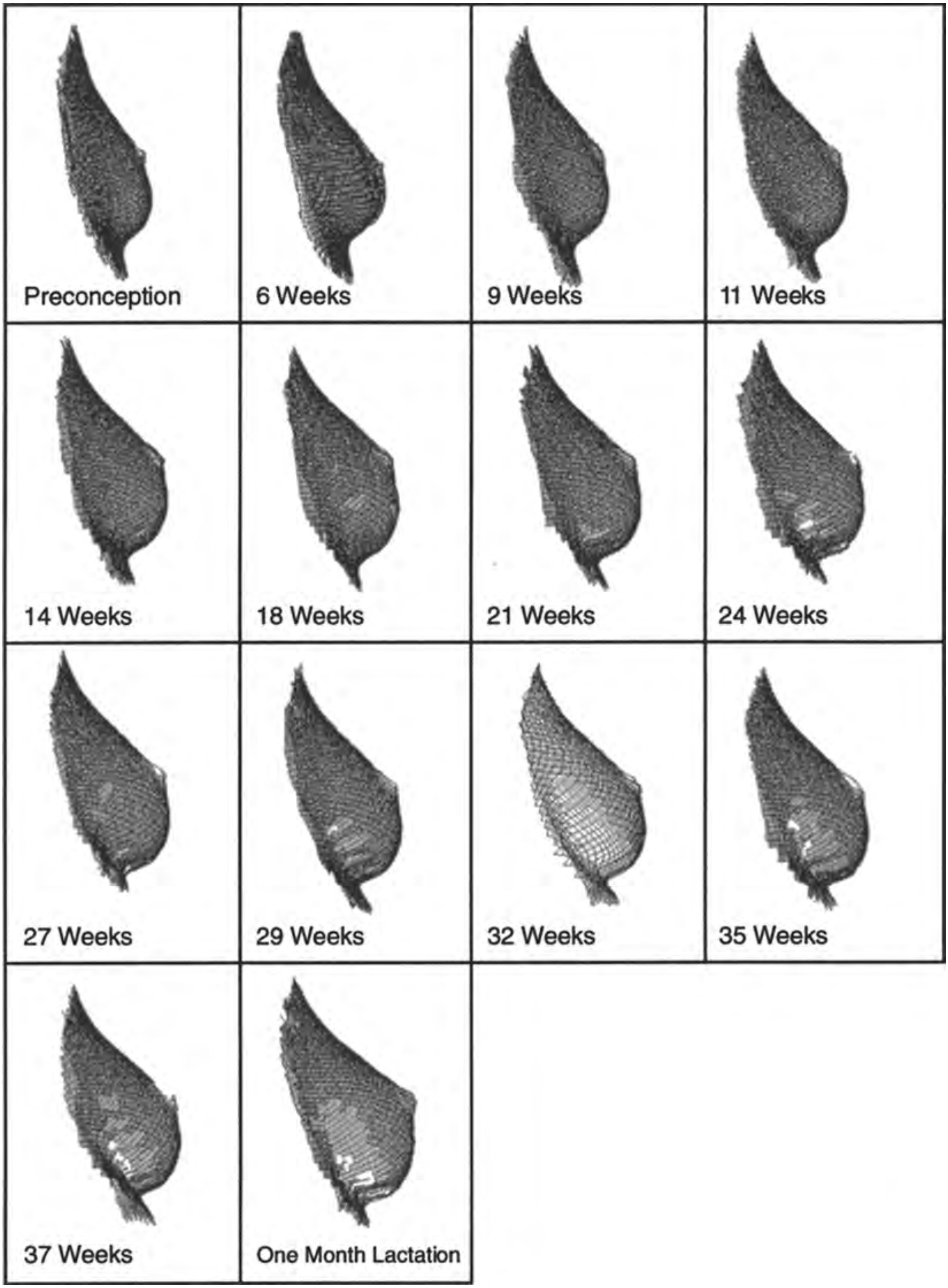
4.3.4 Pregnancy

In some women, changes in the breast (e.g., tenderness related to growth) can provide the first indication of conception and the beginning of the lactation cycle with a progressive increase in breast volume (▶ **Fig. 4.10**). The areola contains large sebaceous glands (Montgomery's glands)

▶ **Fig. 4.9** Innervation of the breast. (a) The dorsal or posterior nerve going to the breast (white), (b) The 4th posterior nerve coming out of the chest below the fourth rib, and proceeding to the breast and the nipple. (Cooper, AP 1840. On the Anatomy of the Breast, Longman.)



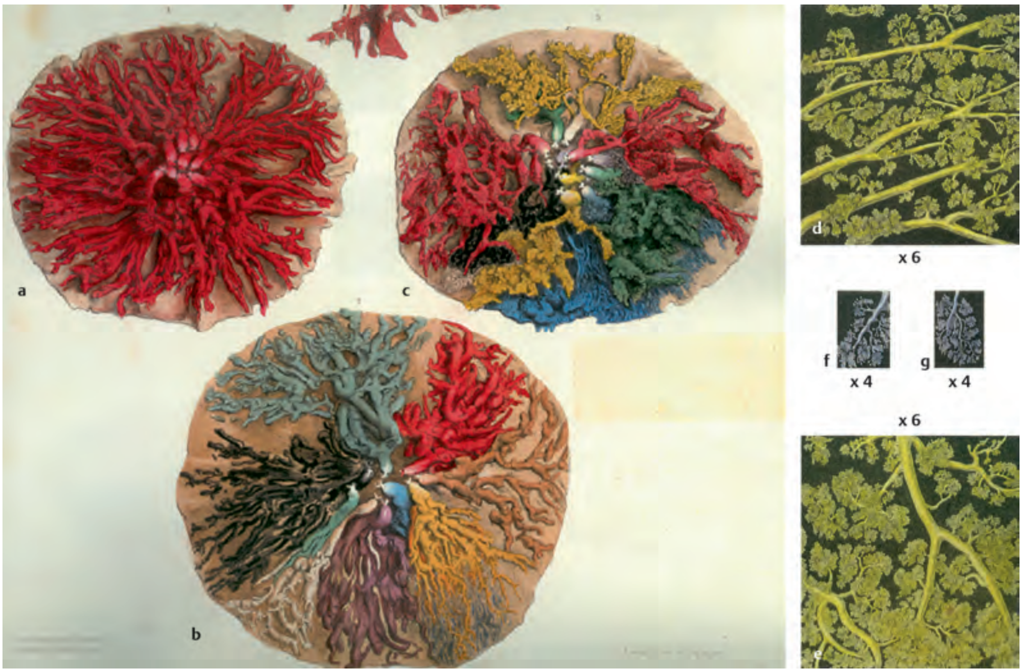
► **Fig. 4.10** Legend on the opposite side.



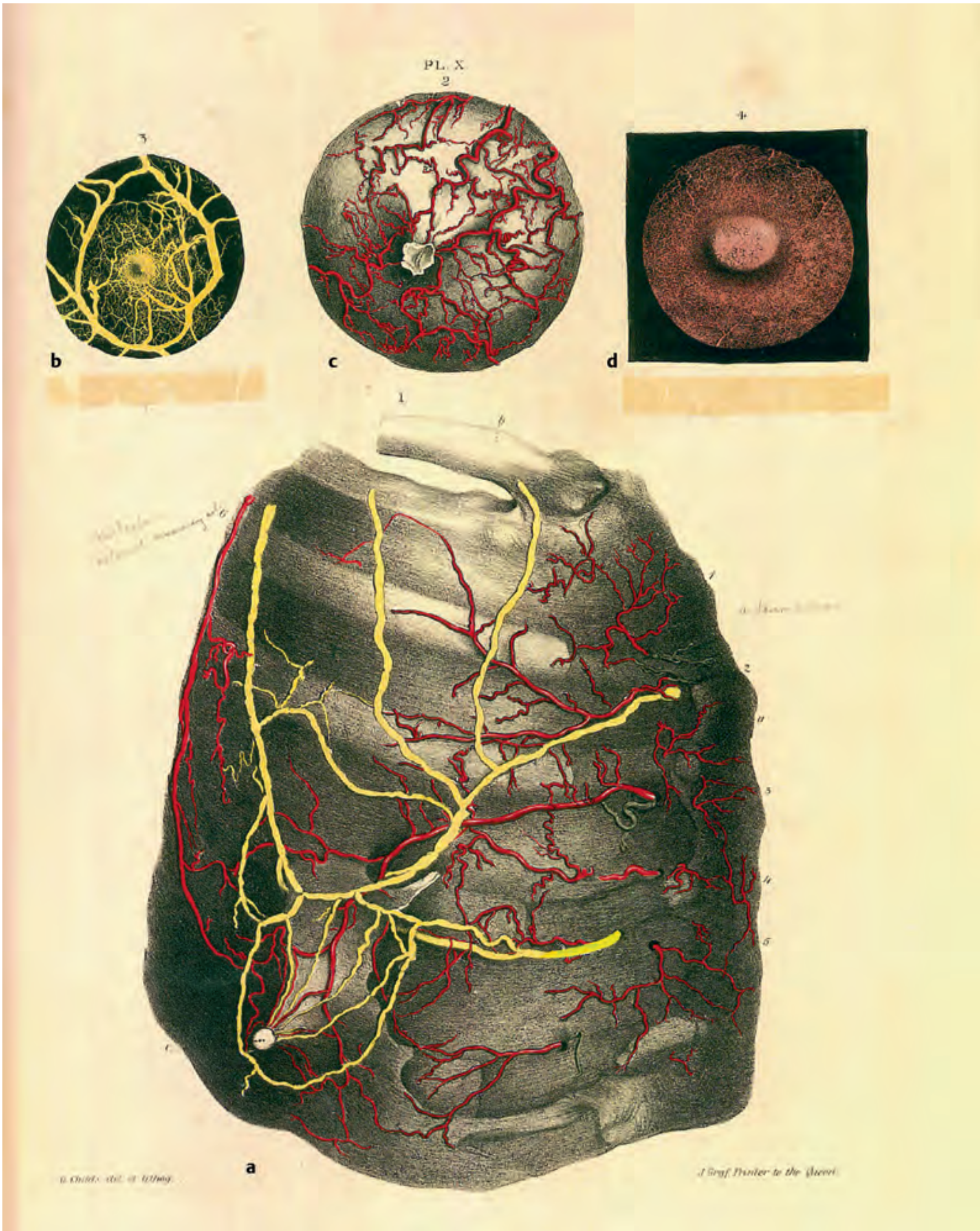
▸ **Fig. 4.10** Increase in the volume of a breast from preconception to one-month postpartum. (Cox D.B. The morphological and functional development of the human breast during pregnancy and lactation. PhD Thesis: The University of Western Australia; 1996) that hypertrophy and form papillae during pregnancy, as well as sweat glands and some hairs. Secretions of the Montgomery glands lubricate and protect the nipple and areola during lactation. Volatilisation of compounds in this secretion may also provide an olfactory stimulus for the infant. Ductal branching and lobular formation (alveolar development) exceeds the normal premenstrual growth by 3–4 weeks of gestation. A lactogenic complex of reproductive hormones (progesterone, oestrogen, and prolactin) and metabolic hormones (growth hormone, glucocorticoids, parathyroid hormone-related protein, and insulin) influence alveolar development in women during pregnancy.

There is extensive lobular-alveolar growth during the first half of pregnancy. However, the glandular parenchyma of the breast does not respond to hormonal stimulation in a synchronous manner. Different areas in the same breast can develop to a greater or lesser degree at any particular time during pregnancy. In the latter stages of pregnancy there is a further increase in lobular size due to the hypertrophy of the cells and the accumulation of secretion in the lumen of the alveoli. The milk ducts have branched and form lobes and the lobes divide into lobules that consist of clusters of alveoli lined with lactocytes (mammary secretory epithelial cells) (► **Fig. 4.11**).

The classic dissections of lactating cadavers by Cooper have also formed the basis for descriptions of the blood supply to the breast (► **Fig. 4.12**). During pregnancy, blood flow to the breast doubles by 24 weeks and then remains constant during lactation. Along with the increase in blood flow, the superficial veins of the breast become more prominent during pregnancy and lactation. The blood supply to the breast arises from the anterior and posterior medial branches of the internal mammary artery (60%) and the lateral mammary branch of the lateral thoracic artery (30%) [14].



► **Fig. 4.11** Milk ducts injected with different coloured waxes. (a) showing the radiated direction and inter-ramification of the milk ducts injected with red wax. (b) milk ducts injected with red, yellow, black, green and brown wax with the lobes spread out over a stone. (c) at the lower part of the preparation the separate ducts are seen passing above and beneath each other, to render the breast a cushion; whilst at the upper part the ducts are single, (d and e) alveoli six times magnified, (f and g) alveoli injected with mercury and four times magnified. (Cooper, AP 1840. On the Anatomy of the Breast, Longman. Plate VI and VII.)



▸ **Fig. 4.12** (a) Arteries (red) and veins (yellow) of the breast from their anterior and posterior sources, (b) veins around the nipple, (c) distribution of arteries upon the breast and around the nipple, (d) veins injected in the areola and nipple. (Cooper, AP 1840. On the Anatomy of the Breast, Longman. Plate X.)

However, there is wide variation in the proportion of blood supplied by each artery between women. In women, as in lactating animals, the ratio of blood flow to milk production is approximately 500:1. No relationship was observed between blood flow and milk production.

4.3.5 Lactating Breast

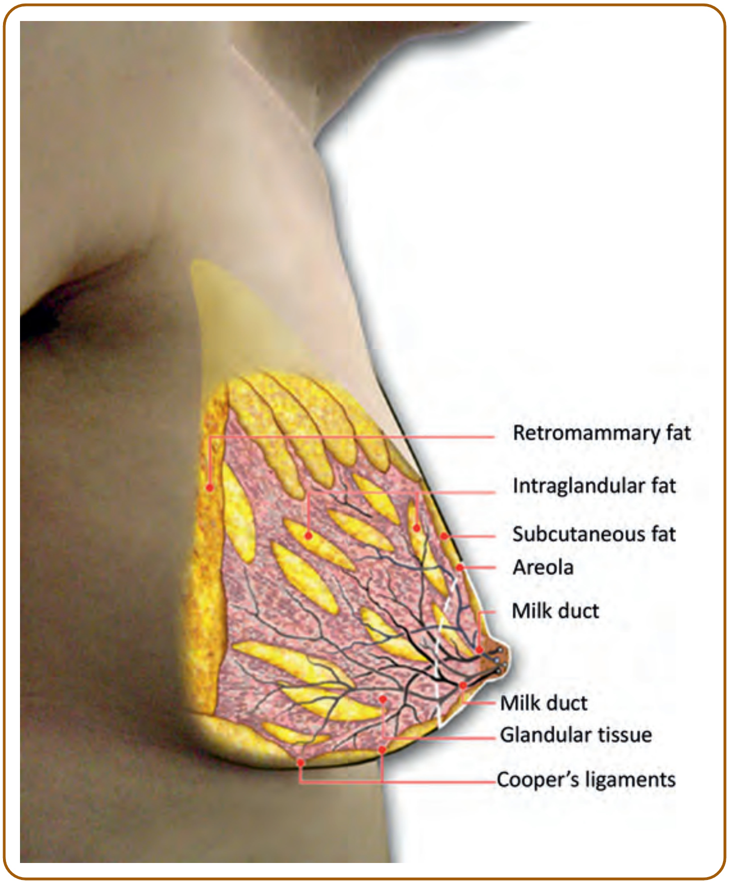
Cooper concluded that the ligaments associated with the mammary fat pad also protected the lactating breast tissue. Indeed, throughout his book he makes numerous statements marvelling at how resilient the breast is to severe blows.

> *'It is, then, a thick cushion of fat placed under the skin, which enables women of the lower class to bear the very severe blows which they often receive in their drunken pugilistic contests.'*

In this connection, Cooper was first to report the vigorous sucking behaviour of the young of some mammals, noting that

> *'… the lamb suckling for a short time to empty the large reservoir of the gland of accumulated milk, and then beating the udder of the ewe with its head as if to put it in mind of secreting more to supply its still pressing wants.'*

It is of interest that fatty tissue is interspersed within the glandular tissue in women but not in other mammals. This suggests that the support from the ligaments may be more important than the pad of fatty tissue in protecting the breast against severe blows. On the other hand,

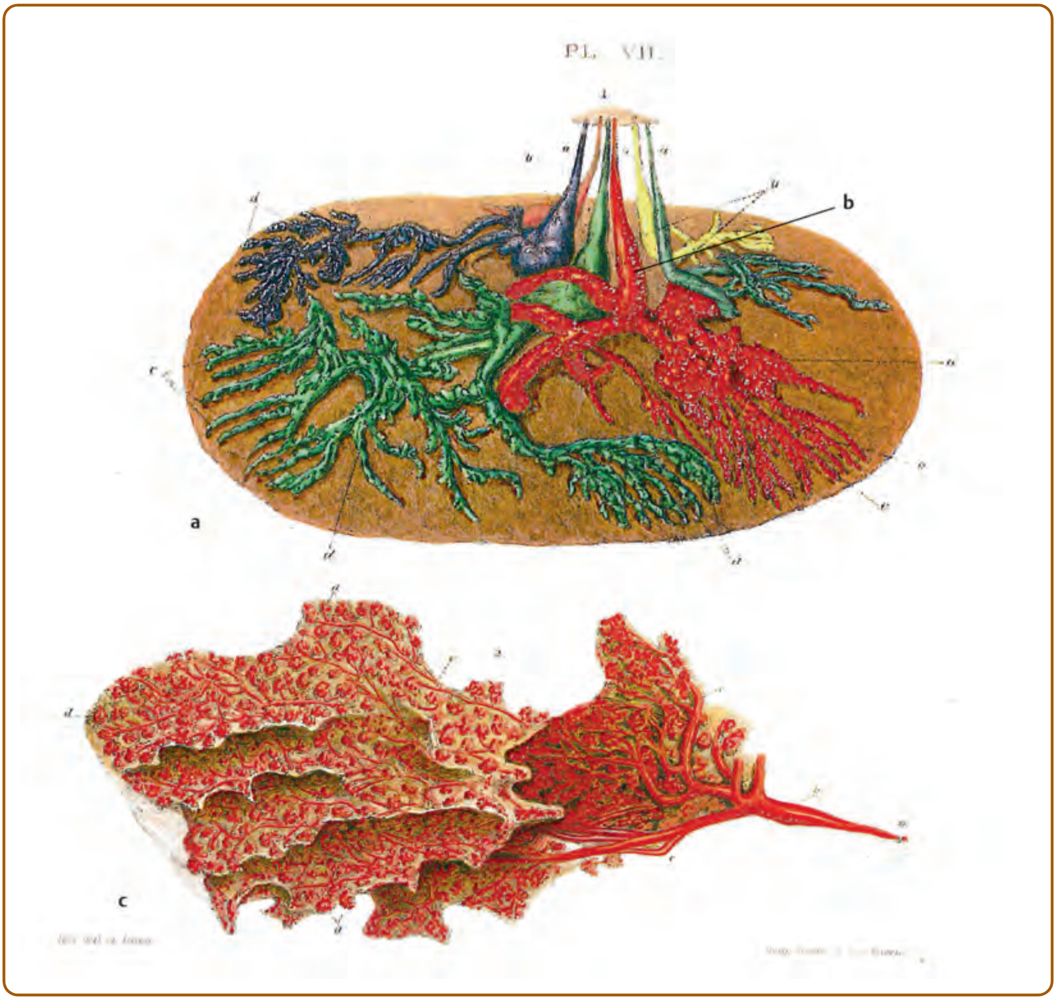


▶ **Fig. 4.13** Anatomy of the human breast. (Ramsay DT, Kent JC, Hartmann RA, et al. Anatomy of the lactating human breast redefined with ultrasound imaging. J Anat 2005; 206(6): 525–534)

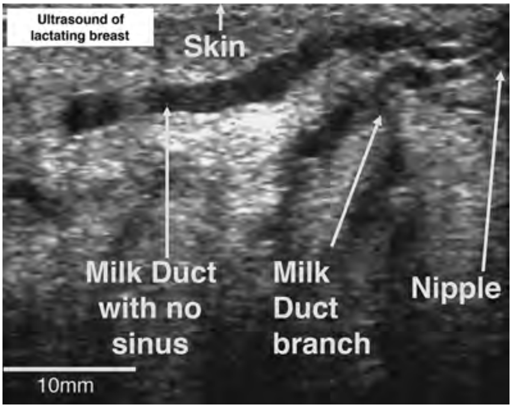
'Very thin women, whose breasts are unprotected by this mode of defence, sometimes show severe bruises; but these in a fortnight or three weeks disappear. Yet it is very certain that at distant periods women apply with tumours in their breasts, which they frequently impute to blows.'

In the literature up to 2005, Cooper's description of the ductal system prevailed and was depicted as a cluster of alveoli joined to small ducts expanding to form larger ducts that drain the lobules. The larger ducts then merge into one milk duct for each lobe. These ducts then open through a pore to the surface of the nipple (▶ **Fig. 4.13**). Cooper stated that the areola

'form a surface which is embraced by the child, and received into its mouth, so that the large lactiferous tubes behind the areola (▶ **Fig. 4.14***) are emptied by the pressure of the lips of the infant. The areola is, therefore, to be considered as an extension of the nipple, the base of which latter is lost in the former: its structure is very similar to the nipple, or mammilla.'*



▶ **Fig. 4.14** Milk ducts injected from the nipple. (a) Six milk ducts, (b) reservoirs or dilatations of the ducts below the nipple, (c) a single lobe. (Cooper, AP 1840. On the Anatomy of the Breast, Longman. Plate VII.)



▶ **Fig. 4.15** Ultrasound images of the milk ducts below the nipple. No reservoirs or dilatations of the ducts were detected and secretory tissue was present immediately below the nipple. (Ramsay, DT 2005 personal communication.)

Recent detailed studies by Ramsay, et al. using ultrasound imaging have not identified large lactiferous tubes behind the areola" (▶ **Fig. 4.15**) [15]. It is likely that the dilation of the "tubes" was an artefact resulting from the injection of hot wax through the pores of the nipple to enable the identification of the milk ducts. In contrast to Cooper's observations, ultrasound imaging clearly shows that the area immediately under the areola is densely packed with lobules containing alveoli. Since it was assumed that the pressure of the lips of the infant emptied the non-existent "large lactiferous tubes", the mechanism by which the infant removed milk from the breast had to be reassessed.

4.4 Physiology

4.4.1 Origin of Milk

The genesis of milk has long intrigued scientists and theories have been recorded back to the time of the Ancient Greeks. Four observations were seminal in the formation of ideas on the origin of milk. Firstly, the absence of menstruation during pregnancy and early lactation; secondly, many women experienced peculiar sensations in the lower abdomen during breastfeeding; thirdly, milk was thought to be synthesised and actively secreted during milk ejection; and finally, lymphatic vessels draining the small intestine were thought to be the origin of milk because they contained a milky fluid. The first and second observations led to the uterine milk theory promoted by Galen, who claimed that the menstrual blood that nourished the foetus was diverted to the breast after birth in special vessels (vas menstrualis, ▶ **Fig. 4.16**). This theory was rejected when it was found that no such vessels existed. Galen's knowledge of the anatomy of the male body was probably more accurate than that of the female body because he was at one time a physician to the gladiators.

▶ **Fig. 4.16** Drawing by Leonardo da Vinci influenced by Galen's teachings showing a vessel from the uterus to the breast that in fact does not exist. (Calder, R. 1970 Leonardo & the Age of the Eye, Heinemann. p176.)

The chyle theory of the origin of milk followed the observation that the lymphatic vessels draining the small intestine into the thoracic duct were white in appearance and, when pricked, a fluid resembling milk flowed out. This theory was soundly discredited by the experiments of Cooper who stated

▸ **Fig. 4.17** Lymphatic vessels of the female breast, (a and b) lymphatics draining from the nipple to the clavicle. The constrictions in the vessel are the valves in the lymphatic vessels that ensures that the lymph flows away from the breast to the lymph nodes. (c) The dense network of lymphatic vessels in the breast. (Cooper, AP 1840. On the Anatomy of the Breast, Longman. Plate XI.)

> *'A most extraordinary opinion has been broached, that the absorbents (lymphatic vessels) carried chyle to the breast (*▶ **Fig. 4.17***) — an opinion at variance with the nature of the fluid, entirely inconsistent with every injection which I have made, and irreconcilable with the valvular structure of these vessels' [10].*

The idea that milk was rapidly synthesised in the breast during milk ejection was questioned in the early 20th century when a clear distinction was made between the continuous process of milk synthesis and the intermittent acute process of milk ejection. This provided the background for development of the current understanding of milk synthesis and secretion.

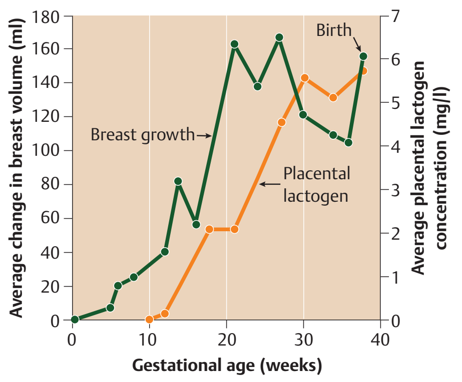
Human placental lactogen secreted from the placenta has an action similar to growth hormone. The increase in breast growth during pregnancy is closely related to the increase in this hormone (▶ **Fig. 4.18**), which disappears within a few hours postpartum. On the other hand, the increasing prolactin concentration in maternal blood during pregnancy is closely related to the increase in amount of lactose excreted in urine. The blood-milk barrier is not fully formed during pregnancy, allowing lactose to diffuse into the maternal blood.

Lactose is not metabolised in the blood but excreted via the urine; this means that lactose excretion in urine over a 24-hour period can be used as a measure of lactose synthesis during pregnancy. It should be noted that this increase in urinary lactose excretion during pregnancy is also closely related to secretory differentiation (▶ **Fig. 4.19**).

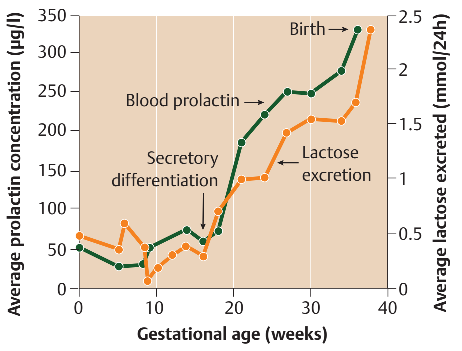
4.4.2 Secretory Differentiation

We now know that the initiation of lactation occurs in two stages. The first stage (secretory differentiation) commences during mid pregnancy when the breast develops the capacity to synthesise unique milk constituents, such as lactose and milk specific proteins. At this time the stem cells within the breast have developed into progenitor cells that in turn have differentiated into lactocytes.

This transition is termed secretory differentiation (previously termed lactogenesis I) [16]. Due to the high levels of progesterone in women, the milk secretion rate (colostrum) is low; on average about 30 mL per day. Secretory differentiation occurs at about 20–25 weeks of gestation and is very close to the time of viable preterm delivery. Thus, it is possible that incomplete maturation of secre-



▶ **Fig. 4.18** Breast volume (mL), a measure of breast growth, and the concentration of human placental lactogen (mg/L) at three-weekly intervals from conception to birth. (Czank C, Henderson JJ, et al. Hormonal control of the lactation cycle. In: Hale TW, Hartmann P. Textbook of human lactation, New York: Springer; 2007)



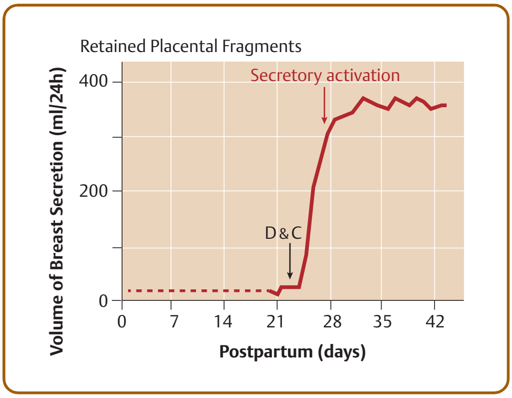
▶ **Fig. 4.19** Concentration of prolactin (µg/L) in blood and the excretion of lactose (mmol/24h) in urine at three weekly intervals from conception to birth. Secretory differentiation commences at approximately 18 weeks of pregnancy. (Czank C, Henderson JJ, et al. Hormonal control of the lactation cycle. In: Hale TW, Hartmann P. Textbook of human lactation, New York: Springer; 2007) tory differentiation could be one of the factors limiting successful development of lactation in preterm mothers.

4.4.3 Secretory Activation

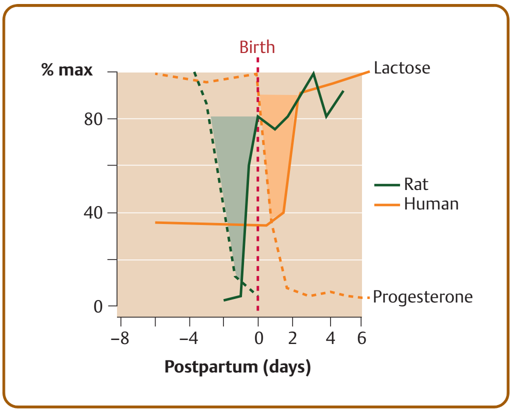
Secretory activation (previously termed lactogenesis II) is the second stage in the initiation of lactation and occurs during the first 3 days after birth [16]. Secretory activation is characterised by the initiation of copious milk production and is arguably the most important phase of the lactation cycle. Unlike secretory differentiation, secretory activation has to be tightly coupled to the time of birth, so that the newborn can make a seamless transition from the protective environment of the uterus and continuous nourishment from the umbilical vein to the intermittent provision of protection and nourishment from the mother's milk. Appropriate management of secretory activation is crucial for the successful development of optimal milk production. Only one study has investigated the sensitivity of the breast during pregnancy and lactation. This study showed that areola and nipple sensitivity increased markedly within 24 hours postpartum and then declined in the following days [17]. Presumably sensitivity of the nipple at this time provides a signal to the mother (pain) if her infant is not appropriately attached to her breast when feeding. It is of concern that little medical follow-up of lactation occurs after administration of pain relief to the mother. Analgesia can prevent the mother sensing when her baby is incorrectly attached during a breastfeed and thus predispose her to nipple trauma.

Oestrogen withdrawal was once favoured as the stimulus for secretory activation because pharmacological doses of estrogenic hormones inhibited milk synthesis. These findings encouraged Gunther to recommend graded doses of diethylstilbestrol as a method of suppressing postpartum breast engorgement [18]. This practice has since been abandoned due to long-term unfavourable outcomes. The classic findings of Kuhn in 1969 clearly demonstrated that progesterone withdrawal was the lactogenic trigger in rats, but progesterone withdrawal has since been shown to be the universal trigger for secretory activation in all Eutherian mammals including women [19]. Indeed, Neifert, et al. found that secretory activation was inhibited after birth in a woman with retained placental fragments [20]. Milk secretion (secretory activation) rapidly increased from about 10 mL/24 h to about 350 mL/24 h on day 28 after curettage (▸ Fig. 4.20) [20]. In this context it should be noted that progesterone synthesis occurs in the placenta in women but that oestrogen synthesis requires the presence of both placenta and foetus.

While precipitous progesterone withdrawal occurs just before birth in most mammals, this



▸ **Fig. 4.20** Milk production (mL/24h) in a woman with placental retention from 20 to 44 days postpartum. Dilatation and curettage was carried out at day 23 to remove placental fragments.



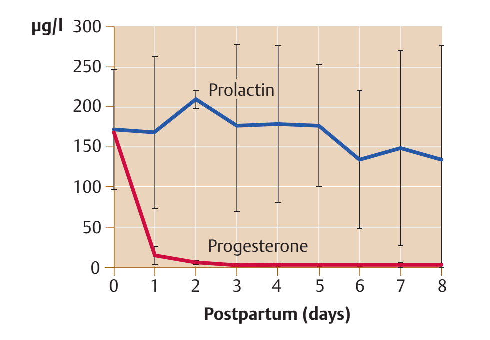
▸ **Fig. 4.21** Concentration of progesterone (% of maximum values) in blood and lactose (% of maximum values) in mammary secretion from –6 days prepartum to 5 days postpartum in women and rats. (Reproduced from Hartmann, P.E. 1990. Unpublished data.)

abrupt withdrawal occurs after birth in women following placental delivery. As a result, secretory activation occurs 30–40 hours after birth (► Fig. 4.21). This seems counterintuitive to the high-energy requirements of the newborn infant. However, unlike the newborn of most other mammals, the human newborn has high levels of body fat (10–15%) to draw on for its energy requirements. This feature has facilitated the survival of newborn infants for days without nourishment, such as after earthquakes. It is likely that the protective role of human milk (innate immunity) and, in particular colostrum, is as important as its nutritional role. Therefore, the small volume of colostrum secreted after birth (~30 mL/24h) [21] with its high concentration of protective glycoproteins, oligosaccharides, and fatty acids facilitates protection of the surfaces of the respiratory and gastrointestinal tracts against pathogenic microorganisms.

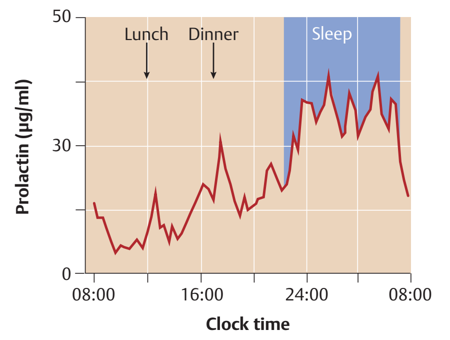
The withdrawal of progesterone from the maternal blood is rapid, declining by more than 10-fold within 3 days postpartum, and the literature is quite consistent on the nature of this fall (► Fig. 4.22). Due to this rapid decline, accurate timing between the delivery of the placenta and blood sampling would likely improve the precision of these values. In contrast to parturition, changes in the concentration of progesterone in maternal blood during established lactation do not appear to influence milk production, perhaps due to down-regulation of progesterone receptors in the breast. Once lactation is established, milk production is not coupled to progesterone levels during the menstrual cycle and progesterone-containing low dose contraceptives do not appear to inhibit lactation. Thus, the important role for progesterone centres on the early postpartum period. In view of the universality of the progesterone withdrawal mechanism, it is puzzling that more attention has not been given to the potential effects that subtle changes in progesterone withdrawal could have on the immediate and long-term synthesis of breastmilk, particularly as there are potential therapeutic options in relation to regulating progesterone receptors in the breast at this time.

The administration of Bromocriptine (to suppress prolactin secretion) inhibits secretory activation in women suggesting that prolactin is required for this stage of gland development [22].

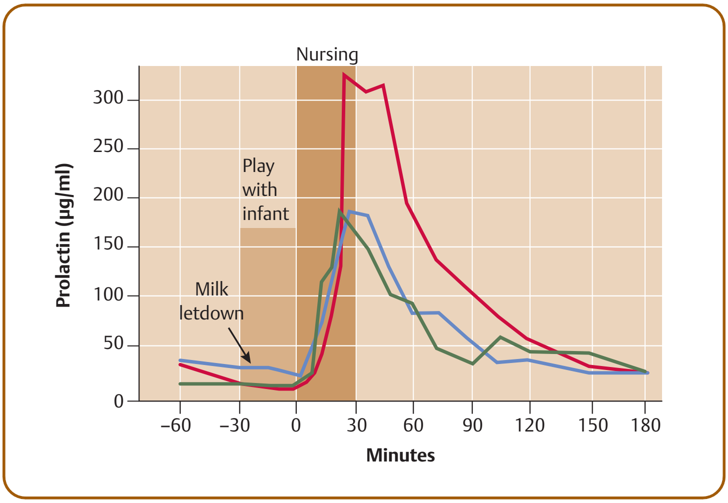
Furthermore, a number of studies have concluded that milk production can be increased by the administration of galactogogues (e.g., domperidone and metoclopramide) that increase blood prolactin. Indeed, these medications are often prescribed when women present with either low milk supply or perceived low milk supply. Unfortunately, measurements of blood prolactin and milk production are rarely made prior to medication administration to justify their use.



► **Fig. 4.22** Concentration of progesterone (µg/L) and prolactin (µg/L) in blood of women from birth to 8 days postpartum. (Boss M, Gardner H and Hartmann P. Normal Human Lactation: closing the gap [version 1; referees: 4 approved]. F1000Research 2018, 7(F1000FacultyRev):801 (doi: 10.12688/f1000research.114452.1))



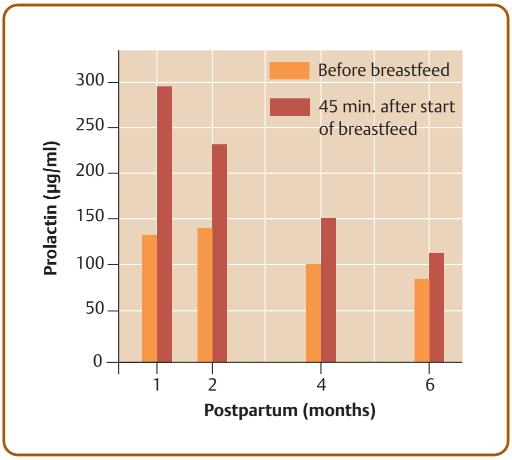
► **Fig. 4.23** Circadian changes in the concentration of prolactin (µg/L) in the blood plasma of 8 normal women. (Reproduced from Yen, S., Jaffe, R. 1999. Prolactin in Human Reproduction. In: Reproductive Endocrinology. 4th ed. Philadelphia: WB Saunders Co.)



► **Fig. 4.24** Concentration of prolactin (µg/L) in the blood plasma of breastfeeding women from 60 minutes before to 180 minutes after the commencement of breastfeeds.

While the literature on progesterone withdrawal is quite consistent, the literature for prolactin is not (► **Fig. 4.23**). Prolactin concentrations reported for mothers in the immediate postpartum period vary greatly and averages don't make much sense. The reason for much of this variation is probably due to sample collection. It has been shown that the concentration of prolactin has a circadian rhythm, with the lowest concentrations during the day and high concentrations during sleep (► **Fig. 4.24**). In addition, prolactin concentration increases at mealtimes and doubles when measured before a breastfeed to about 30–45 minutes after the commencement of the breastfeed. This response decreases from one to six months of lactation (► **Fig. 4.25**). Much of the large variation between samples might be removed if care was taken to standardise blood-sampling procedures in relation to infant's breastfeeds, time of day, and meal times. Obviously, with the wide use of domperidone and metoclopramide, it is very important to establish reference values for postpartum prolactin concentration in maternal blood. Although it is clear that prolactin is required for secretory activation, it probably does not play a rate-limiting role during normal secretory activation and in established lactation.

Glucocorticoid receptors are present in the cytosol of lactocytes. When bound with glucocorticoids, these receptors translocate to the nucleus and act synergistically with prolactin-activated

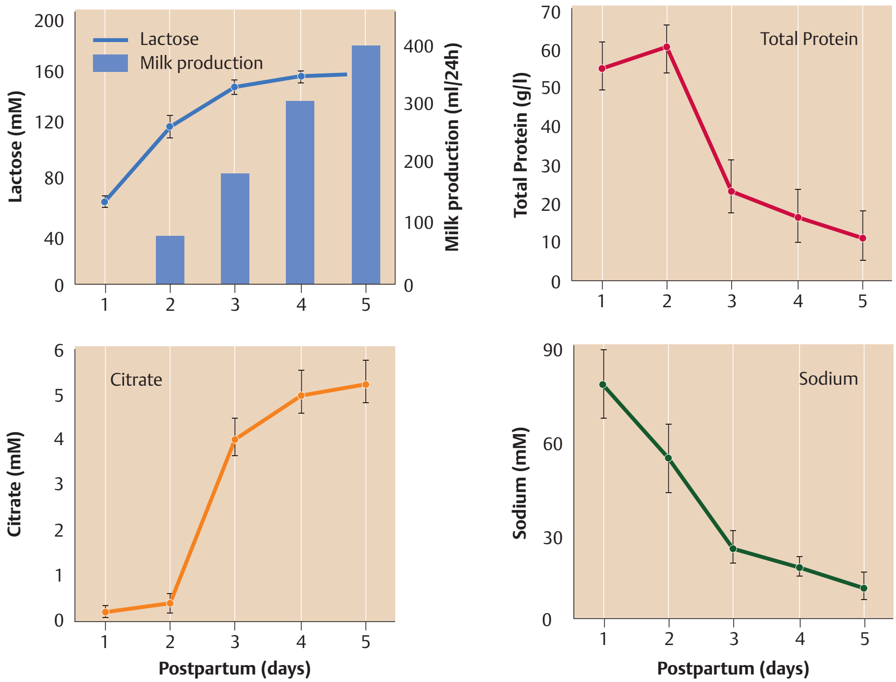


► **Fig. 4.25** Concentration of prolactin (µg/L) in the blood plasma of 11 lactating women at 1, 2, 4, and 6 months of lactation. Blood samples were taken immediately before and 45 minutes after the commencement of the breastfeed. (Reproduced from Cox, D.B. 1996. The morphological and functional development of the human breast during pregnancy and lactation. PhD Thesis: The University of Western Australia; p3-6 3-7.)

transcription factors to enable the synthesis of milk proteins. While progesterone binds to the glucocorticoid receptor, it does not translocate to the nucleus and deactivate the milk synthesis genes.

Despite the obvious association between pregnancy and secretory differentiation and activation, pregnancy is not an essential prerequisite for lactation. There are numerous reports of the induction of mammary growth and lactation arising from repeated application of stimulation by either suckling or massage in non-pregnant women. Although responses are highly variable, there are reports of infertile women establishing exclusive breastfeeding by the application of suckling and massage for just a few weeks.

By definition, the ideal method for determining secretory activation is to measure milk production. However, this is quite difficult to do in the immediate postpartum period. Furthermore, milk synthesis at this time is greatly influenced by the ability of the infant to remove all of the available colostrum. In many women the onset of lactation is accompanied by a sudden feeling of breast fullness and leakage. If this is not managed properly it can lead to extremely engorged and painful breasts. Nevertheless, this is a subjective assessment of secretory activation. The metabolic changes that occur in the breast offer more precise objective assessments. The withdrawal of progesterone triggers the closure of tight junctions between lactocytes. Synthesis and secretion of lactose rapidly increases, drawing water with it to maintain osmotic equilibrium. As a result of these metabolic changes, the concentrations of sodium, chlorine, and total protein decrease. Conversely, lactose and citrate concentrations, and milk production increase as mammary secretion transitions from colostrum to milk over the first 5 days postpartum. Thus, analysis of mammary secretion for sodium, chloride, citrate, and total protein over this early postpartum period can be used to assess the progress of secretory activation (▶ **Fig. 4.26**). Unfortunately, there is not sufficient appropriate research available to enable the establishment of reference values for these milk constituents during this crucial period in the lactation cycle.



▶ **Fig. 4.26** Milk production (mL/24h) and the concentrations of lactose (mM), total protein (g/L), citrate (mM) and sodium (mM) in mammary secretion from day 1 to day 5 of lactation, that is, during secretory activation.

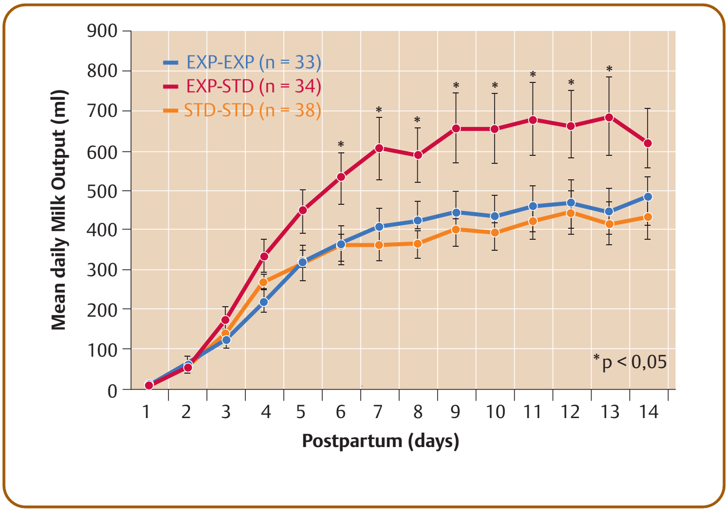
▸ **Tab. 4.1** Prevalence of exclusive breastfeeding postpartum (%).

	6 weeks	14 weeks	6 months
Group 1: Standard care	51	34	14
Group 2: Steps 1–9 alone	90	76	45
Group 3: Steps 1–10	81	47	14

The importance of secretory activation is clearly demonstrated from three recent rather subtle intervention studies that focused on the first 3 days postpartum. Yotebieng and colleagues randomly assigned clinics to three groups to investigate optimisation of the Baby Friendly Hospital Initiative (BFHI) ten steps to successful breastfeeding [23]. Steps 1–9 focus on promotion and establishment of breastfeeding in the clinical setting after birth. Step 10 promotes the establishment of breastfeeding support groups and referral of mothers to these on discharge from either hospital or clinic. The primary outcomes were initiation of lactation (commencing breastfeeding within 1 hour of birth) and exclusive breastfeeding. Exclusive breastfeeding was higher in groups 2 and 3 at 14 weeks but surprisingly was only significantly higher in Group 2 at 6 months (▸ **Table 4.1**). Leaving aside the unexpected finding that the results for the 1–9 steps group (Group 2) were significantly better than those for the controls and the 1–10 steps group (Group 3), these findings clearly show that interventions at birth can have very significant long-term effects presumably associated with a critical learning period.

Morton, et al. showed that combining hand massage techniques with electric pumping increased milk production in preterm mothers at 2 weeks and beyond [24]. The treatment was only applied in the immediate postpartum period and again emphasises the importance of the secretory activation period. Similarly, in another study of preterm mothers, Meier, et al. used an experimental suction pattern that was designed to resemble the suckling patterns of neonatal infants [25]. The pattern was applied until the onset of secretory activation (approximately for the first 80 hours postpartum). Mothers were then changed to the commercial pattern for the electric breast pump. Interestingly, this intervention in the first 80 hours after birth increased milk production significantly at 1 week postpartum and by 2 weeks postpartum. The experimental group were producing approximately 60% more milk than the standard electric breast pump group (▸ **Fig. 4.27**).

Although there is compelling evidence that human lactation is “hard-wired” and essential for the



▸ **Fig. 4.27** Milk production (mL/24h) in three groups of mothers 33 to 38 preterm from birth to 14 days postpartum. One group used an experimental suction pattern that was designed to simulate the baby suckling, another group received the experimental pattern until secretory activation (~80h postpartum) and then the standard pattern and the final group only received the standard pattern. (Reproduced from Meier, P. P., et al. 2012. Breast pump suction patterns that mimic the human infant during breastfeeding: Greater milk output in less time spent pumping for breast pump-dependent mothers with premature infants. J Perinatol, 32, 103–110.)

healthy growth and development of infants, these studies show that even subtle intervention in the first 3 days after birth can have major influences on the success of lactation. It is likely that, as in other mammals, the period from just before parturition to the immediate postpartum period is vitally important for both birth and lactation. Perhaps Michel Odent's non-intervention approach in relation to childbirth may also apply to successful secretory activation and the establishment of breastfeeding [26]. Nevertheless, it is indisputable that removal of colostrum and then mature milk from the breast is essential for the continuation of milk production. Thus, milk removal is essential for secretory activation as well as established lactation. Two physiological processes, maternal milk ejection and infant breastfeeding, are required for the removal of milk from the lactating breast and normal lactation.

4.4.4 Milk Ejection

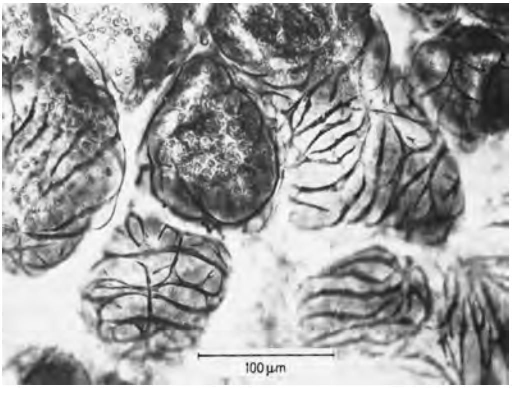
The history of the understanding of the milk ejection reflex is important because it illustrates how a simple misunderstanding of a physiological process can impact on the understanding of a whole physiological process — in this case, the physiology of lactation. In the 19th century it was generally accepted that milk was synthesised in the breast from components carried to it in the blood. First, it was thought that blood components were filtered off to form milk. However, some milk components were found not to be present in blood and therefore it was concluded that active synthesis of some components occurred in the breast. Then a stalemate existed for more than a century in the understanding of milk synthesis and secretion. This arose because of the erroneous conclusion that milk ejection (milk let down) resulted from very active synthesis and secretion of milk (due to stimulation by the infant's sucking) with either little or no synthesis of milk at all other times. Cooper was on the right track when he stated that

> *'The secretion of milk may be said to be constant or occasional; by the first, the milk tubes and reservoirs are constantly supplied by means of a slow and continuous production of fluid, so that the milk is thus, in some degree, prepared for the child. By the occasional, is to be understood that secretion which is called by mothers and nurses, the draught of the breast, by which is meant a sudden rush of blood to the gland, during which the milk is so abundantly secreted, that if the nipple be not immediately caught by the child, the milk escapes from it, and the child when it receives the nipple is almost choked by the rapid and abundant flow of fluid; if it lets go its hold, the milk spurts into the infant's eyes.' [10].*

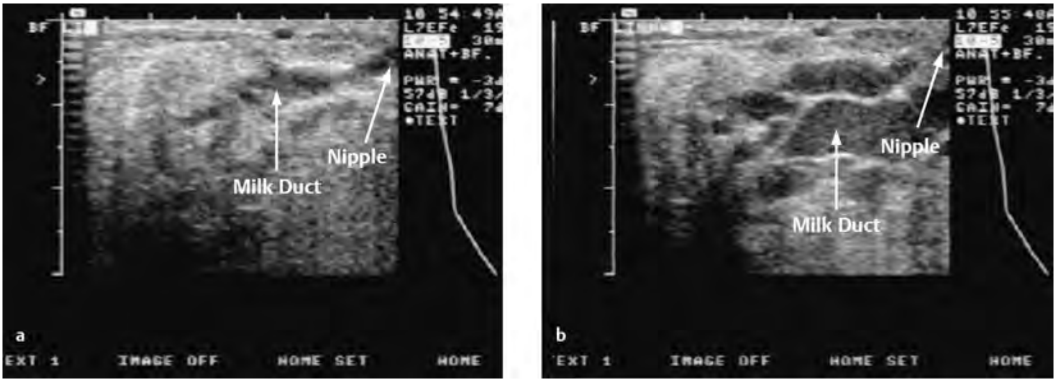
More than 100 years later it was still claimed that milk secretion was mostly confined to the periods of sucking. Finally, in 1941 Ely & Petersen carried out studies in cows and correctly concluded,

> *'The letting down of milk is a conditioned reflex operated by sensory stimuli associated with milking. Afferent impulses reach the central nervous system and release oxytocin from the posterior pituitary, which in time causes a rise in milk pressure probably because of the contraction of muscular tissue which is believed to surround the alveoli and small ducts' [27].*

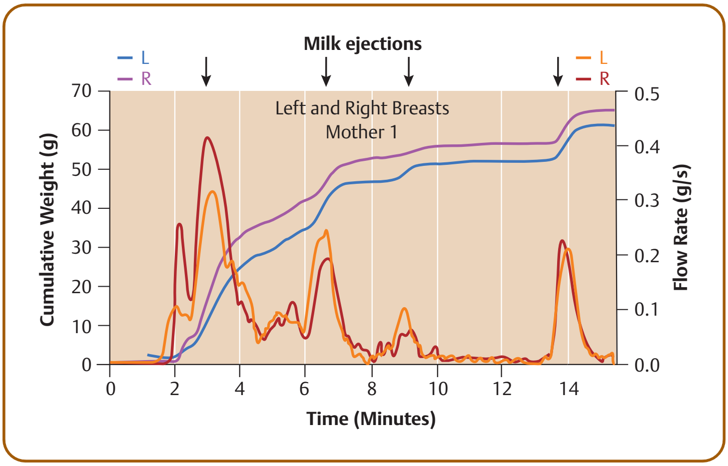
It is now known that myoepithelial cell processers surround the alveoli (▶ **Fig. 4.28**) and contract when stimulated by oxytocin, forcing the milk along the milk ducts towards the nipple.



▶ **Fig. 4.28** Myoepithelial cells surrounding contracted alveoli from the mammary gland of a lactating goat. (Cowie, A. T., Forsyth, I. A., Hart, I. C. 1980. Lactation. Hormonal control of lactation. Springer. p194.)



▶ **Fig. 4.29** Ultrasound image of a milk duct (a) prior to milk ejection and, (b) one minute after milk ejection. White flecks in the ducts in the image (b) are fat globules.



▶ **Fig. 4.30** Rate of milk flow and accumulated weight of milk in left and right breasts during breast expression. The peaks in milk flow relate to the number of milk ejections that occurred during the expression period. (Reproduced from Prime, D. K., et al. Using milk flow rate to investigate milk ejection in the left and right breasts during simultaneous breast expression in women. Int Breastfeed J. 4, 10.)

Milk ejection can be measured either by the increase in milk duct diameter viewed by ultrasound imaging (▶ **Fig. 4.29**) or by the change in milk flow rate when milk is expressed using an electric breast pump. Mothers have several milk ejections during a breastfeed (▶ **Fig. 4.30**). Each mother has a particular pattern of milk ejections during a breastfeed, and this pattern holds throughout the lactation and for subsequent lactations. Thus, the initial sucking of the infant is important in initiating the first milk ejection but subsequent milk ejections are intrinsic to the mother. Failure to release oxytocin is rare for breastfeeding mothers. Milk ejection may be identified by changes in the infant's sucking pattern (from rapid initial sucking to a slower suck and swallowing pattern). Although 88% of mothers sense the first milk ejection, almost all mothers fail to sense subsequent milk ejections.

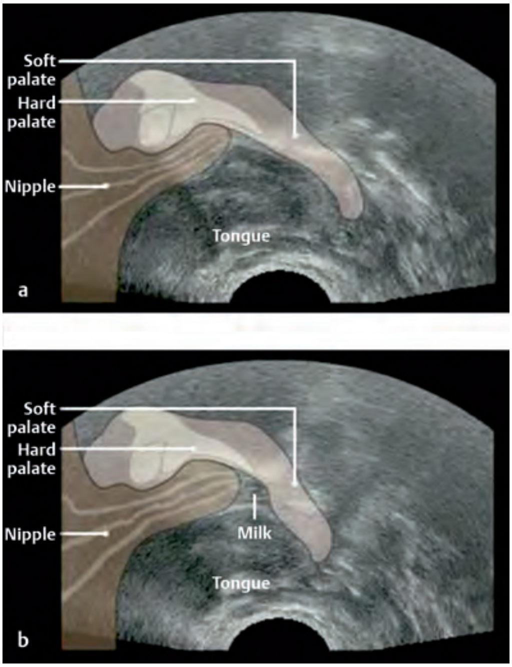
Maternal sensation of milk ejection varies. Mothers have reported sensations such as a pleasant tingling, pins and needles, sharp nipple pain, warmth, thirst, sleepiness, and mild nausea before milk flow increases. In addition, as noted by Cooper, milk can spurt from the breast for a distance of a meter or more in some women. These sensations are more common in early lactation. Milk ejection usually occurs within one minute of putting the baby to the breast but can occur at other times (for example when the mother thinks about her baby) because milk ejection is a conditioned reflex. Like other conditioned reflexes it can be inhibited by stress. However, women successfully breastfeed through severe stresses such as injury, wars, and famine. Stresses that inhibit milk synthesis are the less obvious stresses that undermine maternal confidence, such as either concerns about the adequacy of her milk supply or the quality of her milk. Again, Cooper commented on this anomaly:

> *'A female of luxury and refinement is often in this respect a worse mother than the inhabitant of the meanest hovel, who nurses her children, and brings them up healthy under privations and bodily exertions to obtain subsistence, which might almost excuse her refusal.' [10]*

4.4.5 Infant Suck, Swallow, and Breathe

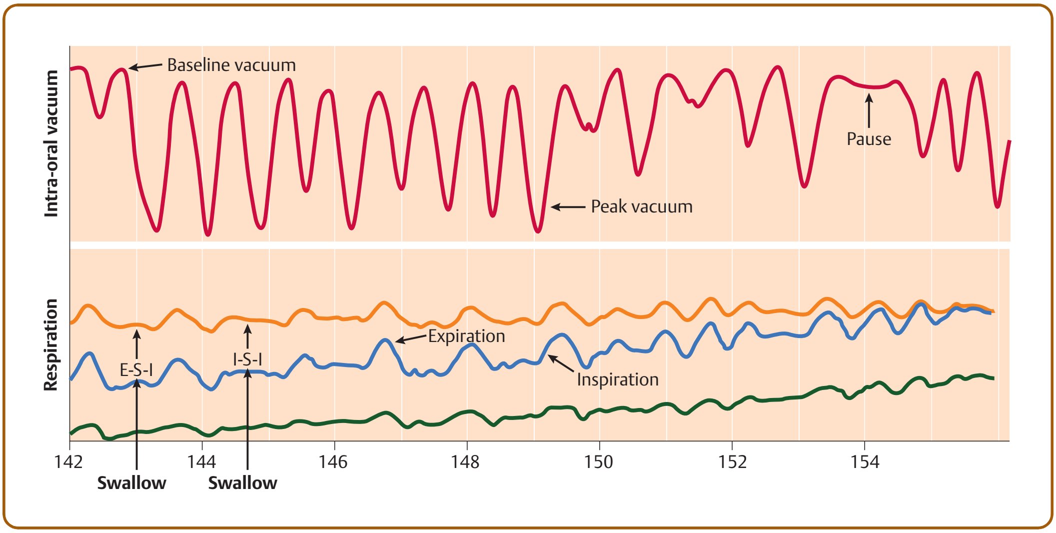
The finding that lactiferous sinuses were not present in the lactating human breast led to the reassessment of the suck-swallow-breathe reflex. When considering the nature of infant sucking, it is important to ensure that only breastfeeding infants are considered because the dynamics of suckling are different in bottle-fed infants. Breastfeeding is a very complicated process in that it requires the coordination of sucking, swallowing, and breathing. This is reflected by the attention that clinicians give to positioning and attachment of the baby at the breast. However, this intervention is very subjective, and advice has changed with time without support from evidence-based research. For the development of an evidence-based assessment of breastfeeding, it was important to develop synchronized continuous measurements to describe this complex behaviour. Information was gathered from synchronised ultrasound imaging of tongue movement and milk flow, the intraoral vacuum generated by the downward movement of the tongue, and respiratory-inductive plethysmography to identify sucking, breathing, and swallowing (▶ **Fig. 4.31**).

First, it was important to define nutritive and non-nutritive sucking. Nutritive sucking showed milk flow coupled with frequent swallowing. In non-nutritive sucking, little milk was removed from the breast and swallowing occurred only occasionally due to the accumulation of saliva. Non-nutritive sucking bursts were shorter with a tendency to occur towards the end of a breastfeed compared with nutritive sucking.



▶ **Fig. 4.31** Sagittal mid-line images of an infant's oral cavity during breastfeeding showing stylised overlay of ultrasound images showing the soft palate, hard palate, nipple and tongue, (a) tongue up (baseline vacuum), (b) tongue down (peak vacuum). (Geddes, D., Sakalidis V. 2015. Breastfeeding: How do they do it? Infant sucking, swallowing and breathing. Infant, 11; 146–150.)

Nutritive sucking is achieved by an intraoral vacuum (negative pressure), which is generated by the downward movement of the infant's tongue during feeding and intermittent positive pressure generated within the milk ducts at milk ejection. Infants attach to the breast and generate a baseline vacuum that stretches the nipple to within 5–7 mm of the junction between the hard and soft palates. Under the influence of this vacuum, milk ducts in the nipple expand and milk flows into the oral cavity space bounded by the tip of the tongue, the hard-soft palate junction, and the oral epithelial lining of the cheeks. The vacuum is released as the tongue rises, and compression of the nipple allows the milk to be cleared from the oral space to the pharyngeal area at each suck. The milk bolus



▸ **Fig. 4.32** Simultaneous recordings of infant intra-oral vacuum and respiration (respiratory inductive plethysmography, RIP) during a breastfeed. The intra-oral vacuum shows a variable baseline vacuum (latch vacuum) and a peak vacuum (sucking vacuum). The respiratory trace measures respiration as inspiration effort and expiration effort and absence of a signal indicates a swallow. The inspiratory phase of swallowing can be identified (E-S-I, expiration-suck-inspiration; I-S-I, inspiration-suck-inspiration).

may remain in this area for a number of sucks before it is swallowed (▸ **Fig. 4.32**).

Sakalidis and Geddes found that infants were able to simultaneously suck and swallow, and suck and breathe, but not breathe and swallow [28]. Breastfeeding infants did not have a consistent suck-swallow-breathe pattern. Respective ratios can range from 1:1:1 to 12:1:4 during nutritive sucking to from 2:0:1 to 23:1:23 for non-nutritive sucking. This range for nutritive sucking is not surprising as the rate of milk flow rapidly increases and decreases at each milk ejection, particularly during the first few minutes of a breastfeed. In addition, there is large variation in the pattern of release of oxytocin between mothers.

In summary, these studies clearly show that the application of vacuum by the infant is critical for successful milk removal. Sucking dynamics with good coordination of the suck-swallow-breathe reflex are evident in the early postnatal period for term babies. However, changes in oxygen saturation, heart rate, feed duration, and the applied vacuum change in relation to neurological maturation and conditioning as lactation proceeds.

4.4.6 Established Lactation

In the 1970's, the slowing of infant growth at 2–3 months of age in low and middle-income countries was of great concern. Maternal diets in these countries were very poor compared to international recommendations. As such, it was concluded that poor infant growth was due to infants receiving insufficient breastmilk from their mothers. This conclusion was consistent with research on dairy cows, dairy goats, and sows that showed that increased food intake was required to support milk production. The summation of these factors resulted in the slogan, 'Feed the nursing mother and thereby feed the child' [29]. This slogan was readily accepted at the time because it was logical and consistent with contemporary nutritional knowledge. Nevertheless, Ann Prentice and her colleagues studied poorly-nourished lactating women in The Gambia and well-nourished lactating women in the UK [30]. They concluded that

> *'the processes controlling lactation performance are remarkably similar and that the same control mechanisms will be revealed in most other communities'.*

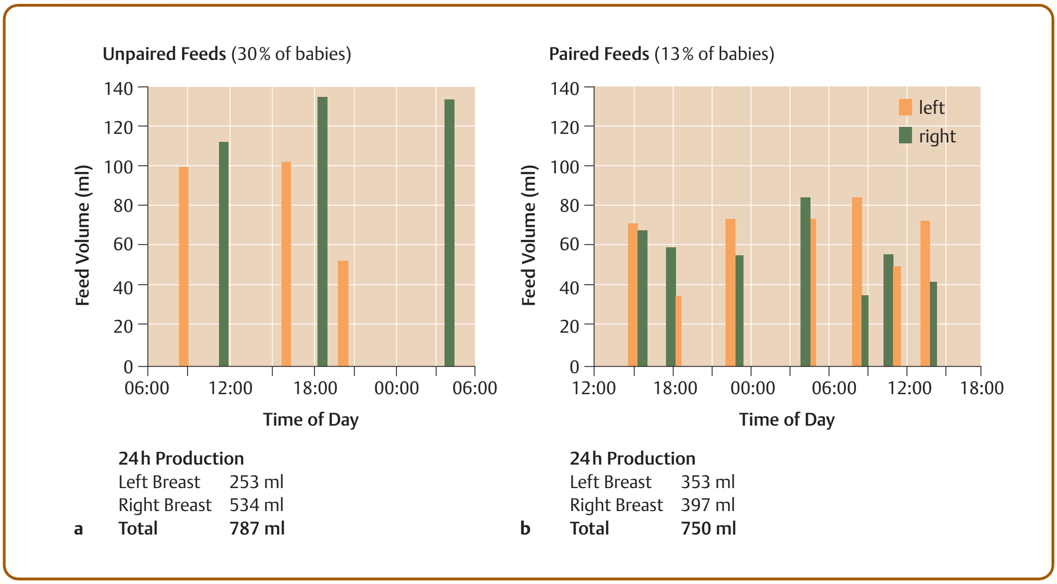
They also concluded that

> *'there is a strong drive towards milk production in lactating women, often to the detriment of maternal tissues, and that even low dietary intakes observed in most countries in the developing world do not fall below the threshold at which lactation performance is compromised'.*

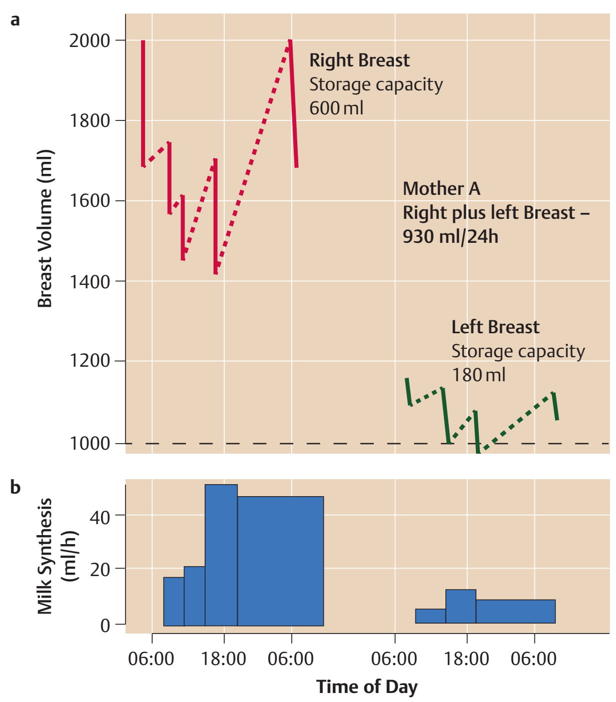
This was surely a seminal finding as it not only supported the concept that human lactation is "hard-wired" but totally reversed the mindset of scientists investigating the control of the synthesis of human milk. The question then became "How does the mother regulate her milk synthesis to meet the unpredictable appetite of her baby?"

Many studies have shown that the infant only consumes enough milk to satisfy its appetite and that variable milk volumes are taken at each breastfeed regardless of whether the feeds are unpaired or paired (▸ **Fig. 4.33**). Studies in dairy animals have also found that goats milked three times per day produced more milk than if milked twice daily. Furthermore, if half the udder was milked three times per day while the other half was milked twice per day, the udder-half milked three times per day consistently produced more milk. This effect was clearly shown in women by the finding that when the breast was drained of milk, the rate of milk synthesis was high and when the breast was filled with milk the rate of milk synthesis was low (▸ **Fig. 4.34**). Conclusions drawn from these studies were that the regulation of milk synthesis was local within each breast (autocrine), and that the hour-to-hour regulation of milk synthesis was relatively independent of endocrine influences.

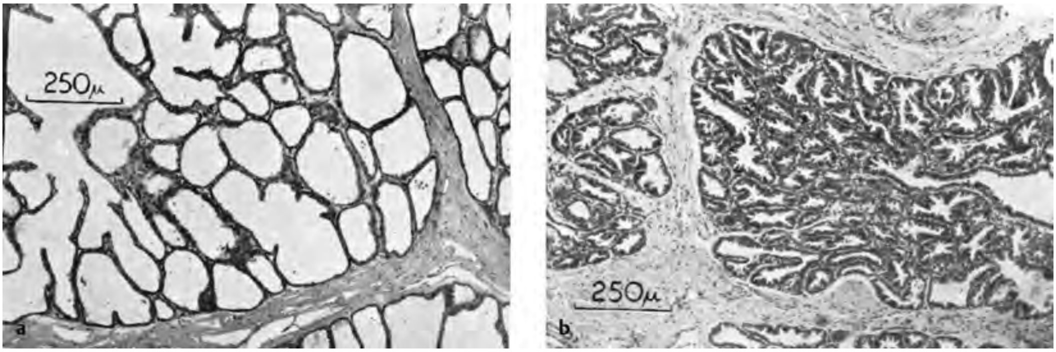
However, a compensatory response was also found in dairy animals. That being, if the rate of milk removal was reduced in one udder-half, a compensatory increase in milk production occurred in the other udder-half without a change in the frequency of milk removal. These findings have important implications for human lactation. If a mother can store a lot of milk in her breasts then she could breastfeed at less frequent intervals. On the other hand, if she has a small storage capacity the breast will fill with milk more quickly and down-regulate milk synthesis sooner. This means that more frequent breastfeeds are required to maintain milk production in mothers with low storage capacity. It has been proposed that the



▸ **Fig. 4.33** Volume of milk consumed at each breastfeed from left and right breasts over a period of 24h, (30% of babies consistently fed from only one breast at each breastfeed and only 13% of babies fed from both breasts at each breastfeed; n=70).

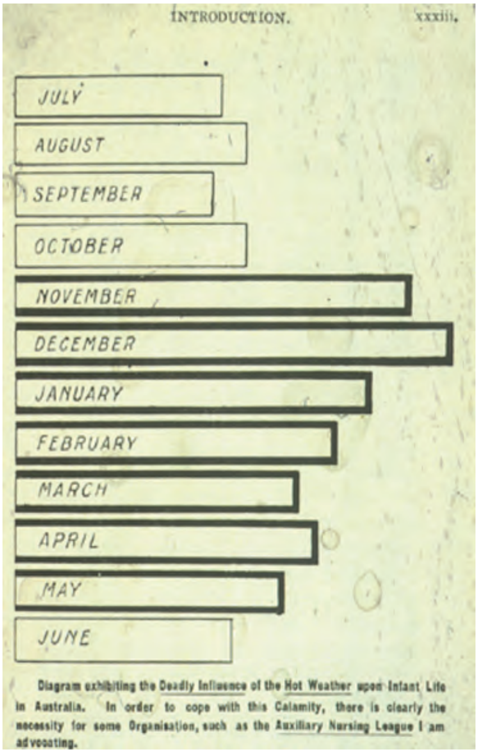


▶ **Fig. 4.34** (a) Changes in breast volume for each breast at each breastfeed over a 24h period. (b) The rate of milk synthesis between each breastfeed for each breast over a 24h period.



▶ **Fig. 4.35** Part of a lobule from the left half of the mammary gland of a lactating goat fixed while distended with milk (a). The right half of the mammary gland of the same goat which was milked out as completely as possible before autopsy (b); note the contracted lobules with collapsed alveoli and ducts lined with a thick folded epithelium. (Folley, S. 1956. The Physiology and Biochemistry of Lactation, London, Oliver and Boyd. p90.)

down-regulation of milk synthesis is controlled by a feedback inhibitor of lactation [31]. However, identification of such a compound remains elusive. Alternatively, it is possible the down-regulation of milk synthesis is related to major morphologic changes in the secretory parenchyma during transition from full to drained gland (▶ **Fig. 4.35**). This change could expose or mask receptors in the lactocytes to either up regulation or down regulation depending on whether the alveoli were distended or drained of milk, thereby regulating the lactocytes' response to lactocrine hormones.



▶ **Fig. 4.36** Death of babies in summer from diarrhoea 1895–1904. Deaths of babies in summer from diarrhoea and high incidence of tuberculosis in army recruits prompted the Government to establish Child Health Nurses who were trained by free immigrants who, in turn, learnt hygiene on sailing boats coming to Australia. (Muslett, P. 1903. Australian Medical Guide, Sydney, William Brooks and Co.)

Healthy exclusively breastfed infants have a mean daily intake of 750–800 mL/24 h from one to six months of lactation; however, the range is wide (from 500 to 1200 mL/24 h) [32]. There is a relationship between infant growth and milk production but, unexpectedly, no relationship between infant growth and total energy, protein, fat, or lactose intake from breastmilk. The relatively constant milk production from one to six months of lactation is most likely explained by the relatively slow growth of the human infant. The energy saving from the decrease in the ratio of surface area to body mass is probably sufficient to sustain infant growth over the first six months of life.

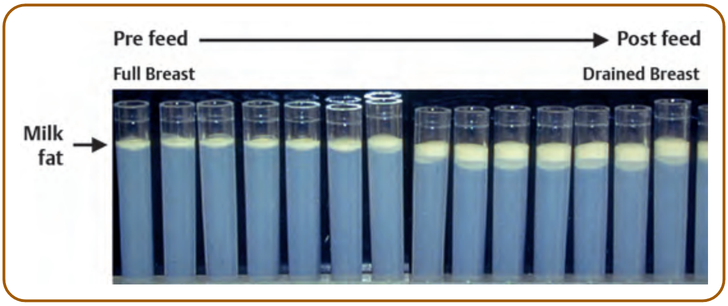
Fluid intake during lactation is also important for both mother and her baby. Lactating women should maintain adequate fluid intake but be aware that fluid consumed in excess of natural thirst does not increase milk synthesis. Additionally, the infant has limited capacity to concentrate its urine, and therefore any increase in the osmotic load (for example, from the consumption of cows milk that has a much higher sodium content than human milk) will lead to an increase urine output. This explains why summer diarrhoea, resulting from dehydration in hot, dry climates, was a problem 100 years ago. For this reason, early last century, mothers in Australia were advised not to wean their babies in the summer months (▶ **Fig. 4.36**).

4.4.7 Reference Ranges

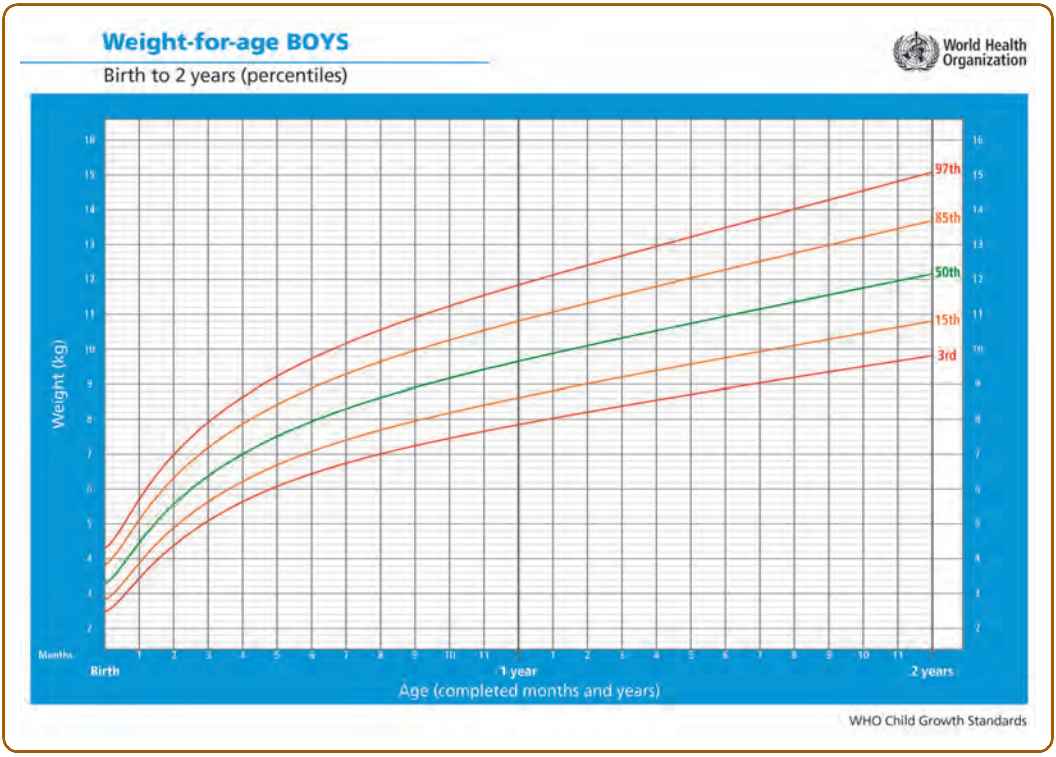
The biochemical composition of human milk is spectacularly complex. It contains 900 proteins, 200 oligosaccharides, 1,000s of triacylglycerols, ~100 metabolites, and many bioactive peptides, hormones, cytokines, and cells, together with a full complement of minerals and vitamins. Some of these components (e.g., milk fat) vary from beginning to end of both a breastfeed and breast expression (▶ **Fig. 4.37**), over the day, with diet, and during the lactation period. Unfortunately, with the notable exception of breastfed infant growth (▶ **Fig. 4.38**, ▶ **Fig. 4.39**), there are no reference ranges for normal values (i.e., predicted values that cover 95% of individuals) for milk production and milk composition. Thus, values currently given for milk production and concentrations of breastmilk components are flawed.

Standardised experimental inclusion and exclusion criteria are required for development of protocols to define normal ranges carefully for human lactation in the mother and her infant. This is an important prerequisite for establishing an objective evidence-base for the diagnosis of problems associated with human lactation.

Measurement of 24-hour milk production provides an objective measure of breast function and has been shown to be useful to both mother [33] and clinician (Kent, personal communication

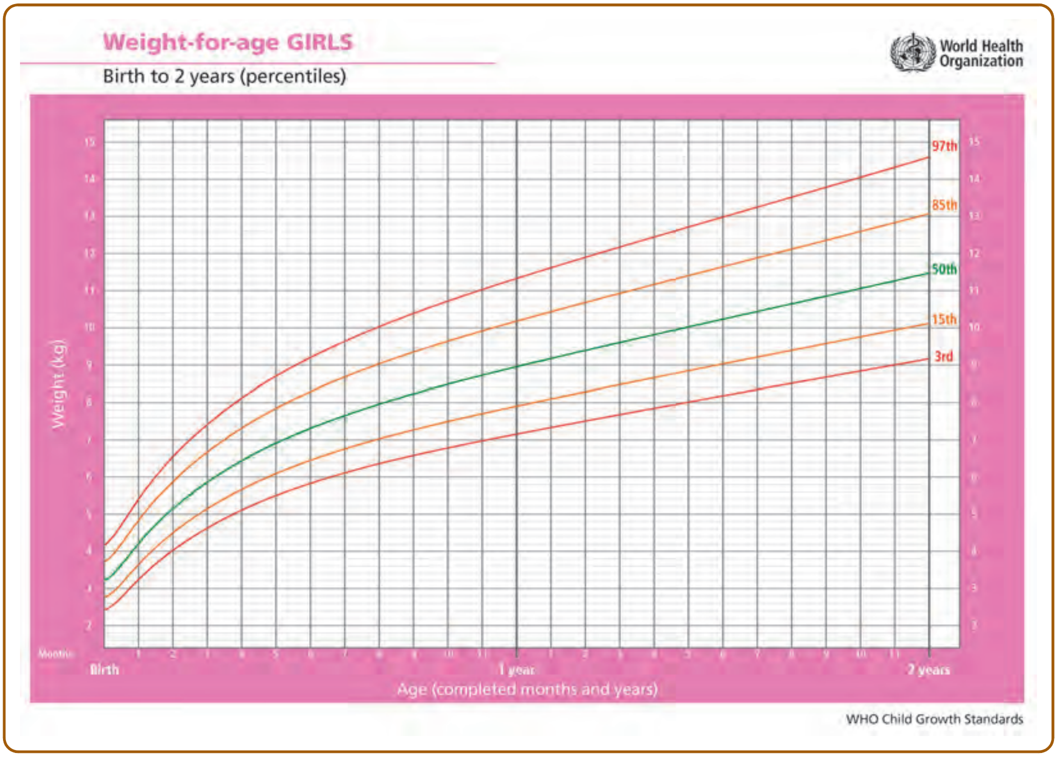


▸ **Fig. 4.37** Serial samples of breastmilk collected during breast expression. The samples were centrifuged to separate the cream showing the increase in the fat content of breastmilk from a low concentration in milk from a full breast and a higher concentration of fat in milk from a drained breast. (from Hartmann, P.E. 1985. Unpublished data.)



▸ **Fig. 4.38** Reference ranges for the growth of breastfed boys. (from WHO Multicentre Growth Reference Study Group. WHO Child Growth Standards based on length/height, weight and age.)

2016). Conversely, the measurement of milk intake at a single breastfeed is of less value because milk intake is controlled by the infant's appetite and can vary greatly from one breastfeed to the next. The measurement of 24-hour milk production is useful in tracking changes within the mother-infant dyad but is not useful in determining whether the level of milk production is normal. More stringent assessment of the recruitment of mother-infant dyads would likely reduce the current wide range for normal milk production. Similar concerns are valid for maternal and infant endocrine and metabolic parameters. This highlights the urgent need to establish reference ranges for objective diagnosis and treatment of problems associated with human lactation.



▶ **Fig. 4.39** Reference ranges for the growth of breastfed girls. (from WHO Multicentre Growth Reference Study Group. WHO Child Growth Standards based on length/height, weight and age. Acta Paediatr Suppl 2006; 450: 77–86.)

4.5 Changes to Physiology in Mother and Infant

Physiologically, there are two very important aspects to human lactation. First, lactation is important for the mother and her baby and secondly, the importance of lactation in relation to breastfeeding behaviour and breastmilk composition must be considered. This is a very large topic and therefore only some pertinent points can be discussed here. Much of the importance of lactation has focused on the infant (Table 2a) but the importance to the mother (Table 2b) must also be considered.

- Importance of lactation for the infant:
  - Immunological protection (both innate and acquired)
  - Optimal nutrition
  - Optimal metabolic development
  - Optimal neurological development
  - Prebiotic components that promote favorable microbiota in the infant
  - Probiotic transfer of a favourable microbiome to infant
- Importance of lactation for the mother:
  - Recovery from childbirth
  - Cholesterol clearance
  - Suppression of maternal fertility
  - Glucose control in diabetic mothers
  - Improved bone mineralisation
  - Reduced obesity
  - Reduced risk of breast and ovarian cancer
  - Reduced risk of cardio-vascular disease
  - Increased self esteem
  - Improved IQ

A good illustration of the complexity of human lactation in relation to the mother can be illustrated by examining calcium metabolism during pregnancy and lactation. In the past, nutritionists were aware of the high levels of calcium in breastmilk and thus it was concluded that breastfeeding was an impost on calcium metabolism. To emphasise this, textbooks claimed "for every child a tooth" and high calcium diets were recommended for pregnant and lactating women. Research from Ann Prentice's group challenged this orthodoxy by showing that increasing calcium supply to international recommendations in the diet of mothers in populations with low calcium intake was neither beneficial for mothers during pregnancy and lactation nor for their children [34]. She showed that intuitive thinking is not always supported by research. Thus, studies in The Gambia showed that breastfeeding Gambian mothers who received calcium supplements during pregnancy had accentuated bone mobilisation during lactation, and that their lower bone mineral density persisted long term. These unexpected findings raise mechanistic questions about the underlying physiology of calcium metabolism during pregnancy and lactation, and illustrate the importance of a complete basic understanding of calcium metabolism before clinical intervention. Presently, the nutritional advice offered by James in 1912 seems appropriate.

> *'There is no special food for the production of milk: That which is best for the general health of the mother is the best for the child.' [35]*

The importance of the intimate but fragile metabolic relationship between mother and infant is clearly illustrated in Hofer's studies [36]. Breastfeeding is related to complex signals that pass from mother to infant and from infant to mother. There are significant subtle interchanges that occur during human lactation. Hofer determined that the mother-infant relationship is built on many layers of sensory complexity. What seems to be a single physical function, such as either grooming or nursing, is actually a kind of umbrella that covers stimuli of touch, balance, smell, hearing, and vision, each with specific effects on the infant. He identified a 'private realm of sensory stimulation constructed by the mother and infant from numberless exchanges of subtle cues'. Hofer discovered that a mother precisely controls every element of her infant's physiology, from heart rate to release of growth hormones, and from appetite to the intensity of activity. Hofer says:

> *'The mere presence of the mother not only ensures the infant's well being, but also creates a kind of invisible hot house in which the infant's development can unfold. Mother and offspring live in a biological state that has much in common with addiction. When they are parted, the infant does not just miss its mother, it experiences a physical and psychological withdrawal from a host of her sensory stimuli, not unlike the plight of a heroin addict who goes cold turkey. For a baby, the environment is the mother,'*

Furthermore, it was known that a mother must keep her infant warm for its body and brain to mature; however, Hofer discovered that thermal contact with the mother regulated the infant's behaviour and activity as well. Conversely, it has also been shown that the infant influences the mother's metabolism and cycle of activity primarily through the act of breastfeeding. These findings provide a basis for understanding the beneficial effects of skin-to-skin contact. In addition, recent research has shown that breastfeeding and vaginal birth are physiologically important because they facilitate optimal passage (inoculation?) of maternal symbiotic microorganisms to the infant.

This is of particular importance when considering the composition of human milk and function of the components in the infant. Transfer of nutrient and bioactive components from mother to infant occurs though colostrum and milk after birth. The substitution of infant formula for human milk deprives the infant of the nutrients in human milk (e.g., essential amino acids and human casein) and of the many bioactive and immunoprotective factors (e.g., oligosaccharides, lactoferrin, and lysozyme) directed specifically against pathogens in the infant's environment. Human milk components also compensate for the immature functioning of infant metabolism, in which endogenous digestive enzymes, secretory immunoglobulin A, taurine, choline, nucleotides, and long-chain polyunsaturated fatty acids are insufficient. The importance of these nutritive and bioactive components makes human milk superior to even the best infant formula.

4.5.1 Menstrual Cycle

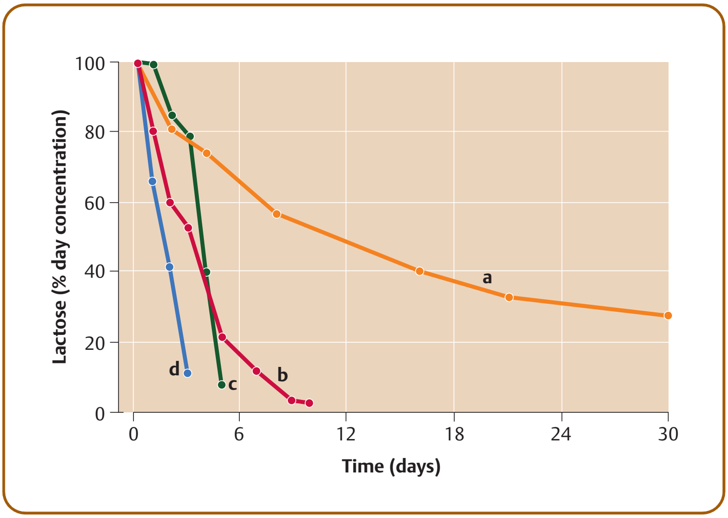
Postpartum amenorrhoea lasts for approximately 55–60 days in non-breastfeeding women. However, this period is much more variable in breastfeeding women and can extend up to 2 years and beyond. The long period of lactation in traditional societies increases the duration of amenorrhoea and child spacing, with associated benefits to the mother and child. While lactational amenorrhoea is evident on a population basis, variation between mothers in the timing of the return of menstruation indicates that lactational amenorrhoea does not alone provide a reliable method of birth control.

4.5.2 Weaning and Involution

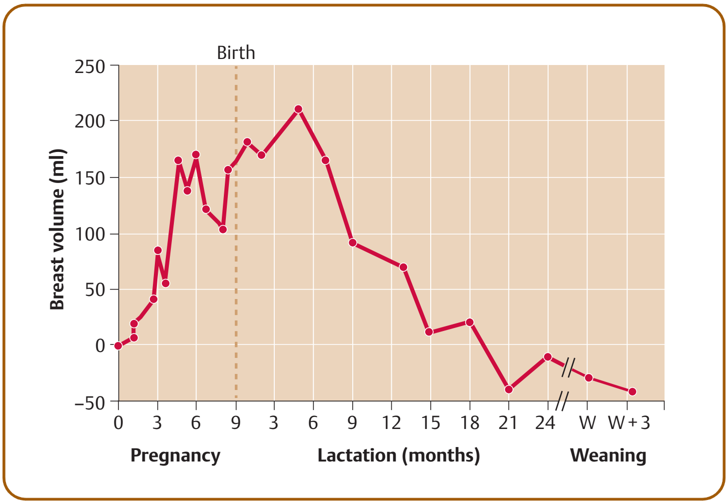
Weaning after six months of lactation is normally a gradual process, commencing with the baby having fewer breastfeeds while consuming additional foods. This is coupled with the gradual involution of the secretory and ductal tissue in the breast by apoptosis (programmed cell death), an increase in prominence of fatty tissue, and mammary parenchyma slowly returning to ducts and terminal end buds containing a colostrum-like fluid with very high concentrations of innate protective compounds. Once milk removal has completely stopped, mammary secretion takes more than 4 weeks to stabilise in women compared with about a week in most other mammals (▶ **Fig. 4.40**).

In some mothers, breastfeeding may continue into the next pregnancy and even to the next lactation (tandem feeding). It is unlikely that breastfeeding into a new pregnancy has any undesirable effect on either the infant or the mother, as two thirds of all cows milk that we drink is from pregnant cows.

Complete weaning of the infant marks the end of the lactation cycle and the breast returns to its non-lactating (resting) state. Studies have monitored the changes in breast volume over the entire lactation cycle (▶ **Fig. 4.41**). The first significant reduction in breast volume occurs after six months of lactation and precedes the first significant decrease in milk production. After milk production has ceased, there is no significant difference between breast volume prior to conception and that measured after complete weaning.



▶ **Fig. 4.40** Concentration of lactose (% of day zero value) in the mammary secretion of (a) women, (b) cow, (c) sows, and (d) rats from 0 to 30 days after removal of milk had ceased. (By permission of Oxford University Press. Reproduced from Hartmann, PE et al. 1985. Variation in the yield and composition of human milk. Oxford Reviews Reproductive Biology, 7, 118–167.)



▸ **Fig. 4.41** Relative change in breast volume (mL) from pre-conception (relative volume, zero), through pregnancy, lactation and weaning. (Reproduced from Czank C, Henderson JJ et al. Hormonal control of the lactation cycle. In: Hale TW, Hartmann P. Textbook of human lactaion, New York: Springer; 2007)

4.6 Conclusion

Finally, it is appropriate to conclude this chapter with another quote from Cooper:

> *"If a woman be healthy and she has milk in her breasts, there can be no question of the propriety of her giving suck. If such a question be put, the answer should be, that all animals, even those of the most ferocious character, show affection to their young, do not forsake them, but yield them their milk, do not neglect, but nurse and watch over them; and shall woman, the loveliest of nature's creatures, possessed of reason as well as instinct, refuse that nourishment to her offspring which no other animal withholds, and hesitate to perform that duty which all animals of the Mammalia class invariably discharge?*
> *Besides it may be truly said that nursing the infant is most beneficial both to the mother and the child, and that women who have been previously delicate, become strong and healthy whilst they suckle." [10].*

Key Points

- Astley Cooper in 1840 was the first person to focus on the physiology of the lactating breast but it was not until a 150 years later that modern ultra sound technology provided a new insight into the workings of this amazing organ
- Today it is understood that lactation occurs in several stages. Beginning with alveolar development and secretory differentiation during pregnancy, followed by secretory activation during the first 3 days after birth and ending with involution during weaning
- Lactation is intricately controlled by endocrine and autocrine processes requiring the removal of milk to sustain it
- Complex signals pass between mother and infant during breastfeeding which have subtle influences on the infants' physiological well-being

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Emeritus Professor Peter E. Hartmann, E/Prof, PhD, BRurSc is a Senior Honorary Research Fellow at The University of Western Australia. He has published more than 200 research papers and numerous reviews and book chapters on lactation in dairy animals and women. He has received numerous awards including the Macy-Gyorgy award, La Leche League International Award of Excellence for contribution to supporting breastfeeding, and the Rank Prize for Nutrition. He is a Fellow of Nutrition Society of Australia, co-editor of a Hale & Hartmann's Textbook of Human Lactation, and a Member of the Order of Australia.

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5 Why Breastfeeding?

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Expected Key Learning Outcomes

- **The importance of optimum nutrition in the first months after birth**
- **The effect of early nutrition on later life**
- **The importance of good health and nutrition for mothers during pregnancy and throughout lactation**

5.1 Introduction

There is no other period of time in human life when the quantity and quality of nutritional supply are of greater importance than during the first months after birth. This is due to the extremely rapid growth of infants who normally double their birth weight in 4–5 months and triple it in the first year; such a growth rate demands a very high requirement of energy and nutrients per kilogram of body weight [1], [2]. The capacity to compensate for a diet that is insufficient in quantity or inadequate in nutritional value is limited. Body reserves of nutrients are very restricted and, particularly during the first months of life, some body functions are not fully developed, such as nutrient absorption, metabolism, and renal conservation. In addition to this fast rate of body mass gain there is a rapid development and differentiation of tissues and organs. During this period of developmental plasticity, environmental cues such as nutrition and metabolism have modifying effects on growth, development, and long-term function and health. An increasing body of evidence indicates that nutrition, particularly during the first two years of life, has a marked impact on later physiology, health, and disease risks; this is commonly referred to as the ‘metabolic programming of lifelong health and disease’ or the ‘developmental origins of adult health’ [1], [3], [4].

5.2 The Evolution of Lactation

Breastfeeding is the natural form of infant feeding and is universally recommended [5]. The composition of human milk is believed to have developed during a very long evolutionary process to match the needs of both lactating women and their infants optimally. Lactation and milk feeding in mammalian species is believed to have evolved over a period of about 250–300 million years, and to have originated from synapsid animals that provided fluid from cutaneous glands to protect their parchment-shelled eggs from desiccation [6], [7]. These ancestral cutaneous glands are thought to have evolved by combining features of skin glands into new functional entities. Gland secretions were then provided with antimicrobial properties to protect eggs and hatchlings from infection, and organic components to supplement offspring nutrition [8]. The immune properties of milk from various mammalian species show wide variation in anti-inflammatory and immunomodulating agents, including immunoglobulins, iron-binding proteins, lysozyme, oligosaccharides, and leukocytes. This variability appears to compensate for differences in developmental delays in early postnatal production of antimicrobial factors among species [9], [10]. Moreover, the composition and concentrations of different immunological agents in mammalian milks relate to differences in placental type and function, lactation pattern, and environments and also follow different evolutionary strategies.

Similarly, the evolutionary development of highly nutritious milks has led to diverse variation in mammary gland anatomy, milk output, length of lactation, and nutrient content (▶ **Table 5.1**, ▶ **Table 5.2**), and in the relative contribution of milk feeding to the offspring’s total nutrient supply during their initial growth period. For example, the wide inter-species variation in milk protein content, a key driver of offspring growth, is

▶ **Tab. 5.1** Selected anti-infectious and anti-inflammatory components in human milk.

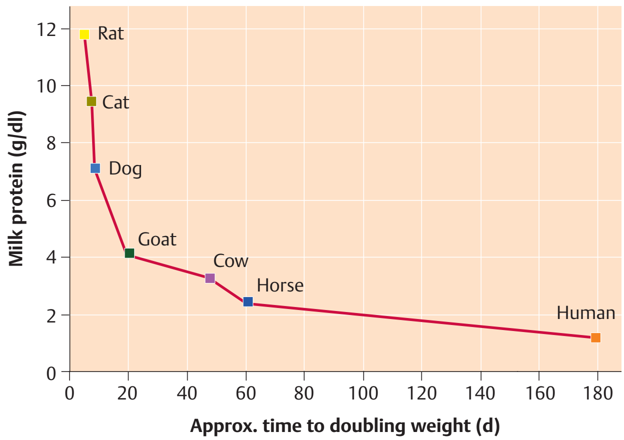
Cellular components	Humoral and other components	
Neutrophil, granulocyte, macrophages	Immunoglobulins (sIgA, IgG, IgM, IgD)	Haptocorrin
Lymphocytes	Complement and complement receptors	Osteopontin
Mammary gland epithelial cell membranes	Toll-like receptors	Fibronectin
Milk fat globoli membranes	Soluble CD14	Lactoperoxidase
	β-Defensin-1	Human milk oligo- and polysaccharides and glycoconjugates
	Cytokines, e.g. IL-10, TGFβ	Monoglycerides and non-esterified fatty acids
	TNFα and IL-6 receptors	Complex lipids
	IL-1 receptor antagonist	Nucleotides
	κ-Casein, α-lactalbumin	Mucins
	Lysozyme	Lactadherin
	Lactoferrin, lactoferricin B and H	
Modified from [57].		

▶ **Tab. 5.2** Milk composition (% weight) among nine species.

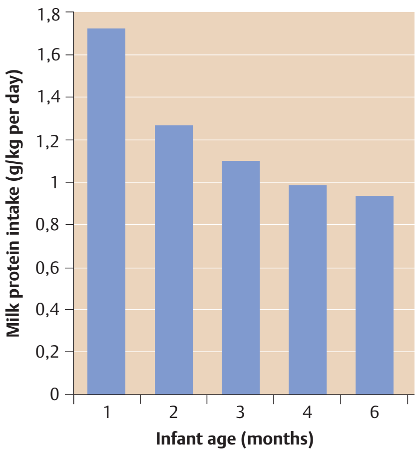
	Water	Protein	Fat	Lactose	Ash
Human	87.7	1.8	3.6	6.8	0.1
Cow	86.6	3.4	4.6	4.9	0.7
Buffalo	84.2	3.9	6.6	5.2	0.8
Sheep	79.4	3.5	8.6	4.3	1.0
Pig	89.6	1.3	4.8	3.4	0.9
Dog	75.4	11.2	9.6	3.1	0.7
Rat	68.3	11.3	14.8	2.9	1.5
Whale	70.1	9.5	19.6	1.8	1.0
Seal	32.3	11.2	34.8	2.6	0.9

closely related to offspring growth velocity (▶ **Fig. 5.1**). The relatively low protein concentration in human milk is an adaptation to the lower needs of human infants who have slower weight gain rates compared to, for example, calves or kittens. Moreover, the protein supply in human milk falls substantially with increasing duration of lactation. The protein intake per kilogram body weight of a breastfed infant at 6 months represents only about 55% of the intake after birth (▶ **Fig. 5.2**). Underlining evolutionary adaptation of lactation to the needs of the species, this change is in accordance with the decrease in protein requirement with increasing postnatal age, which is a consequence of a slowing of infant growth rate.

Recent genome studies provide support for the hypothesis that during the evolution of lactation, the maternal energy cost of breastfeeding has been limited while aiming to maximise offspring survival. In effect, this would have promoted survival of the maternal-offspring pair and therefore survival of the species. The genome analysis of



▶ **Fig. 5.1** Protein content of mammalian milks relative to time to doubling of offspring weight. Note the low human protein milk content in humans matching relatively slow offspring growth.



▶ **Fig. 5.2** Decrease in milk protein intake in a breastfed human infant in the first six months reflecting the decrease in infant growth rate. Milk protein intake is calculated as 75% of crude protein intake.

seven mammalian species (human, cow, dog, mouse, rat, opossum, and platypus) indicates a high degree of conservation of milk genes and mammary genes. Such conservation seems to have evolved more slowly than for other genes, even in cows selectively bred for effective milk production [7]. The most variable parts of the lactome were those with nutritional or immunological characteristics. This leads to speculation that evolutionary selection (specifically of these genes) occurred in response to different environmental and nutritional needs and to infectious challenges. Interestingly, most conserved genes are those for proteins of the milk fat globule membrane, suggesting they may have a central biological role.

In spite of its high metabolic cost, the evolution of lactation has been accompanied by the global biological success of mammalian species. This supports the hypothesis that there are major benefits to lactation due to the nutritional and antimicrobial properties of milk and the associated extended period of mother-infant contact. The regular and frequent transfer of milk, particularly in humans and other non-human primates, provides offspring with close interaction with their mother and therefore more learning opportunities, which may have facilitated the development of high levels of intelligence found in humans and other primates.

While we have yet to learn much about the evolutionary process of lactation over the last 250–300 million years and the biological consequences for humans today, the available evidence indicates that human breastfeeding has evolved to be highly adapted to the needs of both mothers and infants. A tempting question is whether new areas of vulnerability might arise from the discordance between the slow evolutionary adaption of the human genome affecting biological characteristics such as breastfeeding and human milk composition and the rapid environmental and human lifestyle changes particularly within the last century. These questions warrant investigation in future studies.

5.3 Assessing Health Effects of Breastfeeding

There is considerable data supporting the health effects and benefits of breastfeeding for mother and infant, and these have been evaluated in systematic reviews [10], [11], [12], [13], [14], [15]. Given that breastfeeding is widely considered as the natural and optimal mode of infant feeding, it is generally thought unethical to randomise infants to either breastfeeding or breast milk substitutes. As such, the evidence is almost entirely based on epidemiological data from observational studies. A limitation to this is that the decision to breastfeed and the duration and exclusivity of breastfeeding are associated with a variety of factors that predict health outcomes, e.g., socioeconomic status, education, and lifestyle factors including smoking habits, physical activity, dietary choices, and use of preventive healthcare. Thus, there is a high risk that the effects and effect sizes of breastfeeding are overestimated if there is no adjustment for such confounding factors. Even with adequate adjustment, there remains the risk of residual confounding, partly because not all confounders can be quantitatively assessed. A review and analysis by Ip and co-workers details the methodological issues and considerable differences in the quality of studies assessing breastfeeding effects. This report rated study quality with regard to study methodology when evaluating the evidence, a practice not often considered by other authors. Ip, et al. concluded that prospective longitudinal cohort studies provide a better opportunity for adequate assessment of confounding variables than retrospective or cross-sectional studies [14].

The author of this article is aware of only one randomised controlled trial performed at the end of the 20th century. In this trial conducted in four antenatal clinics in Nairobi, Kenya, women infected with human immunodeficiency virus type 1 (HIV-1) infection were randomly assigned to either breastfeeding (n=185) or formula feeding (n=186) their infants to assess potential effects on vertical HIV transmission [16], [17]. Mortality rates adjusted for HIV-1 infection status, morbidity, and nutritional status were monitored during the first two years of life. Today, enhanced knowledge of strategies to mitigate the risk of HIV transmission during breastfeeding and particularly effective antiretroviral therapy has changed the approaches to breastfeeding in HIV-positive women in low income countries. Therefore, such a randomised trial in HIV-positive women would no longer be feasible today.

However, it has been considered ethical to cluster-randomise hospitals to standard or enhanced breastfeeding promotion. With the aim to evaluate the effects of breastfeeding promotion in hospitals on breastfeeding success, such a cluster-randomised trial (the PROBIT trial) was performed in 31 hospitals in Belarus [18]. The PROBIT trial compared an experimental intervention modelled on the World Health Organization and United Nations Children's Fund Baby-Friendly Hospital Initiative with a control intervention. The experimental intervention emphasised health care worker assistance with initiating and maintaining breastfeeding, and lactation and postnatal breastfeeding support [18]. Although not primarily designed for such a purpose, the study followed children to later ages to evaluate the health effects of varying breastfeeding duration [19], [20]. Studies have also randomised breastfed infants to earlier or later introduction of complementary feeding, and hence to different durations of exclusive or predominant breastfeeding [21], [22], and to earlier or later introduction of specific complementary feeds [23], [24], [25]. These rare randomised trials are extremely valuable, but their conclusions are limited to the questions originally addressed. The discussion on the health effects of breastfeeding presented here is based primarily on observational studies, with the caveat that the reported effects and effect sizes are likely to be confounded by other variables usually associated with breastfeeding (e.g., socio-economic status and health promoting behaviour within families) that are generally difficult to fully adjust for.

5.4 Breastfeeding and Maternal Health

Breastfeeding requires energy that is derived both from the maternal diet and from lipolysis of maternal fat depots [26]. Breastfeeding, particularly breastfeeding of longer duration, such as for more than three months, therefore has the potential to facilitate regression of maternal fat deposits that accumulate during pregnancy [27]. However, a recent meta-analysis concluded that the role of breastfeeding on postpartum weight change remains unclear [13].

While depression during pregnancy predicts shorter duration of breastfeeding, it remains unclear as to whether breastfeeding has any effect on the severity of maternal postpartum depression [13]. R. Chowdhury, et al. identified 12 studies that explored associations of breastfeeding and lactational amenorrhoea [13]. They concluded that amenorrhoea at six months after birth was 23% more likely to occur with exclusive or predominant breastfeeding versus no breastfeeding and 21% more likely versus partial breastfeeding. Thus, exclusive or predominant breastfeeding can contribute to spacing of childbirth on a population basis but should not be considered a secure contraceptive approach.

With respect to long-term effects of breastfeeding on maternal health, a very large number of studies have explored its association with the occurrence of mammary carcinoma. In a meta-analysis of 98 studies, ever breastfeeding was associated with a 22% risk reduction of developing breast cancer later. The risk reduction was 7% for breastfeeding for less than six months, 9% for 6–12 months, and 26% for breastfeeding for more than 12 months [13]. It has been estimated that one case of breast cancer could be prevented among every 200 women who breastfeed for more than 12 months, assuming a lifetime prevalence of 12.9% [28], [29]. However, there is evidence of publication bias, and therefore effect sizes of the association between breastfeeding and breast cancer prevention may be overestimated [13].

Additionally, in a meta-analysis of 30 studies, a 30% reduction on the risk of later ovarian carcinoma was reported in women who breastfed at any time compared to those who never breastfed [13], with some indication of a greater effect with longer versus shorter breastfeeding duration. The estimated effect size was slightly lower when the analysis was restricted to high quality studies only.

Studies on bone mineral density report heterogeneous results, with no conclusive evidence of the effect of breastfeeding on women's risk of osteoporosis later in life [13].

5.5 Breastfeeding and Infant Health

Breastfeeding with its major nutritional and immunological benefits was the only safe choice for infant feeding in European countries until the late 19th century. Based on the empirical evidence of the major benefits of breastfeeding for child health, the Law Book of the State of Prussia (1792) introduced a legal obligation that mothers must breastfeed to protect their children. This Prussian law book included the following statements:

> *§67. A healthy mother is obliged to breastfeed her child.*
> *§68. How long she should breastfeed shall be decided by the father.*
> *§69. But if the health of mother or child would suffer from his decision, he must subdue under the opinion of the expert.*

Until the late 19th century, breastfeeding by wet nurses was the only reasonable alternative to breastfeeding by the infant's own mother. As early as in the 10th century AD, the Persian Canon of Medicine by Avicenna emphasised the role of wet nursing, stating, 'Breast milk is the best for the child …' and 'Is the mother prevented from breast-feeding, the wet nurse should be between 25 and 35 years of age, healthy, of good and honourable manners, and having given birth 1½ to 2 months before.' Wet nurses remained popular in the 18th and 19th centuries among affluent city families in Europe. In 1780, more than 80% of infants born in the city of Paris were reported to be fed by wet nurses, and 4,000–5,000 wet nurses were employed in the city of Hamburg in the 18th century [30].

In 1865, the German chemist Justus von Liebig developed the first suitable breast milk substitute based on chemical analysis of human milk composition [31]. This triggered the development of bottle milks that could serve as feasible replacements for breastfeeding. In 1885, in Germany, the mortality of breastfed babies up to the age of 10 months was 6- to 8-fold lower for breastfed infants than for infants fed the available animal milk preparations (▶ **Table 5.3**). Today, the mortality of non-breastfed infants in low and low-to-medium income countries remains considerably higher than that of breastfed babies [32]. A recent systematic review of studies in low and low-to-medium income countries reported an increased risk of all-cause mortality in predominantly (relative risk 1.5), partially (relative risk 4.8), and non-breastfed (relative risk 14.4) infants compared to exclusively breastfed infants [33]. However, the quality of the evidence was poor to very poor [33].

The reported effects of breastfeeding on infant mortality in Europe in the 19th century, and in low- and low-to-medium income countries today, appears to be primarily related to the reduced risk of infection by breastfeeding. A meta-analysis of five cohort studies of good and moderate methodological quality showed that breastfeeding was associated with a significant reduction in the risk of acute otitis media. Comparing breastfeeding at any time with exclusive formula feeding, the risk of acute otitis media was reduced by 23% (95% CI: 9% to 36%) [14]. When comparing exclusive breastfeeding with exclusive formula feeding, the reduction was 50% (95% CI: 30% to 64%) after either more than three or six months duration [14]. These results were adjusted for potential confounders. Similarly, a review of 24 studies from the USA and Europe indicated that all forms of breastfeeding were associated with a risk reduction for acute otitis media; odds ratios were 0.57 with exclusive breastfeeding for six months and 0.67 for breast feeding at any time versus never breastfeeding [34]. Among 100 infants breastfed for 6 months, an estimated 13 cases of acute otitis media (incidence 27%) could be prevented compared to formula feeding [35], [29]. Breastfeeding has also been associated with a one half to one third reduction in the risk of acute gastroenteritis

▶ **Tab. 5.3** Infant mortality up to the age of 10 months in Germany year 1885 in breastfed and infant fed animal milks.

Age (months)	Mother married		Mother unmarried	
Deaths/10,000 infants	**Breast fed**	**Fed animal milk**	**Breast fed**	**Fed animal milk**
0	196	1,028	267	1,252
1	76	580	143	915
2	64	544	63	887
3	58	478	75	801
4	49	441	46	720
5	44	424	31	525
6	42	444	80	417
7	47	325	26	389
8	50	282	38	363
9	47	259	45	260
10	59	218	81	276
Total mortality (%)	7.3	46.4	8.5	68.1

Data from Prof. Arthur Schlossmann, from the Children's Hospital, Heinrich Heine Universität Düsseldorf collection, Germany

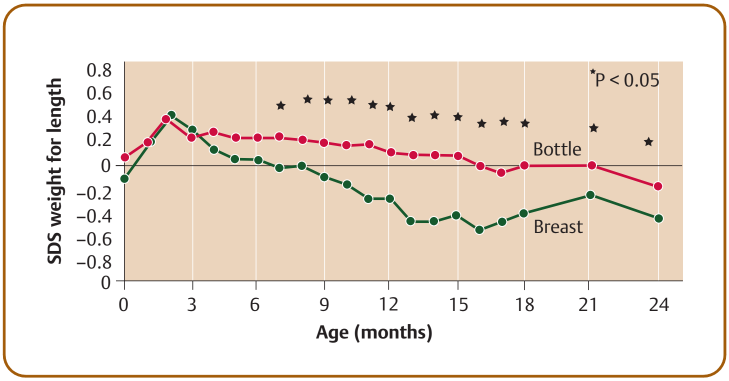
[14]. Accordingly, breastfeeding 100 infants for six months could prevent 15–63 diarrhoea episodes (at an annual incidence of 0.9–1.9 episodes) and 2–6 hospital admissions [29].

Additionally, breastfeeding has been linked with a 15–36% reduction in mortality from 'sudden infant death syndrome' (SIDS) [14], [36]. It is therefore estimated that one SIDS death could be prevented per 10,000 infants breastfed [29], [37].

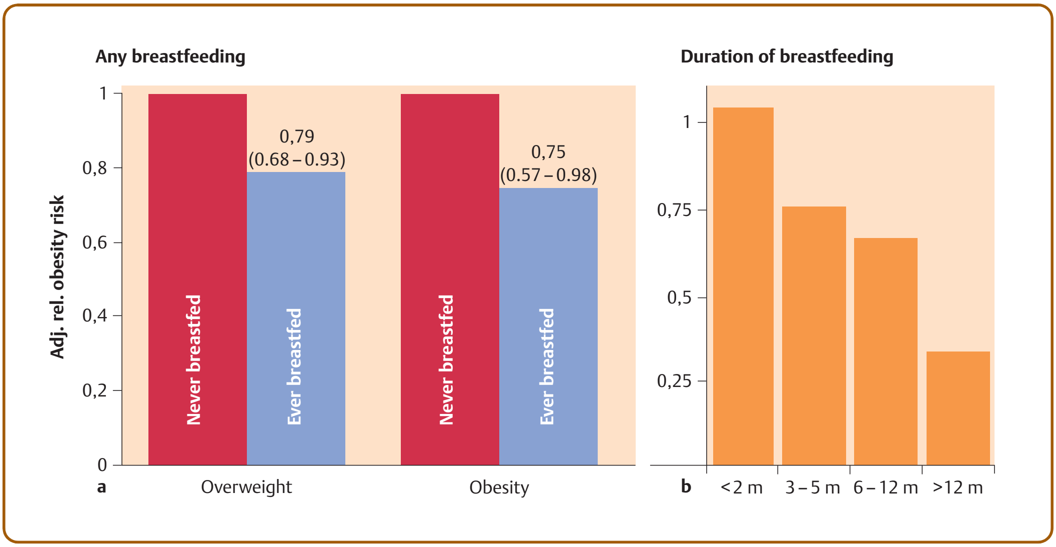
Systematic reviews and meta-analyses of observational studies report that breastfeeding may reduce the risk for disorders later in life [5], [38], [14], [39] such as obesity (risk reduced by 12%; about three cases of obesity prevented per 100 breastfed infants) [38], [29], [40]. Added plausibility for a causal protective effect of breastfeeding against later obesity arises from a randomised controlled trial. This trial demonstrated that a reduction in protein intake in infancy to levels closer to those provided by breastfeeding afforded good protection against obesity at school age [41], [42]. With regard to the underlying mechanism, we consider growth patterns in infancy a major predictor of later obesity risk [4], [43]. Children who gain weight more rapidly during the first and/or second year of life have a marked increase in risk of becoming overweight and obese later in life [4], [43]. In the Darling Study in California, body weights of breastfed and bottle-fed infants were found to be similar during the first months of life, although previously bottle-fed infants were significantly heavier than previously breastfed infants from 6–24 months [44], [45], [46] (▶ **Fig. 5.3**). Interestingly, infant growth was similar between infants breastfed exclusively for four and six months [21] and the protective effects against obesity appeared to be similar for exclusively and predominantly breastfed infants but were greater with longer duration of breastfeeding [47], [48] (▶ **Fig. 5.4**).

Breastfeeding has also been associated with a modest risk reduction of asthma (by about 10%) and atopic dermatitis (by about 5%). However, a major issue influencing study quality was the frequent failure to adjust for key confounders, most commonly socio-economic status and family history of allergy, and the definitions of outcome measures were very variable between studies [49], [50]. In the cluster randomised PROBIT trial, breastfeeding promotion intervention resulted in an increase in exclusive breast feeding at three months (44.3% versus 6.4%; $p < 0.001$) and a significantly higher prevalence of any breastfeeding at all ages up to and including 12 months. However, no reduction in the risks of allergic symptoms and diagnoses or positive skin prick tests were found among the 13,889 children who were followed up at the age of 6.5 years [20]. In fact, after exclusion of six sites (three experimental and three control) with suspiciously high rates of positive skin prick tests, sensitisation risk was significantly increased in the experimental group for four of the five antigens versus the control [20].

A randomised trial tested whether early introduction of allergenic foods (i.e., peanut, cooked egg, cow's milk, sesame, white fish, and wheat) in the diet of breastfed infants would protect against the development of food allergy [22]. Some 1,303



▶ **Fig. 5.3** Growth (standard deviation scores of weight for length) of breast and bottle fed infants up to the age of 24 months.



▸ **Fig. 5.4** Lower risk of overweight and obesity at early school age among more than 9,000 children in Bavaria, Germany (adjusted for confounding variables) in children ever breastfed versus never breastfed.

exclusively breast-fed infants aged three months were randomly assigned to the introduction of six allergenic foods at the age of three months or to exclusive breastfeeding to six months of age with the introduction of the allergenic foods thereafter. In the intention-to-treat analysis, there was a non-significant trend to slightly less food allergy with early compared to later introduction of allergenic foods (5.6% versus 7.1%). In the per-protocol analysis, the prevalence of any food allergy was significantly lower in the early-introduction group than in the standard-introduction group (2.4% versus 7.3%, p=0.01), as was the prevalence of peanut allergy (0% versus 2.5%, p=0.003) and egg allergy (1.4% versus 5.5%, p=0.009) [22]. In this study, the prevalence of allergy to peanut and egg as well as the prevalence of positive responses on skin prick testing to peanut, egg, and raw egg white were inversely associated with the consumed amount of solid foods containing antigens. These data raise the question as to whether exclusive breastfeeding for six months, which is an important and life-saving strategy for promoting health and preventing infections in low-income countries, may be less optimal for infants in affluent countries where there is a relatively low threat of common infections but a high disease burden due to allergy. It appears possible that introduction of smaller quantities of allergenic foods may have protective effects.

Breastfeeding has also been associated with strengthening maternal infant bonding and promoting offspring cognitive development. After adjustment for major confounders, previously breastfed adolescents and adults have mean IQ test results that are 2–3 points higher compared to previously non-breastfed subjects [38], [15]. One causal factor appears to be the lipids in human milk. These comprise the long-chain polyunsaturated fatty acids, omega-3 docosahexaenoic acid (DHA) and omega-6 arachidonic acid (ARA), which are incorporated in considerable amounts into the lipid-rich brain of growing infants [51], [52]. Indeed, magnetic resonance imaging of the brain structure of 133 healthy infants and young children revealed that breastfeeding led to increased white matter development in later maturing frontal and association brain regions. Positive relationships between white matter microstructure and breastfeeding duration are also exhibited in several brain regions; these are anatomically consistent with observed improvements in cognitive and behavioural performance measures [53]. Given that previous morphometric brain imaging studies showed that increased white matter volume, sub-cortical grey matter volume, and parietal lobe cortical thickness were linked to higher IQ values, these findings support the hypothesis that constituents of human milk may beneficially affect both brain structure and function.

Gene environment interaction studies strengthen the conclusion of a causal effect of breastfeeding on cognitive development. In the UK ALSPAC study, 5,934 children were tested for IQ at the age of about eight years; those who showed homozygosity for less common variants of the Fatty Acid Desaturase (FADS) gene had the largest IQ benefit from breastfeeding. Homozygosity confers a low ability to synthesise DHA and ARA endogenously, and breastfeeding (which provides DHA and ARA) therefore appears to have compensated for the more limited endogenous conversion in these children [54], [51], [55]. The apparent small effect size on IQ values may be of considerable practical relevance for achievements in life. In a prospective cohort study in over 3,000 people followed from birth to the age of 30 years, those who were breastfed for one year had an IQ benefit of 3.8 points, a 0.9 years longer time in education, and a 23% higher income compared to those not breastfed (all adjusted for other confounding factors) [56].

5.6 Conclusion

Breastfeeding is the natural choice of infant feeding. As a consequence of a long-lasting evolutionary process, it is well adapted to the biology of both mothers and infants. There are numerous accounts of the major benefits of breastfeeding for both maternal and infant health. However, uncertainties remain on actual effect sizes due to the observational nature of most of the evidence, which is prone to (residual) confounding. Women who breastfeed may particularly benefit from enhanced regression of maternal fat deposits that accumulate during pregnancy, and from a reduction in the risk of mammary and ovarian carcinomas. In breastfed infants, the risk of infections, particularly of acute otitis media and acute gastroenteritis, can be attenuated, with an apparent major benefit for survival in low and low-to-medium income countries. Breastfeeding is also associated with a reduced risk of sudden infant death syndrome and with a consistent, modest risk reduction of later obesity by about 12%. A small risk reduction for asthma and eczema has been reported, but some methodological issues and uncertainties exist. There is good evidence for a small benefit of breastfeeding on later cognitive ability, which has been associated with a major advantage for later educational achievement and income. These data should prompt health care professionals around the world, along with policy makers and the general public, to firstly, actively promote, protect, and support breastfeeding, and secondly, support women's good health and high quality of nutrition before and during pregnancy, and during lactation as these directly and positively impact on milk and breastfeeding outcomes.

Key Points

- There is intensive and rapid infant growth alongside tissue/organ development and differentiation during the first few months of life, therefore optimum nutrition in the form of breastfeeding is required to meet the needs of the growing infant
- Nutrition early in life has a marked impact on later physiology, health, and disease risks; it metabolically 'programmes' the future health of the infant
- Breastfeeding is the best choice for infant feeding and ensuring maternal good health. High quality of nutrition before and during pregnancy and lactation can directly and positively impact milk composition and breastfeeding outcomes

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Part 2
Different Perspectives

6 Introduction

Rafael Pérez-Escamilla, Prof, PhD

In this section, Donna Geddes and Foteini Kakulas (see chapter 7), describe the beneficial bioactive properties of human milk that offer optimal infant nutrition, protection against an array of communicable and non-communicable diseases, as well as developmental benefits. They fully justify the notion that human milk is equivalent to personalized medicine for infants and underscore that breastfeeding also offers major health advantages to women including a reduction in risk of ovarian and breast cancer as well as diabetes and heart disease.

Jennifer Hahn-Holbrook in chapter 8, examines how human milk relates to psychological function in women and identifies psycho-social barriers for breastfeeding that need to be addressed by breastfeeding promotion programmes.

These findings are fully supported by Amy Brown and Maureen Minchin in their respective chapters on the social aspects of breastfeeding (see chapter 9) and the history of breastfeeding (see chapter 14).

Amy Brown concludes that breastfeeding mothers report experiencing less stress and negative affect in their daily lives when compared with formula-feeding mothers and that the association between breastfeeding and maternal depression appears to be complex and bidirectional.

In chapter 10, Ashley Fox synthesises the three main frameworks from which breastfeeding promotion policy has been developed: the women's rights, children's rights and global human rights. Understanding how these frameworks, alone or in combination, influence different breastfeeding promotion policies and what impact if any they have on advancing or hindering optimal infant feeding behaviours globally is a complex area that deserves to be further researched.

As indicated by Subhash Pokhrel (see chapter 11), lack of breastfeeding support costs billions of dollars to national economies every year, thus it is important that these tools and services are considered part of the essential packages covered by health care systems.

Rebecca Mannel (see chapter 12), highlights the need for women to have access to diverse tools and expert services to be able to feed human milk to their children. Specifically, women who need to extract breast milk should have access to effective breast pumps, women should have more access to deliver in Baby Friendly Hospitals and to skilled lactation support to manage a breastfeeding problem.

In chapter 13, Rowena Merritt presents an in-depth analysis of the WHO International Code for Marketing of Breast Milk Substitutes and explains why even in the few instances when the code has been enforced it has not yielded the expected results. Merritt argues that this is because formula companies invest very large sums of money marketing their products directly to mothers through mass media, printed advertisements, incentives, free samples, social media, and health providers. Furthermore, she posits that learning from the marketing strategies from infant formula companies could be used to promote breastfeeding through sound social marketing approaches.

This section concludes with a chapter from Maureen Minchin (see chapter 14) who provides a view of breastfeeding throughout history and highlights the importance of lactation for infant survival.

7 Human Milk: Bioactive Components and their Effects on the Infant and Beyond

Donna Geddes, PhD, PostGrad Dip (Sci), DMU; Foteini Kakulas, PhD, BSc, Research Fellow

Expected Key Learning Outcomes

- The main components of human milk and what they provide to the infant
- The importance of colostrum (the first milk produced after delivery)
- The importance of providing fresh mother's own milk whenever possible
- The superiority of human milk over man-made formula

7.1 What Science Tells Us about Human Milk

Human milk (HM) contains a spectacular array of molecular and cellular components that provide nutrition, protection, and developmental signals for the infant. The human infant is immature at birth compared to newborns of other mammals; colostrum delivers a concentrated dose of immune and bioactive factors that protect the infant against pathogens and promotes immune and other system development. During established lactation, HM continues to provide components such as proteins (> 900 types) that are highly bioavailable and protective for the infant; fats, especially long-chain polyunsaturated fatty acids, which are implicated in cognitive function; peptides, such as the appetite control factors leptin and ghrelin that influence long-term appetite control; and sugars, such as HM oligosaccharides (HMO, > 200 types) that both act as decoys for pathogens and promote the growth of beneficial bacteria. This unique fluid also contains a myriad of vitamins and minerals, some of which are influenced by the maternal diet. Further, HM contains viable cells, which range from stem cells that survive and integrate into the infant's tissues to fully differentiated milk-producing cells, and immune cells that respond to both maternal and infant infections.

The advantages that HM confers are numerous for both mother and infant, making it far superior to artificial formula that is derived mainly from cow's milk and plant sources such as soy. Breastfed infants benefit enormously compared to their formula-fed counterparts, with more optimal growth and development, a decreased incidence and severity of infections, and a decreased incidence of conditions including diabetes, lymphoma, leukaemia, obesity, and allergy. Importantly, mothers' health is also enhanced by lactation, with early benefits being more rapid uterine involution and weight loss along with amenorrhoea. She is also at lower risk for breast and ovarian cancer, osteoporosis and hip fractures, diabetes, and cardiovascular disease. Psychologically, she benefits from increased levels of confidence and attachment to her baby.

Many of the advantages associated with breastfeeding are delivered via the components of HM, the concentrations of which are species-specific.

7.2 Key Properties of Human Milk and their Functions

HM contains macronutrients, micronutrients, bioactive molecules, cells, and microbiota, making it a dynamic living fluid that can change according to infant needs. The molecular components are either synthesised by the lactocytes or imported into milk from the breasts' blood supply [1].

The milk macronutrients fat, protein, and carbohydrate are in appropriate quantities to support optimal infant growth, but often have multiple roles, such as providing protection from infection or promoting organ and system development (▶ **Table 7.1**).

▸ **Tab. 7.1** The major molecules in human milk and their functions.

Major macronutrients in human milk	Functions
Fat	
In general	• Greatest source of energy (50–60% caloric intake) • Highly variable component • Transfer of fat soluble vitamins • Some fatty acids have antimicrobial properties
Short-chain fatty acids	• Source of energy • Maturation of the gastrointestinal tract
Medium-chain fatty acids	• Source of energy • Peripheral glucose utilisation • Maturation of the gastrointestinal tract
Long-chain fatty acids	• Source of energy • Infant visual and neural development • Antiviral and antiprotozoal effects • Modulate the immune system
Sphingomyelins (in milk fat globule membrane)	• Central nervous system myelination • Improved neurobehavioural and visual development of low-birth weight infants
Protein	
Casein	• Amino acids are nutritive • Main source of calcium and phosphorus • Softer curds, resulting in more rapid gastric transit compared to formula
Peptides (derived from digestion of casein)	• Antimicrobial, immunomodulatory, antithrombotic, antihypertensive, and opioid effects
Whey	
Lactoferrin	• Binds iron • Protects against iron dependent pathogens • Its by product lactoferricin has direct antimicrobial effects
Lysozyme	• Bacteriostatic and bactericidal properties • Supports growth of infant commensal bacteria • May support infant growth particularly those preterm
Secretory IgA	• Antipathogenic effect • Neutralises toxins and viruses
α-Lactalbumin	• Lactose synthesis • Binds zinc and calcium • Matches amino acid requirement of infant • Immune protection • Gut maturation and development
Bile salt-stimulated lipase	• Digestion of fat • Infant growth
Mucins	• Inhibit pathogen binding
Other proteins	
Osteopontin	• Gut barrier function • Immune response
Amylase	• Digestion of oligo- and polysaccharides • Antibacterial functions
Haptocorrin	• Absorption of vitamin B_{12}

▶ **Tab. 7.1** continued

Major macronutrients in human milk	Functions
	• Antimicrobial activity
Cytokines	• Anti-inflammatory effect, reduces the severity of infections • Recently been linked to infant body composition
Growth factors	• Stimulate cellular growth • Involved in infant intestinal growth • Regulation of development of multiple organs • Anti-inflammatory properties
Carbohydrate	
Lactose	• 30–40% total energy • Calcium absorption • Prebiotic for gut colonisation
Human milk oligosaccharides	• Protects from infection, with antimicrobial and anti-adhesive functions, and alters host cell responses • Infant brain development • Prebiotic for gut colonisation

7.2.1 Fat

The fat content of HM contributes to a significant portion of the caloric intake of the term infant (50–60%) [2]. There is enormous variation in HM fat content that is on average 41 g/L, with a 3-fold variation within and between women (22–62 g/L) [3]. This corresponds to a range of approximately 1–20% fat. Fat content changes within a feed, gradually increasing from beginning to end, and is related to the volume of milk in the breast [4]. Interestingly, fat content appears to be at its maximum approximately 30 minutes from the end of a feed, potentially reflecting milk synthesis [5]. This creates issues when sampling for assessment or scientific research, as each mother's fat content varies differently according to milk volume. Further, factors such as gestation, stage of lactation, parity, maternal age, diet, and nutritional status are known to influence fat content. For example, a low caloric intake is associated with increased HM palmitic acid (C_{16}) content [6], [7].

The fat globule is secreted by lactocytes. It comprises a core that consists almost entirely of triacylglycerols (TAG, 98–99%), and a surrounding outer membrane of phospholipids, cholesterol, glycolipids, proteins, and glycoproteins. The TAGs are either saturated or unsaturated fatty acids that are either short, medium or long-chain fatty acids [8], [9]. The lactocyte is capable of synthesising only short-chain (SCFA) and medium-chain fatty acids (MCFA). Long-chain fatty acids (LCFA) and long-chain polyunsaturated fatty acids (LCPUFA) are imported from the maternal bloodstream. These include the omega-3 fatty acid docosahexaenoic acid (DHA) and the omega-6 fatty acid arachidonic acid (AA). LCFA make up the bulk of the fat composition (85%), followed by MCFA (13%); the remainder are LCPUFA and SCFA. The total HM fat content is largely not affected by maternal diet [10], [11], [12] but the fatty acid composition is. For example, DHA concentration is higher in HM from women with high fish intake [13] whereas higher MCFA concentrations are found in HM from women consuming a low-fat high-carbohydrate diet.

The infant absorbs fat from HM better than from other species' milk. This is likely due to differences in triacylglycerol structure [14] and the action of bile salt-stimulated lipase, which breaks down HM fat. While HM is high in fat, there is no evidence that fat intake in the first two years of life is related to being overweight or obese later in life. However, increased protein intake is associated with rapid growth [15] and later obesity. Further, fat intake in the first two years of life has not been associated with development of non-communicable diseases [16]. Importantly, fat also provides a means of transfer of fat-soluble vitamins to the infant.

The above, together with the brain growth-stimulating functions of certain HM fats, e.g., omega-3 fatty acids, support the beneficial rather than detrimental effects of HM fat for the infant. HM fat is important for normal infant development because DHA and AA are implicated in neural function and are integrated into the retina and brain [13]. Indeed, breastfed infants have higher levels of DHA and AA in their blood and brain (grey and white matter, and brain cortex) compared to formula-fed infants [17]. Improved visual function [17] and higher IQ is also characteristic of individuals who were breastfed as infants [17].

Stark differences have been documented between breast and formula-fed infants, with breastfed infants having higher plasma levels of DHA and AA, higher levels of DHA in the brain at autopsy, improved visual function [17], and higher IQ (up to 15 years) compared to their formula-fed counterparts [17]. These advantages are attributed to the unique fatty acid profile of HM. Similarly, sphingomyelins (implicated in myelination of the nervous system) have been recently shown to improve neurobehavioural and visual test scores in premature infants fortified with sphingolmyelins [18]. Some fatty acids also provide protection particularly against lipid-coated microorganisms [19], [20], [21]. Further, higher concentrations of HM n6 polyunsaturated fatty acids (n6 PUFAs) have been associated with lower risk of mother-to-child transmission of human immunodeficiency virus (HIV, [22]).

7.2.2 Protein

The nitrogen content of HM (1.71 g/L ± 0.31) consists of protein (approximately 75%) and non-protein (approximately 25%) components [23].

Non-protein nitrogen consists of molecules such as free amino acids, peptides, creatine, creatinine, nucleic acids, nucleotides, urea, uric acid, ammonia, amino sugars, polyamines, and carnitine [24]. These are functional in the infant, having effects on growth and development as well as providing protection. For example, nutritionally, nucleotides and nucleosides are involved in rapid growth (as in the preterm infant) [25], gut and microbiota development, and immune function [26], [27]. Carnitine and taurine are essential for fatty acid metabolism; carnitine is involved in lipolysis, ketogenesis, and thermogenesis, while taurine plays a role in fat absorption, bile acid secretion, and hepatic and retinal function [28]. In immunity, a number of proteins and products of digestion provide protection against pathogenic bacteria and viruses, and support development of the immune system [29], [30]. Typically, many of these components have multiple functions.

Protein levels in HM are relatively low (approximately 1% on average), but they are highly bioavailable and specific to the human infant, and mainly produced by lactocytes [27]. Protein content is highest after birth (average 15.8 ± 4.2 g/L), declining to relatively constant levels in mature milk (average 6.9 ± 1.2 g/L) [31]. Protein in HM accounts for 5% of the infant's energy, which satisfies the 5.6 PE% (percentage protein energy, PE%) mean protein requirement for 6-month-old infants. Infants do not therefore require extra protein, particularly considering that extra protein early in life has been associated with obesity later in life [32], [33]. As the infant grows, the required PE% decreases to a mean of 3.8, with a safe upper level of 5.2 PE%. PE% in the range of 5–20 is considered acceptable for children aged 1–3 years [34]. However, this is often exceeded by 3–4 times, with the major source of protein being whole bovine milk that has 20 PE% [35].

Both the quality and quantity of protein consumed in the first two years of life impacts on infant growth, neurodevelopment, and long-term health. High protein intake in these first two years has a negative impact on health [36]. Here, the protein intake of formula-fed infants is typically greater and the composition different to that of breastfed infants, particularly in relation to amino acid content. While this marked difference has compelled formula companies to produce lower protein formulae to mimic the growth rates of breastfed infants [37], [38], the protein composition is very difficult to match.

Three major groups of HM protein exist:

- Caseins, as micellar structures suspended in solution
- Whey, water-soluble proteins
- Mucins, associated with the milk fat globule membrane

Casein

Caseins are major proteins in mammalian milk and account for 13% of the total protein [27]. The high levels of caseins in bovine milk give it its characteristic white appearance, while HM has a pale blue appearance because of its low casein content. Caseins are predominantly nutritive, providing the infant with essential amino acids and minerals. The casein micelle is the main source of calcium and phosphorous, and is necessary for infant bone mineralisation [39]. The enzyme protease in the breast and the infant's stomach breaks down casein into smaller peptides that have multiple effects, including antimicrobial, immunomodulatory, antithrombotic, antihypertensive, and opioid effects. The low casein content of HM is also responsible for the slower growth rate of human infants compared to other mammalian offspring [40].

Casein is only mildly digested in the stomach [41]. Caseins are then precipitated and more slowly digested than whey proteins. Since the casein level is lower in HM compared to cow's milk, it forms a softer curd in the stomach that is more easily digestible; it therefore passes through the stomach faster than formula, facilitating frequent breastfeeding [42], [43], [44]. The casein concentration of cow's milk is more than 10-times greater than of HM [45]. Thus, the addition of whey protein to bovine-based formula [46] is necessary to offset some of the high-casein effects such as formation of hard curds in the infant's stomach.

Whey

Whey proteins account for a major proportion of protein in HM (90% and 60% of the total protein content in colostrum and mature milk, respectively) [41]. Whey comprises a large number of different proteins. Those abundant in the whey fraction include the major immunological proteins lactoferrin, lysozyme, and secretory IgA (sIgA) as well as α-lactalbumin and bile salt-stimulated lipase that have nutritional roles [47], [48].

Lactoferrin is present in higher concentrations in HM versus bovine milk and binds to the majority of the iron in HM [49]. Infant iron uptake is assisted by lactoferrin binding to receptors on enterocytes [50], [51]. The addition of bovine lactoferrin to infant formula does not increase infant iron absorption or influence infant growth rate [52], [53], suggesting that bovine lactoferrin either does not bind to the human lactoferrin receptor or that it is inactive due to processing [54]. Iron sequestering by lactoferrin deprives iron-dependent pathogens, thus protecting the infant. However, lactoferrin also has direct effects on pathogens [55] due to lactoferricin, a by-product of its digestion. Lactoferricin has strong antimicrobial effects, antiviral properties, and antitumor activity [56], [57]. Lactoferrin also has anti-inflammatory effects, particularly in the enterocytes of the gastrointestinal (GI) tract, with cell growth appearing to be dose-dependent.

Lysozyme is one of the three major proteins that dominate the whey fraction of milk. It has bacteriostatic and bactericidal properties, and its functions include breakdown of the outer cell wall of Gram positive bacteria [58], inactivation of gram negative bacteria in the presence of lactoferrin [59], inhibition of amoebae [60], and anti-HIV activity [61]. Interestingly, HM lysozyme appears to support resident commensal bifidobacteria in the milk but inhibit growth of adult-like strains of bifidobacteria [62]. There is also evidence that lysozyme added to feeds improves growth in piglets [63], and that there is a positive association between lysozyme concentrations in HM and the growth of preterm infants [64]. With the resurgence of pasteurised human donor milk as an alternative to preterm formula when mother's own milk is not available, the reduction in concentration of lysozyme (and bile salt stimulated lipase) by Holder (heat) pasteurisation may impact preterm infant growth. Recently UV-C pasteurisation has been shown to reduce the loss of bioactivity and increase retention of proteins (i.e., lysozyme, lactoferrin, and sIgA), making it an attractive alternative method to retain donor milk quality [65].

α-Lactalbumin comprises 10–20% of the total HM protein [66]. It is involved in lactose synthesis [67], and also binds zinc [68] and calcium [69]. While zinc and iron absorption improved in monkeys fed formula supplemented with bovine α-lactalbumin [70], no studies have assessed mineral absorption in breastfed infants. Further, the amino acid composition of HM α-lactalbumin matches the infant's amino acid requirements [71]. α-lactalbumin has been shown to protect the infant against several microbes such as Escherichia coli, Klebsiella pneumonia, Staphylococcus aureus, and S. epidermis [72]; however, its antimicrobial activity has not been intensely studied. α-Lactalbumin has also been implicated in GI tract maturation and development [73].

Secretory immunoglobulin A (sIgA) is the most abundant immunoglobulin in HM, contributing up to 25% of total protein content [74]. sIgA is present in greater concentration in colostrum (7–8 g/L) decreasing to lower levels (1.0–2.0 g/L) later in lactation [75]. It provides support for the infant as their immune system matures and becomes more functional [27]. The broncho-entero-mammary pathway facilitates the infant's protective mechanisms. IgA-producing lymphocytes in the maternal bronchi and intestine are transferred to the lactating mammary gland during lactation, and then to HM [76]. sIgA protects the infant by multiple means. It prevents adherence of pathogens to the intestinal epithelial surface, and neutralises toxins and viruses [77]. Its resistance to digestion further facilitates its protective effects in the infant's gut [78].

Bile salt-stimulated lipase (BSSL; 1–2% of total milk protein) plays an important role in the digestion of dietary fats. It is present in bovine milk but absent in infant formula due to the manufacturing process. In the intestinal lumen, BSSL is activated by bile salts allowing it to hydrolyse lipid substrates, such as short- and long-chain triacylglycerides [79]. Pasteurisation of HM inactivates BSSL and is thought to reduce fat absorption in preterm infants [80], [81]. UV-C pasteurisation of HM has been shown to preserve most of the BSSL activity [82], potentially improving fat absorption in the preterm infant, although this has not been tested clinically.

Mucin

Milk fat globule membrane proteins include lactadherin, butyrophylin, xanthine oxidase, and mucins. Few mucins have been studied. Mucin 1 appears to inhibit pathogen binding to the host cell surface, and specifically binds to rotaviruses.

Other proteins

Osteopontin levels are higher in HM than in bovine milk (ratio approximately 10:1) [73]. It has important functions in the development of the gut barrier, and modulates growth factor TGF-β1 and pro-inflammatory cytokines in mice with induced colitis, thus reducing inflammation [83]. There is evidence that both human and bovine osteopontin affect gene expression in the Caco-2 human intestinal cell line, albeit differently. Addition of human or bovine osteopontin to formula-fed infant rhesus monkeys demonstrated that the two osteopontins had different effects in pathways related to development, immune response, galactose metabolism, and cytoskeleton remodelling [84]. A more recent study in human infants showed that osteopontin-supplemented formula did not affect growth, but reduced the incidence of infection versus normal formula, suggesting that osteopontin influences immune function [85].

α-Amylase is present in higher concentrations in HM than in duodenal fluid; its activity is highest in colostrum (when salivary and pancreatic α-amylase activities are low), and decreases with established lactation (days 15–90) [86]. α-Amylase is active at low pH, equivalent to that in the infant's stomach (5.3), and is therefore resistant to degradation [86]. It plays a role in digestion of oligo- and polysaccharides [72], and may also exert antibacterial functions by breaking down polysaccharides in bacterial cell walls [87].

Haptocorrin binds most of the vitamin B12 in HM [88]. Evidence suggests haptocorrin resists digestion, and is taken up by human intestinal cells through binding of holo-haptocorrin to the intestinal brush border [89]. As such, the infant absorbs vitamin B12 early in life. In addition, haptocorrin has exhibited antimicrobial activity [72].

Cytokines in HM, of which 80 have been measured, possess immunomodulatory functions; they include interleukin (IL)1β, IL6, IL8, IL10, tumour necrosis factor-α (TNF-α), transforming growth factor-β (TGF-β), and interferon gamma (IFN-γ) [90]. Many cytokines are anti-inflammatory and likely decrease infection severity in breastfed infants. Interestingly, certain cytokines (IL-6 and

TNF-α) have been linked to infant body composition, with higher IL-6 concentrations associated with less body weight gain, percentage body fat, and fat mass; and TNF-α associated with less lean mass [91].

Growth factors present in HM include epidermal growth factor (EGF) and insulin-like growth factor (IGF)-1, IGF-II, insulin, and relaxin. Growth factors stimulate cellular growth, and those aforementioned have been implicated in the stimulation and regulation of infant intestinal growth [92]. EGF has multiple functions, including regulation of mammary, hepatic, pancreatic, and lung development [91]. TGF-β is higher in colostrum than mature milk. However, lower levels have been found in the milk of preterm mothers whose infants had necrotising enterocolitis; as this was shown in a study of small sample size, this finding remains to be confirmed [93]. Nevertheless, it is feasible that TGF-β has such a clinical effect because the severity of necrotising enterocolitis can be reduced by enteral administration of TGF-β [94]. This effect has been attributed to the anti-inflammatory effects of this molecule.

Given the important roles that cytokines and growth factors in HM play in the protection and development of the infant, particularly the preterm infant, it is relevant to understand whether these factors are preserved in donor milk. Donor milk is used with increasing frequency as an alternative to infant formula for the preterm infant, when mother's own milk is not available or insufficient in volume. Donor milk is most often pasteurised to remove pathogenic bacterial and viruses, and Holder pasteurisation is the most common method used (62.5 °C for 30 minutes). Levels of an array of factors, including EGF, IL-4, IL-6, IL-8, IL-10, TNF-α, macrophage inflammatory protein-α (MIP-1α), monocyte chemotactic protein (MCP), and interferon gamma inducible protein-10 (IP-10), appear to be unaffected by the pasteurisation process, but whether they remain functional remains to be determined [95]. Notably, infant formula does not contain any of these factors.

7.3 Carbohydrate: Lactose

Lactose is the main carbohydrate in HM, comprising 30–40% of the total energy [96], and has a role in calcium absorption. Lactose concentrations increase from 19 g/L in colostrum to 54 g/L at the initiation of lactation [97]. Lactose is broken down by the enzyme lactase into monosaccharides, glucose, and galactose. Galactose is then converted to glucose in the liver. Both galactose and glucose provide fuel for the brain, with galactose being implicated in rapid brain development. Lactose along with HMOs assist colonisation of the infant gut [98].

7.3.1 Human milk oligosaccharides (HMOs)

Human milk oligosaccharides (HMOs) are the third most prevalent milk component; highest concentrations are found in colostrum (20–25 g/L) compared with mature milk (5–20 g/L). More than 200 HMOs exist in HM, with types varying from 23 to 130 among women [99]. HMO composition is further classified into secretors and non-secretors, and these are either Lewis positive or Lewis negative. HMOs are not readily digested in the stomach, with only a small amount absorbed; thus, they do not contribute greatly to infant nutrition, but rather have a wide variety of protective functions [100], [101]. However, there is evidence to suggest that the HMO composition of milk may have a role in infant growth and body composition in the first six months of life [102]. Further, sialylated HMOs are major nutrients for infant brain development, and sialic acid concentrations are higher in breastfed infants' brains than in formula-fed infants [103].

HMOs have an anti-adhesive antimicrobial action, which provides protection from pathogenic diarrhoea-causing organisms, such as E. coli, Campylobacter jejuni, Norovirus, and Rotavirus. The protective effects are dose-dependent, with more HMOs conferring a lower the risk of diarrhoeal disease [101]. HMOs are also associated with reduced HIV transmission [104], a reduced risk of respiratory and urinary tract infections [100], and some protection from specific protozoa such as Entamoeba histolytica [105] through alteration in intestinal cell gene expression. Group B Streptococcus proliferation [106] and invasion of premature intestinal cells by Candida albicans is reduced by HMOs [107].

Additionally, HMOs have prebiotic effects, providing metabolic substrates for the growth of bacteria such as bifidobacteria and lactobacilli [101], [108]. Indeed, HMOs are the first prebiotic encountered by the infant at or shortly after birth. Due to the variability of HMO composition between women, the prebiotic effects on gut microbiota and health are likely to differ between infants [106].

7.4 Vitamins and Minerals

Human milk provides a full complement of both water- and fat-soluble vitamins and minerals for the infant [109]. The vitamin content of HM is influenced by maternal vitamin status, particularly for those that are water-soluble. It is important that thiamine (B1), riboflavin (B2), vitamins B6 and B12, vitamin A, iron, and iodine are consumed in sufficient amounts by the mother to ensure that satisfactory levels are delivered via milk to the infant [110]. In contrast, levels of total calcium (250 mg/L), phosphate (150 mg/L) in HM are independent of maternal diet.

Vitamin D is produced by skin when exposed to ultraviolet light. It is critical to bone health as it is involved in the regulation of calcium and phosphorus absorption by the infant. It is also important in innate and adaptive immune system health. HM concentrations of vitamin D (25-hydroxyvitamin D) are linked to maternal serum concentrations, with low vitamin D levels in milk associated with low levels in maternal serum concentrations [111], [112], [113]. Because of the increased risk of skin cancer, there is concern that the precautions taken against excess exposure to sunlight has resulted in an increase in cases of maternal vitamin D deficiency. This is reflected in the increased incidence of rickets [114]. Where maternal vitamin D deficiency is suspected, vitamin D supplementation has been shown to directly increase both HM vitamin D concentration and infant 25-hydroxyvitamin D status [115]. Regardless, the American Academy of Pediatrics currently recommends that breastfed infants be supplemented with 400 IU/day of oral vitamin D from birth [116].

Iron The infant readily absorbs iron in HM and therefore supplementation is not generally required in the first six months. Exceptions include infants born with low iron stores, such as low-birth weight infants and infants of mothers with diabetes [117]. Recently, a study demonstrated that 36% of healthy fully breastfed 5-month-old infants had iron deficiency [118]. Supplementation of breastfed infants (1–6 months of age) with 7.5 mg/day of the elemental iron ferrous sulphate has been found to increase both haemoglobin concentration and mean corpuscular volume compared with non-supplemented breastfed infants [119]. Supplementation also appears to improve infant visual acuity and mental and psychomotor neurodevelopment. These studies have led the American Academy of Paediatrics to recommend 1 mg/kg/day oral iron supplementation of exclusively breastfed term infants and infants receiving more than half of their daily feeds as breast milk from 4 months of age [120].

HM contains an extensive array of trace elements (i.e., copper, zinc, barium, cadmium, caesium, cobalt, cerium, lanthanum, manganese, molybdenum, nickel, lead, rubidium, tin, and strontium) that are easily absorbed by the infant. HM concentrations of these trace elements are influenced by maternal diet, although no global reference values for levels in HM milk exist.

Zinc deficiency is not uncommon (> 20%) [121], [122] with half of all zinc deficient infants being less than 5 years of age. Zinc deficiency is indicated by symptoms including growth retardation, reduced immune function, and GI effects such as diarrhoea. Rapid growth and tissue synthesis requires high levels of zinc. Thus, infants at particularly at risk of zinc deficiency are those who are premature, of low-birth weight, or on a combination diet of HM and plant-based foods of low zinc content [123]. HM zinc levels are not influenced by maternal diet, and supplementation is generally recommended only if complementary foods are low in zinc or in poor resource settings [123].

7.5 Human Milk Microbiome

Emerging evidence suggests that colonisation by microbes of the infant gut early in life programmes beneficial long-term health outcomes. It is also believed that in the first two years of life the gut microbiome is relatively plastic allowing for intervention, whereas in adult life it is much more difficult to change. Conventional belief was that the infant was sterile at birth and bacterial colonisation began after birth. However, more recent evidence has shown that the gut is first colonised *in utero* via the placenta and amniotic fluid, and the composition is modified by mode of delivery [124]. In the immediate postpartum period and up to two years of life or beyond, HM provides a continuous source of commensal, mutualistic, and potentially probiotic bacteria for the infant gut. Indeed, significant differences in gene regulation of intestinal cells have been demonstrated between breastfed and formula-fed infants. Up-regulated genes include those involved in the control of cell differentiation and proliferation as well as barrier function in the breastfed infant. Down-regulated genes in the breastfed infant include those that control hypoxia and apoptosis [125].

HM normally contains an abundance of bacterial species, with hundreds of thousands to tens of millions of bacteria being consumed by the infant daily [3]. The origin of these bacteria is still not clear, although the maternal gut is favoured [124]. Bacteria are transferred via dendritic cells into the lymph or blood and are then transferred to milk. Other sources of colonisation may include the maternal skin and the infant's oral cavity.

Interestingly, breastfed infants exhibit a lower microbial diversity in their intestinal tract compared with their formula-fed counterparts, but they harbour twice as many Bifidobacterium spp. cells. Bifidobacteria are predominant in faecal samples of both breastfed and formula-fed infants, but concentrations in formula-fed infants are approximately half that of breastfed infants [126]. This is speculated to be due to HM bioactive components that favour these bacterial species. However, HM microbial patterns appear to be highly individualised, and remain relatively stable, in terms of the proportion of bacterial genera over the first nine months of lactation.

The factors responsible for individual variation between women are unknown [127], but may be related to diversity of the maternal diet that influences gut flora in the short-term [128]. Further to maternal diet, factors shown to influence HM bacterial diversity between women include whether it is colostrum or mature milk, maternal obesity [129], and mode of delivery (vaginal birth versus elective caesarean section). Delivery mode differences indicate that labour and passage through the birth canal influences HM colonisation [129]. Antibiotics taken by the mother appear to have a disruptive effect on the infant microbiome [130], which is somewhat mitigated by breastfeeding [130], [131], [132]. Antibiotics also affect the HM microbiome, decreasing lactobacilli and bifidobacteria, which has been linked to infant colic [133].

HM contains HMOs that are not found in cow's milk and act as prebiotics. The HMOs reduce the pH of the infant's gut and increase the proportions of beneficial bacteria B. longum, while decreasing E. coli and Clostridium perfringens [134]. Moreover, sIgA, which is abundant in HM, has been shown to play a role in the maintenance of a healthy gut microbiome in animal models [135]. These observations further emphasise the uniqueness of HM, with many of its components working synergistically to ensure optimal health and development of the infant. The specific roles of HM bacteria have not yet been elucidated; however, some strains have been shown to inhibit HIV in vitro [136].

7.6 Appetite Factors

Breastfeeding is associated with lower rates of obesity later in life (12–24% risk reduction) [137]. Causation cannot be inferred due to the inability to control for confounders, such as maternal body mass index, socio-economic status, ethnicity, and between-study differences in methodology and data analysis. Several factors have been implicated in the programming of appetite early in postnatal life, such as milk composition, breastfeeding behaviour, and feeding mode (breast or bottle) [32]. Indeed, it is well documented that when infants are breastfed on demand they self-regulate their milk intake [3], [32] as they rarely drain the breast of milk. Indeed, if milk production is increased by breast expression they do not consume more milk [138].

In addition, patterns of milk intake are highly individualised, with different feeding patterns existing between infants consuming similar amounts of milk over a 24-hour period [3]. Conversely, bottle-feeding tends to encourage infants to empty the bottle and, in the longer-term, to behaviours (e.g., finishing all food on the plate) that may result in a reduced or diminished ability to self-regulate food intake [139]. This is in accordance with the higher weight gain in bottle-fed infants irrespective of whether they are fed formula or HM [140]. Furthermore, it suggests that the mode of feeding, which can influence volume intake, has a significant impact on appetite regulation and satiety cues.

Although its composition is highly variable both within and between mothers, HM also contains hormones controlling appetite, such as insulin, leptin, ghrelin, and adiponectin [141]. These components are highly likely to be bioactive and bioavailable to the infant via a number of pathways, including the high pH and permeability of the infant's gut [142], [143] that enable molecules to be absorbed readily. Further, there are known adipokine receptors in the GI tract to which the molecules may bind [144]. Proteolysis of these components is less likely due to the infant's immature pancreatic function and the high protease inhibitor content of HM [145]. Paracellular diffusion that is enhanced in infancy is a further mechanism of absorption [146].

Hormones controlling appetite are synthesised primarily in adipocytes [147], but also in other cell types [148], [149]. In HM, appetite hormones such as insulin, leptin, ghrelin, and adiponectin, are thought to originate from the maternal bloodstream and from their endogenous production in the mammary epithelium [150], [151], [152]. Nevertheless, the relative contributions of these molecules to HM by the maternal circulation and mammary gland are unknown, and may indeed vary both within and between women. Maternal adiposity, which is influenced by the mother's diet, can influence the maternal serum and HM concentrations of some appetite hormones such as leptin [153]. However, no association has been found for other hormones controlling appetite such as adiponectin [154].

7.7 Metabolites

The current approach to biological research involves the study of whole system biology. Since the post-genomic era, research has focused on alterations in mammary gene expression at the RNA level (transcriptomics) and at the small molecule metabolite level (metabolomics), with the aim of gaining new insights and better understanding of the biological function of cells and organisms [155]. Metabolites that are less than 1.5 kDa in size are end products of cell function and metabolism [156]. Therefore, among the "omic" technologies, metabolomics (the study of metabolites) is suggested to provide the most "functional" information, reflecting the physiological, evolutionary and pathological state of a biological system. Changes in the transcriptome and proteome do not always result in biochemical phenotypes (the metabolome) [157].

Advancement in technology and techniques, including nuclear magnetic resonance (NMR), capillary electrophoresis (CE), gas chromatography (GC), and liquid chromatography (LC), have helped unravel the metabolome of various biofluids, such as urine, plasma, and serum [158]. However, it is only recently that attempts have been made to profile the HM metabolome. Marincola, et al. used proton NMR (^{1}H NMR) and GC-mass spectrometry (MS) to compare preterm HM with preterm formula. Statistical analysis showed distinct differences between HM and formula, with higher levels of oleic and linoleic acids measured in formula [159]. Different metabolic HM profiles between mothers of preterm infants with various gestational ages (23–25 weeks and ≥ 29 weeks) [160] and differences in HMOs in terms of secretors and non-secretors [161] have also been observed. Additionally, milk nucleotides, which play a significant role in encoding genetic information and signal transduction, have been detected using CE-MS in untreated and in pasteurised milk (either by heat or high pressure treatment) [162]. HMO profiles have been characterised using this technique in both HM and in faeces of breastfed infants [163].

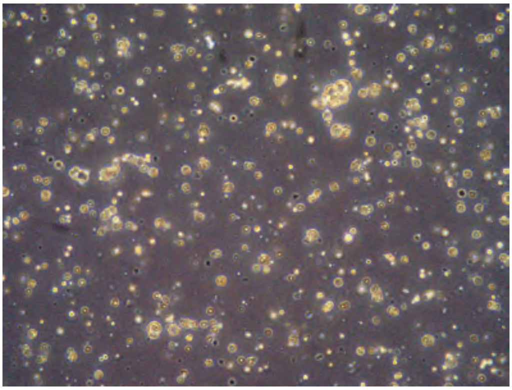
An extensive study of the HM metabolome was carried out following the development of a simple and quick extraction method for HM. This method used a small amount of HM (50 µL) only and enabled analysis with various instrument platforms (GC-MS and LC-MS) [164]. Based on this approach, hundreds of compounds from various compound classes (e.g., glycerolipids, sphingolipids, and carbohydrates) have been identified demonstrating the complementary nature of the HM profiling techniques. Another study employing various extraction solvents (chloroform/methanol and MTBE) and techniques for analysis (GC-MS, LC-MS, CE-MS, and ^{1}H NMR) demonstrated the metabolite complexity of HM, identifying more than 700 compounds in term milk [165]. However, given the complexity of the HM metabolome, metabolomic profiling of HM and the effects of HM metabolites on the infant are still in their early stages.

Various factors such as time of collection (particularly in relation to feeding), stage of lactation, and maternal diet can influence the metabolomic composition of HM. These factors not only make analysis challenging, but are also difficult to control or standardise. Other interactions between the mother and the infant, such as gut microbiome and glycan digestion by microbes, can also greatly influence dyad health and require further investigation [166], [167]. Metabolomics analysis combined with other 'omics' technologies will provide valuable insight into the functional capacity of human lactation as an entire biological system.

7.8 New Discoveries

7.8.1 Cells

For over a century, scientists have known that milk is a cellular fluid, containing various maternal cells that appeared to be primarily of epithelial and immune origin [168], [169], [170] ▶ **Fig. 7.1**. More recent studies harnessing modern analytical technologies, such as singe-cell and gene expression analyses, have revealed a diverse cellular composition in HM. These range from an epithelial cell hierarchy reflecting the lactating breast (i.e., stem cells, progenitor cells, more differentiated milk-secretory cells, and myoepithelial cells) to immune cells originating from maternal blood that protect the breast and infant [171], [172], [173], [174], [175].



▶ **Fig. 7.1** Freshly isolated human milk cells stained with Trypan Blue for cell viability. Cells stained dark blue indicate dead or dying cells.

Numerous maternal and infant factors are known to influence the cellular content of HM, including (a) breast fullness; (b) stage of lactation; (c) health of the mother and infant; and (d) developmental status of breast epithelium [176], [172], [175], [174], [177]. In addition to environmental influences and normal biological variation both within and between women and other mammals, methodological differences between studies and use of non-specific marker technologies have introduced variation in the reported proportions of the different cell types in HM [180]. While mature HM (after the first two weeks postpartum) is dominated by epithelial cells, colostrum contains high proportions of immune cells in accordance with the needs of the immunologically immature newborn [172]. Numbers of immune cells also greatly increase during lactation in response to mother and/or infant infections, providing specific protection of both breast and infant when needed [175]. Further, HM and other species' milks have been shown to be rich sources of stem cells, which are viable, survive in the infant's GI tract and integrate into different tissues, potentially exerting different functions [173].

Different Perspectives

Stem cells in breast milk

Until recently, stem cells were thought to be present only deep within tissues, away from external chemical influences, to preserve their identity and function. Indeed, except for in the embryo, stem cells are found in postnatal organs, with the specific role of tissue repair and regeneration during life. However, stem cells have also been found in body fluids, including the blood, saliva, urine, and milk [179], [30], [180], [181]. Particularly in HM, a cellular hierarchy has been described. This includes early-stage stem cells that are capable of self-renewal and differentiation into cells from all three germ layers, and their breast-derived progeny. The latter are more differentiated epithelial cells, such as lactocytes (milk-secretory cells) and myoepithelial cells [181], [172], [173]. These HM stem cells and their progeny provide a novel non-invasively-accessed source of lactating breast epithelial cells, opening new avenues for investigation of the biology of the human lactating breast and associated pathologies such as low milk supply.

Milk stem cells have been shown to display non-tumorigenic multilineage differentiation properties in vitro. This means that they have the capability of turning into various cell types in culture, such as breast cells that produce milk components, and brain, liver, pancreatic, bone, joint, and heart cells [181]. They also survive in the GI tract of the offspring in vivo [182]. Recent studies in a mouse model demonstrated numerous milk-derived stem cells present intact in the stomach as well as in the thymus, liver, pancreas, kidneys, spleen, and brain of nursing pups. There, they appeared to self-renew, differentiate into tissue-specific cells, and integrate into different organs, potentially contributing to function [182]. They were also detected in the pups' blood at levels up to 1.2% of total cells both during and after the nursing period, and into adulthood. This phenomenon of transfer and integration of allogeneic cells into host tissues (in this case from mother to offspring) is called microchimaerism and is known also to occur from mother to foetus and vice versa during pregnancy [183], [184]. The functional significance of microchimaerism between mother and offspring in utero and via breastfeeding has not been established. However, developmental roles are proposed for cells that are actively transferred to the host, remain alive, integrate in host tissue, and maintained in host tissue to adulthood. Similarly, milk-derived immune cells have been shown to survive in the GI tract of nursed offspring and migrate to different organs, where they provide immunological support early in life [185], [186].

Protective cells in breast milk

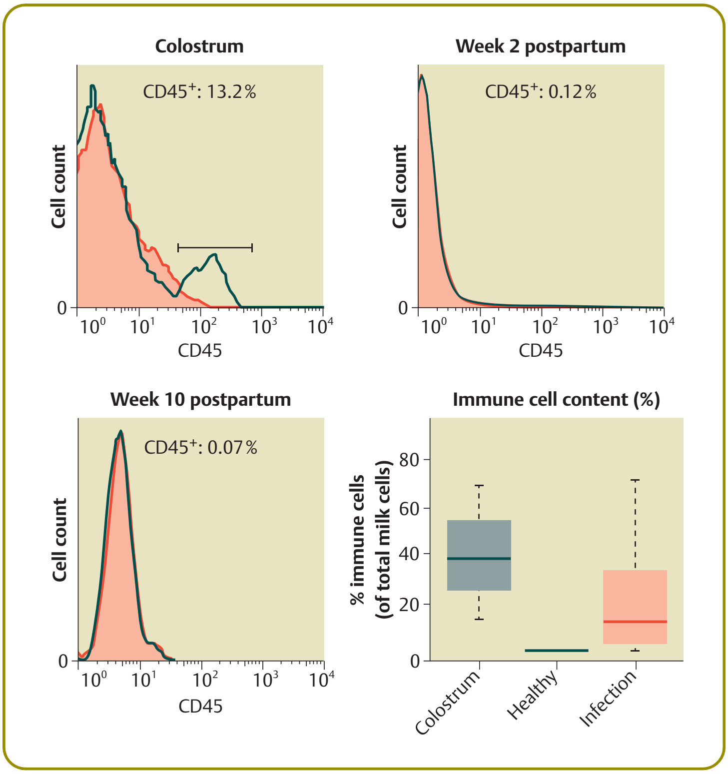
The immunological protection the mother provides to the foetus in utero, together with beneficial microbiota, developmental signals, and nutrients, continues postnatally during breastfeeding. Numerous studies have demonstrated the lower risk of disease and infection in both the short and long term conferred by breastfeeding, with significant reductions in infant and child mortality [187], [188], [189]. These effects are related to HM immunomodulatory biomolecules, such as sIgA, lactoferrin, α-lactalbumin, oligosaccharides, and cytokines. They are also related to immunocompetent cells that originate from the maternal circulation and comprise an important HM component that acts synergistically with immunomodulatory biomolecules.

HM delivers thousands to billions of viable immune cells to the infant daily [175], [174]. Recent studies using modern state-of-the-art techniques such as flow cytometry, which enables accurate marker-specific (not morphological only) single cell analysis, have shown that immune cells are not dominant in mature HM as previously thought. Compared with mature HM, HM immune cell content is significantly higher in the first few days postpartum [175]. This concurs with a time when the infant is particularly susceptible to infections, since its own immune system is still immature [190], with immune cells often comprising the majority of HM cells. However, by week 2 after birth, the HM immune cell content drops to approximately 1–2.5% of total cells. This low proportion is maintained throughout lactation except for periods of infection of the mother, the infant, or both [175]. Yet, this small proportion of immune cells corresponds to the high numbers of immune cells ingested daily by the infant in HM (range approximately 94,000–351,000,000 [175]). These immune cells include those typically found in blood (monocytes, macrophages, granulocytes, T- and B-lymphocytes), with monocytes usually dominating the immune cell component of HM.

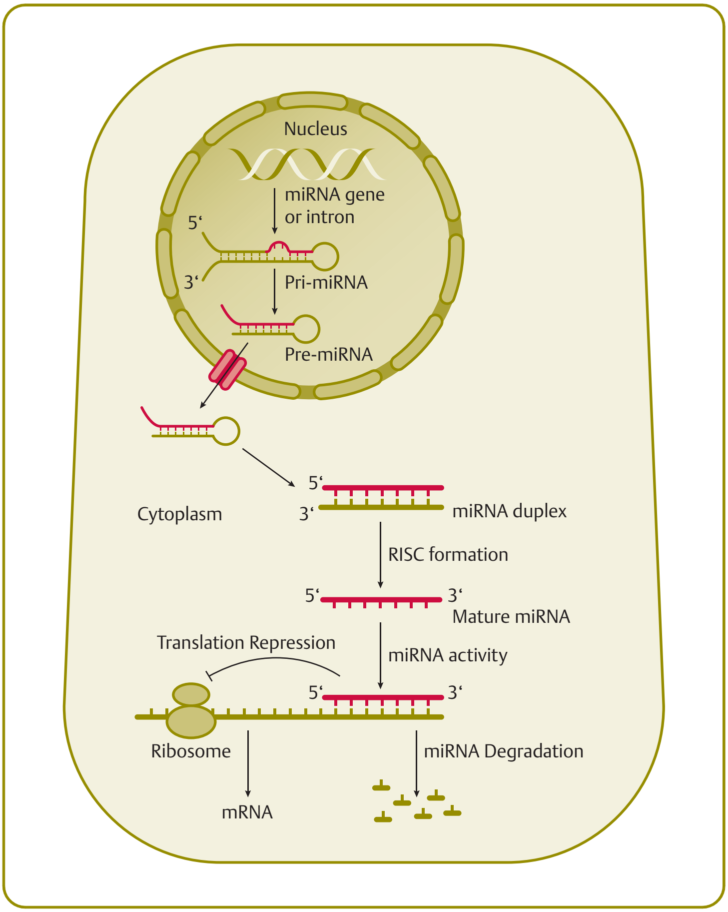
However, infection can alter both the total number of immune cells in HM and the proportions of the different subtypes. During a breast, another organ, or systemic infection, immune cells rapidly increase in HM, reflecting the specific infection and its severity [175], [174] (► **Fig. 7.2**). Upon recovery, HM immune cells then return to normal baseline levels characteristic of the mother-infant dyad. This rapid immune cell response of HM has been shown to be more consistent and dynamic than the response of humoral HM factors. Thus, it could be used to monitor treatment response of a lactating mother, which could prove to be particularly useful in the treatment and management of mastitis [175]. Remarkably, HM responds not only to infections of the mother, but also of the infant, even when the mother is asymptomatic [174], [177], [191]. The backwards flow of milk during milk ejection has been proposed to facilitate this immune cell response, providing specific immunity to the infant's infection and immunological protection related to the infant's needs [174]. Indeed, HM immune cells similar to stem cells survive in the GI tract of the offspring and migrate into different tissues, supporting their role in boosting infant immunity early in life [175], [185], [186].

7.8.2 MicroRNA

Infant immunity is not only boosted by immunocompetent immune cells and molecules such as immunoglobulins, lactoferrin, and lysozyme in HM, but also by small RNA molecules called microRNAs (miRNAs). These are non-coding long RNAs containing about 22 nucleotides. They are abundant in tissues, organs, and body fluids, such as plasma, urine, saliva, seminal fluid, tears, cerebrospinal fluid, and in milk [192] (► **Fig. 7.3**). They are known to play key roles in regulating gene expression at the post-transcriptional level, and are involved in all major biological processes, including cell differentiation, cell cycle, apoptosis, immunity, and development, and in disease [193],



► **Fig. 7.2** Changes in HM immune cell ($CD45^+$) content from colostrum to week 10 postpartum, and between HM samples collected from healthy and infected mother-infant dyads. Maternal and infant infections stimulate a rapid leukocyte response in breast milk. (Modified from Hassiotou, et al. Clin Translat Immunol 2013; 2: e3.)



▶ **Fig. 7.3** The current model of miRNA biogenesis and the proposed model of gene expression regulation. RNA polymerase II/III processes primary miRNA (pri-miRNA) from either independent specific genes (miRNA genes) or from introns (protein-coding genes). Inside the nucleus, precursor miRNA (pre-miRNA) is processed from pri-miRNA by the Drosha–DGCR8 complex. Then, pre-miRNA is transported to the cytoplasm by Exportin 5, where Dicer processes the miRNA duplex. Only one strand of the miRNA duplex (called mature miRNA) is attached to the RNA-induced silencing complex (RISC), which can bind its target (mRNA) for either translation repression or mRNA.

[194]. Since their discovery in HM and other species' milks, very little has been done to address their origin, levels, properties, function in the lactating breast, and fate in the breastfed infant. What recent studies have clearly shown is that the miRNA composition of HM is mother-infant dyad specific [195], similar to that previously reported for other HM components, such as HMOs.

To date, 2,588 mature miRNAs are known to be present in humans (miRBase version 21.0, release 2014) [196], of which more than half have been found in HM [195]. In addition to these known miRNA species, thousands of novel miRNA species have been recently identified in different fractions of HM. The cell fraction of HM has been shown to be one of the richest sources of miRNA, followed by miRNA embedded within the milk fat globule [195], [197]. In milk, in particular HM, miRNAs are present in all major fractions, including cells, lipids, and skim milk, and protected within microvesicles such as exosomes [195]. Their specific 'packaging', along with the infant's more alkaline stomach pH [198] and higher gut permeability compared to the adult [143], contributes to HM miRNA survival in the breastfed infant, their absorption into the bloodstream, and transfer to various organs where they may exert immunomodulatory and developmental functions [195].

Indeed, recent small RNA sequencing studies in different HM fractions have revealed that known and novel miRNA molecules are abundant in HM and are key regulators of immune responses, body fluid balance, thirst, appetite, and system development, including the neural and immune systems.

As such, a functional significance for miRNAs is suggested in the infant [195]. Further, study of the uptake of exogenous food- and bovine milk-derived miRNAs in the adult GI tract has indicated high stability (in contrast to messenger RNAs), even in the adult gut, uptake into the blood, and function in specific organs such as the liver [199], [200], [201], [202], [203], [204].

Recently optimised methodology to extract miRNAs from different HM fractions has emphasised the importance of standardisation and optimisation of milk collection, storage, and processing for comparative miRNA studies [195], [199]. Particularly for studies investigating the miRNA content of different milk fractions, milk fractionation prior to freezing (instead of storing whole milk) ensures that the miRNA content integrity of each milk fraction is maintained and cross-contamination between fractions during freezing is avoided [195]. Moreover, each milk fraction requires a slightly different procedure for optimal miRNA extraction. The filter column-based extraction method provides better miRNA yields and quality compared to other published methods such as those based on phenol/chloroform [197]. These optimisation studies provide a basis for more comprehensive miRNA profiling analyses of HM and other species' milks.

Although factors that may influence HM miRNA content and composition are not well established, studies have recently shown that milk removal during breastfeeding and lactation stage can affect the HM composition with regard to miRNAs. Postfeed milk is known to contain more cells than prefeed milk [5], and post feed milk cells were shown to contain more miRNAs, some of which were upregulated post-feeding [205]. Many of the upregulated miRNAs were associated with the synthesis of milk components, reflecting changes occurring in the mammary gland in response to milk removal by the infant. In addition to these short-term changes, long-term changes in HM miRNA composition with lactation have also been demonstrated. In a study examining the HM miRNA profile in the first six months of lactation, approximately one third of miRNAs were differentially regulated. This was despite similar expression of 70% of commonly identified miRNAs in milk cells and lipids. Most changes occurred around month 4 of lactation, during the transition from exclusive to non-exclusive breastfeeding [206]. Further studies are required to determine the dynamic short- and long-term changes in HM miRNA content, and how these can be used to improve understanding and assessment of lactating breast function and the diverse roles of HM in the infant.

7.9 What Does the Future Hold?

Among the different HM components with bioactivity in the infant, cells, miRNAs, and metabolites can be used as novel diagnostic markers of lactating breast health status and performance. For example, in a recent gene expression study in stem and other cells of the lactating breast accessed via HM, differences in breast epithelium maturation between mothers who gave birth at term and preterm, and between obese and non-obese mothers were identified [207]. These findings provide a potential molecular explanation for the low milk supply that is often seen in mothers giving birth preterm and who are obese. Thus, gene expression analyses of HM cell content could potentially be used as an indirect indicator of breast maturation and in the management of low milk supply [207], [178].

Moreover, recent miRNA studies in the mammary gland and HM have identified miRNA candidates as potential biomarkers of lactation performance. In addition to their involvement in mammary gland development [208], [209], the types and expression levels of miRNAs differ distinctly between lactating and non-lactating mammary glands [210]. More specifically, miR-29 s were found to regulate important lactation-related genes in mammary epithelial cells in the dairy cow, while decreased miR-29 s expression was associated with reductions in lactoprotein, triglycerides, and lactose [211]. Further, miRNAs of the lactating gland accessed via HM have been shown to originate primarily from the lactating epithelium [195], and to be involved in the synthesis and regulation of milk nutritional components (e.g., lactose, triacylglycerol, fatty acids, growth hormone, and insulin receptor) in immune responses and in development [195]. These findings make HM miRNAs attractive targets for diagnostic studies of lactating breast function.

Milk miRNAs have been shown to respond to infections of the lactating udder in the cow [212], [213], implicating their involvement in dynamic immune responses to gland infections. In addition to milk miRNAs, the rapid HM immune cell response to breast infection could provide a novel means to assess mothers' response to treatment. More specifically, mastitis is a serious infection of the lactating breast that causes pain, inflammation, and irritation, symptoms that often persist and result in premature cessation of breastfeeding. HM immune cell profiles specifically change during mastitis; they continue to change while the inflammation is resolving [174], providing an easily assessable marker to monitor infection, facilitating early and effective intervention, and enabling continuation of breastfeeding.

A better understanding of factors that influence HM composition can open new avenues for specialised patient-specific treatment of fragile infants, such as those born preterm, or with specific genetic conditions or deficiencies. For example, it is still not well understood how the maternal diet affects HM composition, with effects on fatty acids being reported. Moreover, physicians can take advantage of the dynamic composition of HM to boost growth and development of preterm infants. It is long known, for example, that post-feed (hind) milk is significantly richer in fat than pre-feed (fore) milk. Selective feeding of the preterm infant with post-feed milk may confer developmental benefits, and requires further investigation. In addition, new understanding of the importance of the HM microbiome in infant gut and immune system development, and its specificity for a given mother-infant dyad, has triggered investigations of refaunating donor HM with mothers' own milk [214].

Over the years, it has become clear that different HM fractions (cells, lipids, and skim milk) have different properties and contain different components, each contributing unique and important functions in the infant. It is therefore important to maintain the functional integrity of these components when expressed milk is provided to the infant. This is better achieved when HM is given fresh (not previously frozen or processed) to the infant. In susceptible infants such as those born preterm, frozen and pasteurised milk has been typically administered in neonatal intensive care units (NICUs) due to organisational constraints and safety concerns. Yet, in more recent years, some NICUs around the world are exclusively providing fresh, unfrozen, unpasteurised mother's own milk to preterm infants, with positive outcomes. This practice ensures provision of live cells, stem cells, and protective immune cells to the infant, which otherwise would be excluded from their diet. Additionally, miRNAs with potential important regulatory, immunoprotective, and developmental functions are present in HM cells and other components.

Further investigation of the benefits and safety of providing fresh, unfrozen, and unpasteurised HM to preterm infants is needed to address the effects of withdrawing such HM components from the preterm infant diet. This is particularly important as they could potentially improve infant development, provide additional immunoprotection, and reduce infection, death, and hospitalisation times [178]. Indeed, animal studies have shown that breastfeeding confers significant protective functions against necrotising enterocolitis [215], which could be mediated by HM stem cells, immune cells, and other HM components [178].

Further to the preterm infant, HM stem cells may provide medical benefits for infants with genetic diseases or life-threatening conditions and adults [172]. Regenerative medicine is a rapidly developing field that is researching the therapeutic application of the properties of stem cells with multilineage potential. With the recent discovery of induced pluripotent stem cells (iPSCs), i.e., somatic cells that are artificially modified at the gene expression level to display stem cell properties, new horizons have opened for their transplantation into diseased host tissues to facilitate tissue regeneration and restore function [216], [217].

However, many barriers still remain before the iPSC technology can be routinely and safely implemented in the clinical setting. This includes producing genetically identical cells that maintain pluripotency over multiple passages, and that can be reliably differentiated in vitro and in vivo and transplanted into the patient without the risk of cancer or teratoma formation [218]. Immunogenicity of iPSCs (even with syngeneic cell transplants), incomplete iPSC transformation and differentiation, and retained epigenetic memory of transformed cells are still major issues that need to be addressed before iPSC technology can be realistically considered for clinical research [219], [220], [221]. The main current advantages of iPSC technology relate to informing laboratory research, rather than to clinical use. More recently, it has become apparent that studies in pluripotent cells with potential clinical promise need not be limited to iPSCs; stem cells with pluripotent features exist in the adult body, typically providing regeneration/repair cues and facilitating homeostasis in tissues with a high cell turnover. Among these are HM stem cells that possess pluripotent features, non-tumorigenic characteristics, and a natural survival, integration, and tolerance in the offspring. Together, this suggests that they may prove to be excellent candidates for stem cell therapies in infants and/or adults [173].

Human milk is one of the most complex live biofluids in existence, offering a myriad of benefits for both mother and infant. A multitude of molecules in HM are only just being identified and their functions elucidated. Greater knowledge will open up the possibility of manipulation of HM components that are critical for the most fragile infants. It will enable the field of lactation diagnostics to develop, providing a much-needed service for lactating women experiencing breastfeeding dysfunction and breast pathologies. Recent research has indicated that human milk also offers the promise of new therapeutic applications for humanity in the future.

Key Points

- Human milk contains macronutrients, micronutrients, bioactive molecules, cells, and microbiota, making it a living fluid that readily adapts to individual infant needs and provides nutrition, protection, and developmental signals for the infant
- Colostrum albeit low in quantity is highly valuable as it delivers a concentrated dose of immune and bioactive factors that protect the newborn infant in its initial days of life
- Fresh mother's own milk is recommended whenever possible because freezing or pasteurising, will destroy its bioactive components resulting in some loss of benefits
- Human milk is one of the most complex biofluids in existence and is optimally adapted within each mother/infant dyad thus cannot be reproduced in bovine derived formula

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8 The Psychological Effects of Breastfeeding

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Expected Key Learning Outcomes
- The importance of breastfeeding for mother and infant well-being
- The psychological impact of breastfeeding on the mother and her infant
- The influences on a mother's decision to breastfeed

8.1 Introduction

Breastfeeding confers a plethora of psychological benefits to both mothers and their infants. However, while breast milk is widely appreciated as the ideal nutritional source for developing infants, the psychological benefits of breastfeeding are often overlooked. Expectant mothers are besieged with opinions and facts related to the costs and benefits of breastfeeding. Most of this information pertains to infant health, leaving mothers unaware of the potential psychological benefits of breastfeeding. Studies show that women are generally aware that breastfeeding carries potential advantages for their infant's intelligence and immune functioning, but unaware that it dampens the maternal stress response and doubles the amount of slow wave sleep that mothers enjoy [1], [2]. Ironically, breastfeeding is also perceived as an onerous sacrifice undertaken by mothers to nurture their children, whereas the emerging science highlights ways in which breastfeeding aids new mothers in meeting parenting challenges.

Herein, emerging insights from experimental, epidemiological, and comparative research are highlighted to provide an evidence-based overview of the effects of breastfeeding on mothers. Additionally, some of the psychological impacts of breastfeeding for infants and mother-infant dyads, and the significant cultural and psychological impediments to breastfeeding are addressed and proposals made to surmount these obstacles.

The chapter starts with a brief overview of how hormones broadly shape maternal psychology during breastfeeding. The next sections focus on the mother, reviewing what is known about how breastfeeding impacts maternal stress regulation, postpartum depression risk, bonding, sensitivity to infant cues, sleep disturbances, and defence of the infant. This is followed by a review of the effects of breastfeeding on infant psychology, covering topics ranging from infant attachment to maternal programming of infant temperament through bioactive hormones in mothers' milk. Moving the focus back to the mother, some of the psychological barriers to breastfeeding, such as cultural taboos about public lactation, partner opposition to breastfeeding, postpartum depression, and maternal guilt at breastfeeding "failures", are discussed. We conclude with a summary of the psychological benefits that breastfeeding can and cannot offer mothers and their babies.

8.2 Psychological Implications for Mothers

8.2.1 Oxytocin and Prolactin

The hormonal and biological changes during lactation mediate many of the benefits of breastfeeding for mothers. Lactation is a biologically unique period in the female lifespan, characterised by hormonal shifts, suppression of reproductive function, and changes in metabolic processes. The two most important hormones associated with lactation are oxytocin and prolactin. Oxytocin facilitates smooth muscle contractions during labour and enables the release of milk during lactation. Prolactin is primarily responsible for the production of breast milk. Prolactin levels gradually rise over the course of pregnancy, eliciting changes in breast tissue that stimulate milk production. Oxytocin levels also rise, eventually quadrupling to stimulate labour [3]. After birth, prior to breastfeeding, oxytocin aids milk ejection [4].

A mother's body appears evolved to take infant stimuli as cues to release oxytocin in anticipation of feeding, as mothers who have been separated from their infants prior to feeding do not display this anticipatory oxytocin release [5]. As the nipple receives tactile stimulation during feeding, oxytocin and prolactin are released in pulses controlled by nerve fibres linked to the hypothalamus [6]. Relative to non-breastfeeding women, breastfeeders typically display higher prolactin levels, indicating that prolactin levels are modulated by breastfeeding frequency and infant demand for milk [7]. Oxytocin levels remain elevated for a short time after each breastfeeding session but return to baseline relatively quickly [6].

Although oxytocin and prolactin are widely appreciated as key biological mediators of birth and lactation, researchers are now beginning to understand the significance of these hormones for maternal psychology and behaviour. Oxytocin and prolactin circulate within the brain, activating specialised receptors across diverse brain regions, and hence should be expected to influence mental as well as physical outcomes [8], [6]. Indeed, comparative studies in nonhuman animals point to the contributions of oxytocin and prolactin in critical maternal behaviours such as grooming, defensive aggression, and sensitivity to infant cues [8], [6]. As such, there are strong grounds to expect them to also influence human maternal thoughts, feelings, and actions.

8.2.2 Maternal Bonding

Mother-infant bonding is one of the chief motives to breastfeed reported by women [9]. The same sentiment is often echoed within the scientific literature, where breastfeeding is frequently assumed to foster maternal bonding (e.g., [10]). Despite this, strikingly few studies have actually investigated this question. In this section, the modest literature on lactation and mother-infant bonding is discussed, with an emphasis on animal studies in light of the dearth of human studies. This section focuses on maternal bonding, while subsequent sections focus on the effects of breastfeeding on infant attachment to the mother.

Across mammalian species, lactation has been found to be critical for eliciting maternal behaviour because it triggers release of oxytocin and prolactin [11]. Upon injection of oxytocin [12] or prolactin [13] into the brain, female rats exhibit maternal behaviours. Conversely, maternal behaviours are significantly reduced if oxytocin or prolactin blocking agents are injected into the rat brain shortly after giving birth [14], [15]. However, lactation-induced hormonal shifts appear less crucial for instigating maternal behaviours in nonhuman primates, in whom early developmental and social experience make larger contributions [16]. Similarly, in Rhesus monkeys, oxytocin antagonists introduced into the brain impair certain maternal behaviours, yet leave others intact [17].

Many observations in non-human primates indicate that maternal behaviours can emerge without lactation, as in cases where females without offspring of their own carry and groom infants [18]. In humans, breastfeeding is unnecessary to establish maternal bonding, as attested by the exceptional caregiving shown by formula-feeding mothers, fathers, adoptive parents, and extended family. However, it may be hypothesised that lactation enhances certain caregiving behaviours, particularly in challenging circumstances.

Studies in humans demonstrate that oxytocin facilitates maternal bonding. Plasma oxytocin levels measured during both pregnancy and postpartum are predictive of behaviours related to maternal bonding, including maternal vocalisations, feelings of positive affect, eye gaze directed at infants, affectionate infant touching, and attachment-related ideation [19]. Furthermore, mothers who engage in more frequent (compared to less frequent) affectionate touching while playing with their children have elevated oxytocin levels [20]. These findings suggest that breastfeeding may intensify positive maternal behaviours to the extent that lactation stimulates bursts of oxytocin. Indeed, of five studies that test whether breastfeeding promotes maternal bonding, four have found some supportive evidence (see Martone & Nash 1988 for a null result [21]).

Else-Quest and colleagues observed mother-infant interactions at 4 and 12 months after giving birth, and found that breastfeeders showed more positive and rich mother-infant interactions at 12 months (but not at 4 months) than mothers who never initiated breastfeeding [22]. In another study, mothers who provided more than half of their infant's nutrition via breast milk for the first 5 months after birth reported greater levels of emotional bonding with their babies in comparison to mothers who provided less than half of their infant's nutritional needs via breastfeeding, or who did not breastfeed at all [23]. Additionally, mothers who were not breastfeeding at 3 months following birth reported less sensitivity to their babies' needs than women who were breastfeeding up to that time [24]. Recently, Jonas and colleagues found that women who were breastfeeding at 3 months were rated by independent observers as more sensitive to their infant's needs during a 30-minute infant interaction at 6 months than mothers who were not breastfeeding at 3 months [25]. Interestingly, the association between breastfeeding and heightened maternal sensitivity was only observed in mothers who reported a high level of psychological stress. Mothers who reported very little psychological stress exhibited a high level of maternal sensitivity regardless of their breastfeeding behaviours at 3 months. These results raise the intriguing possibility that breastfeeding may be especially important in facilitating maternal sensitivity when mothers are facing stressors, which can undermine parenting behaviours.

While consistent with the hypothesis that breastfeeding facilitates maternal bonding and caregiving, the above findings warrant caution as few studies corroborate maternal behaviour with objective observations. In addition, it may be the case that mothers who elect to breastfeed are dispositionally more attuned to their infants or are more prone to self-report greater sensitivity. Consistent with these alternative interpretations, studies have shown that mothers who expressed the intention to breastfeed during their pregnancies also reported greater maternal sensitivity at 3 months [24], and that willingness to breastfeed is correlated with the strength of the mother-infant bond. For example, the quality of mother-infant bonding behaviour observed 2 days after giving birth has been found to predict exclusive breastfeeding at 6 months after birth [27]. It is also important to consider that, although there may be benefits of breastfeeding for maternal sensitivity, mothers who had never breastfed in the above studies exhibited levels of maternal sensitivity that were well within the normal clinical range [22]. Thus, the question is not whether breastfeeding is necessary, but whether it is helpful, especially under conditions of maternal stress.

To summarise, existing evidence provides limited support for the hypothesis that breastfeeding promotes maternal bonding. Prospective or experimental studies, as well as objective measures of maternal bonding, should be employed to resolve this important question.

8.2.3 Maternal Stress Regulation

Caring for an infant can be intensely stressful, with maternal stressors ranging from psychosocial preoccupations with being a "good" mother [28] to physical challenges such as sexual dysfunction and sleep deprivation [29]. New mothers find themselves responsible not only for their baby's welfare, but also for the simultaneous demands of partners, other children, themselves, and career needs [30]. Although often offset by the intrinsic rewards of parenting, mothers also appear to experience sustained, heightened vigilance toward potential hazards to their children, which is related to activation of neurobiological stress systems [31]. In light of the demands of parenting, it is of little surprise that about 20% of new mothers report depressive symptoms within the first year after giving birth [32]. Fortunately, nature may have crafted breastfeeding to help manage this stressful period [33], [34].

Converging lines of evidence indicate that breastfeeding modulates maternal stress responses [34], [35], [36]. Initial evidence derived from rodent studies showed that lactating rats were remarkably resistant to stress relative to non-lactating rats, as measured by reduced hormonal and cardiovascular signs of anxiety in response to electric shocks, frightening predators, or complex mazes [37].

Human studies have found comparable negative associations between breastfeeding and stress. Breastfeeding human mothers exhibit significantly diminished hormonal stress responses (i.e., lower cortisol and adrenocorticotrophic hormone levels) during stressful physical exertion compared with non-breastfeeding mothers or women who have never given birth [38].

Subsequent studies have examined cardiovascular and hormonal stress responses to the Trier Social Stress Task, in which the participant delivers a public speech and performs mental arithmetic in front of a critical audience. These investigations often fail to report lower stress reactivity using hormonal markers but repeatedly show lower cardiovascular stress reactions in breastfeeding mothers relative to formula-feeding mothers. Altemus and colleagues found that breastfeeders exhibited reduced markers of cardiovascular stress (e.g., higher cardiac parasympathetic control, lower basal systolic blood pressure [SBP]) during the Trier task when compared with formula-feeding mothers or women without children [39], and a complementary study reported similar cardiovascular benefits for breastfeeding mothers during the period of anxious anticipation prior to the social stress task [40]. Stress-attenuation related to breastfeeding may be particularly evident in the period immediately following a breastfeeding session, caused by the breastfeeding act rather than by simply holding one's infant. Indeed, mothers who breastfed before the Trier task were found to produce blunted hormonal cortisol responses relative to breastfeeding women who were instructed to hold their babies [41].

Beyond the social domain, the stress-attenuating benefits of lactation appear to generalise to other sorts of challenges. In a seminal study, cardiovascular reactions to hand immersion into painfully cold ice water were compared in exclusively breastfeeding women, exclusive formula-feeding women, women who used both breast milk and formula, and women who had never given birth [42]. Mothers who breastfed more frequently each day had reduced sympathetic reactivity in response to the painful water immersion task when compared with mothers who breastfed less frequently, suggesting a dose-dependent relationship between breastfeeding and stress reduction. Interestingly, the stress-reduction benefits of lactation decreased with time: Breastfeeders with children older than 1 year appeared to derive less stress-attenuation when compared with breastfeeders of younger children. This suggests that the beneficial effects of breastfeeding for mothers track the period of greatest child vulnerability and dependency, potentially reflecting evolutionary design to help new mothers cope.

Additional research supports the theoretical benefits of breastfeeding with regard to everyday stress. Formula-feeding mothers report experiencing less positive mood states, less emotional equanimity, and greater anxiety than breastfeeders [43], [33], [44], [45], [41]. These differences withstand after statistically accounting for likely confounding factors such as maternal age, income, health behaviours, and employment status [46], [47], [48].

The reductions in stress associated with breastfeeding are theoretically driven by oxytocin and prolactin. However, although rodent studies provide robust experimental evidence that lactation-related stress-reduction is mediated by oxytocin [49], [50] and prolactin [51], [8], findings in humans are supportive but correlational. For example, higher plasma oxytocin and prolactin measured during the early postpartum period are predictive of reduced self-reported anxiety [52], [53], and breastfeeders who release higher levels of oxytocin in response to suckling have reduced cortisol levels [54]. Furthermore, breastfeeders with higher levels of oxytocin exhibit markedly reduced indications of stress when anticipating the Trier social stress task when compared with breastfeeders with lower levels of oxytocin [40].

In summary, both studies in humans and comparative studies of non-human animals indicate that physiological stress responses are buffered by lactation. These effects appear to be related to increases in the hormones oxytocin and prolactin, although direct evidence that these hormones mediate stress reduction in humans is sparse. In human mothers, the stress-attenuating benefits of lactation also seem to be most pronounced in the early postpartum period or immediately following individual feeding sessions. Cardiovascular assessments of sympathetic and parasympathetic nervous system activity reveal more consistent differences in stress reactivity between lactating women and control women than do assessments of hormones related to the hypothalamic-pituitary-adrenal axis (e.g., cortisol).

Arguably, the most straightforward measure of the effects of breastfeeding on stress, mood, and emotion derives from self-reports. Consistent with the biological data, breastfeeding mothers report experiencing less stress and negative affect in their daily lives when compared with formula-feeding mothers.

8.2.4 Maternal Coping Strategies

The postpartum period is characterised by severe sleep disturbance, constant efforts to understand infant's needs, and frequent concerns about the baby's safety and wellbeing. These challenges have been faced by lactating mammals for millions of years, and research suggests that, over generations, adaptations may have emerged to help breastfeeding mothers get better sleep, decipher infant cues, and defend their infants [55].

Breastfeeding mothers get twice the amount of slow wave sleep ("deep sleep") at night compared to formula-feeding mothers or women without children. In a study by Blyton, et al., the sleep patterns of 12 exclusively breastfeeding mothers were compared to 12 women without children and seven mothers who were bottle-feeding their infants [56]. Although the total amount of sleep time and time spent in rapid eye movement sleep were similar in all groups, breastfeeding mothers had an average of 182 minutes of slow wave sleep, more than twice that found in the control (86 minutes) and bottle-feeding mothers (63 minutes). There was a compensatory reduction in light non-rapid eye movement sleep in the breastfeeding group. The high circulating levels of prolactin in breastfeeding mothers was most likely responsible for their altered sleep pattern. The fact that breastfeeding promotes longer time in deep, slow wave sleep may be an adaptation to allows new mothers to cope with the frequent night waking caused by young infants.

Other studies suggest that, even though breastfeeding babies wake more frequently to feed because breast milk is digested more rapidly than formula, breastfeeding mothers get slightly more sleep on average than formula-feeding mothers, presumable because breastfed infants settle more quickly than formula fed infants [57].

Breastfeeding is also associated with increased sensitivity to infant cues. It is not known whether this heighted maternal sensitivity is mediated directly through breastfeeding hormones or because breastfeeding facilitates more frequent close contact between mothers and babies. Using functional MRI, the brains of 17 exclusively breastfeeding and exclusively formula-feeding mothers were monitored during exposure to cries from their own and unfamiliar infants [58]. In the first postpartum month, breastfeeding mothers showed greater activation in response to their own infants cry in brain regions implicated in maternal-infant bonding and empathy compared to formula-feeding mothers. Additionally, in a large, longitudinal study of 675 mother-infant pairs [59], mothers who breastfed for longer periods were more sensitive to infant cues of distress at 14 months than mothers who breastfed for shorter durations [59]. Enhanced sensitivity to infant cues by breastfeeding mothers in the early postpartum period could help them (especially new mothers) cope with understanding the needs of their infant. Additional research is needed to clarify the specific role that lactation plays in attuning the maternal brain to her child.

Evidence also suggests that lactation helps mothers defend their infants under attack. Many people are familiar with the adage 'don't come between a mamma bear and her cubs', although the saying 'don't come between a *lactating* mamma bear and her cubs' would be more accurate. Sometimes referred to as maternal defence, maternal aggression or lactation aggression, this period of heightened defensive aggression in mothers after birth is directed toward rival members of the same species (conspecifics) and predators, and typically follows the course of lactation [60]. Maternal defence has been documented in rats and mice [60], prairie voles [61], hamsters [62], lions [63], domestic cats [64], rabbits [65], squirrels [66], and domestic sheep [67]. Among primates, lactating Japanese and Rhesus Macaques display more aggression than females at any other reproductive stage [68], [69], [70].

To test whether lactating human mothers display heightened levels of aggression, women's willingness to deliver aversive sound bursts to a hostile female confederate was compared between breastfeeding, formula-feeding, and nulliparous women [71]. The comparison was made using a competitive game, where aggression was assessed by the combined volume and duration of sound bursts participants inflicted on the confederate who had previously delivered many loud sound blasts to all participants [72]. As predicted, breastfeeders inflicted significantly more aggressive retaliatory sound bursts than formula-feeding or nulliparous women.

In rats, lactation disinhibits aggressive behaviours toward potentially threatening conspecifics by triggering the release of stress-attenuating hormones (oxytocin and prolactin), which has been suggested to reduce mothers' fear during attack [73], [74]. Convergently, mothers with lower SBP (a proxy of less physiological stress) during an aggressive encounter tended to be more aggressive [71]. Breastfeeding mothers also had lower SBP during the encounter than the bottle-feeding or nulliparous groups, and less SBP reactivity to the encounter compared to baseline. Finally, the stress reducing properties of lactation were found to account for much of the heightened aggression observed in breastfeeding mothers, compared to the bottle-feeding or nulliparous women.

In sum, breastfeeding appears to increase mothers' willingness to react aggressively when they or their offspring are under threat. However, lactating mothers do not go looking for fights; lactation aggression likely operates only to promote defensive forms of aggression for protection.

8.2.5 Postpartum Depression

Postpartum depression afflicts approximately 13% of western mothers within the first 3 months after giving birth [75]; the global prevalence rate is unknown but appears to vary considerably across cultures [76]. Postpartum depression should not be confused with either the relatively short-lived postpartum mood disorders such as the 'postpartum blues', which affect between 50% and 80% of western mothers [77], [78], or the serious but rare disorder of postpartum psychosis [79]. Postpartum depression is characterised by feelings of hopelessness, despair, detachment, anxiety, and guilt. Postpartum depression can lead to long-term negative child outcomes with regard to cognitive, emotional, and behavioural development [80], as a result of disrupted parenting behaviours during the critical period of early development [81]. Given the beneficial effects of breastfeeding on stress regulation and maternal sensitivity, links between lactation and postpartum depression have been investigated.

Systematic reviews of the literature have identified numerous studies reporting higher rates of postpartum depression in formula-feeding mothers in comparison with breastfeeding mothers [82], [83]. Although these data support the premise that breastfeeding buffers against postpartum depression, further studies are needed to address causality – does weaning increase mothers' risk for depression or does depression cause mothers to wean? Breastfeeding mothers may be protected against postpartum depression but mothers with depression in pregnancy or early postpartum may be less likely to breastfeed. The former is discussed here, the latter under psychological barriers to breastfeeding.

There are sound reasons to expect breastfeeding to protect against postpartum depression. Breastfeeding triggers the release of oxytocin, and higher oxytocin levels have been found in mothers without depression than in those with depression [84]. Consistent with the notion that momentary increases in oxytocin triggered by breastfeeding might suppress negative affect, mothers who feed their infants both breast milk and formula self-report lower levels of negative mood immediately following breastfeeding than after formula feeding [48]. Regardless of whether these benefits are mediated by oxytocin, breastfeeding is robustly associated with reduced stress [36], which is one of the biggest risk factors for postpartum depression [85]. Also, infants with health concerns can constitute a significant source of stress, and formula-fed infants tend to have greater health problems over the long term [86]. Thus, the ill effects of formula-feeding on infant health may indirectly increase maternal stress, and the related risk of postpartum depression.

Some of the strongest evidence suggesting that breastfeeding is protective against postpartum depression comes from a study of 205 mothers who were asked about depressive symptoms prenatally, and about their breastfeeding behaviours and depressive symptoms repeatedly up to 24 months after giving birth [87]. Mothers who breastfed more times per day at 3 months postpartum had greater reductions in depressive symptoms than women who breastfed fewer times per day at 3 months, even after prenatal depressive symptoms were taken into account. The study suggests that there is a dose-response relationship, whereby a larger degree of early breastfeeding provides a larger degree of protection against latter depressive symptoms. Other studies have found similar protective effects of breastfeeding against subsequent depressive symptoms [83]. Early weaning [23] and never initiating breastfeeding [88], [89] have both been found to predict the onset of postpartum depression. However, duration of breastfeeding is likely important, one prospective study found no association between breastfeeding behaviour at 1 week and subsequent depressive symptoms at 4 and 8 weeks postpartum [90].

In summary, current research suggests that breastfeeding may be protective against postpartum depression but experimental studies are necessary to establish causality and investigate potential mediators of this association. However, as discussed later in this chapter, depression in pregnancy or in the early postpartum can be a barrier to breastfeeding. The relationship between breastfeeding and postpartum depression is therefore complex and bidirectional. Ironically, the women who would benefit most from the antidepressant actions of breastfeeding (i.e., those depressed during pregnancy) are less likely to both initiate and maintain breastfeeding.

8.3 Psychological Impacts of Breastfeeding on the Infant

8.3.1 Attachment

Breastfeeding provides much more than just good nutrition for the developing infant. It provides direct skin-to-skin contact between mother and child, encourages early maternal-child social exchanges, and triggers the infant's natural sucking reflex, calming the infant. For all these reasons, scientists have posited that breastfeeding facilitates the child's attachment to the mother. Surprisingly few studies have investigated the impact of breastfeeding on infant attachment, and those that have tend to find no long-term effect of breastfeeding [10]. In a study of 152 mother-infant pairs examining the association between breastfeeding initiation/duration and the quality of 12-month-old infants' attachment to their mother, breastfed infants were no more likely to be securely attached to their mothers than formula-fed infants [24]. This is perhaps not surprising, given that it is important for human infants to form attachments with many caregivers (fathers, grandparents, etc.) who do not provide breast milk. However, this is not to say that breastfeeding is unimportant to the mother-infant relationship; the study also showed that breastfeeding mothers were more sensitive to their infant's cues than were formula-feeding mothers.

Research suggests that breastfeeding may accelerate development of the infant's preference for and recognition of their mother. In a series of studies, 2-week-old breastfed babies were compared with bottle-fed babies in their preference for the smell of their own mother over that of unrelated breastfeeding women [91]. Babies were exposed simultaneously to two gauze pads placed on either side of their heads, one of which had been worn under the arm of their mother for 8 hours, while the other was worn by an unfamiliar breastfeeding female. Breastfed babies were more likely to orient their bodies towards the scent of their own mother, whereas formula-fed babies showed no preference, suggesting earlier recognition of their mother's scent by breastfed babies. The authors hypothesised that breastfeeding facilitates more maternal-infant skin-to-skin contact than bottle-feeding, which may give breastfed babies increased exposure to their mother's unique olfactory cues and speed their preference for their mothers over other caregivers.

8.3.2 Temperament

The relationship between breastfeeding and infant temperament is complex, and the evidence is contradictory. A cross-sectional study of 655 infants aged 6–24 months found higher levels of socio-emotional development (a composite of measures related to self-regulation, ability to communicate needs, and establishing social relationships) in exclusively breastfed compared to exclusively formula-fed infants, according to maternal reports [92]. Another study, however, found that breastfeeding mothers reported that their infants were more demanding, cried more often, and smiled less often than formula-feeding mothers [93]. Reports by breastfeeding mothers of their babies having more difficult temperaments may be because of the greater vigour and intensity of reactivity observed in breastfed infants [94], resulting from the superior nutritional content of breast milk and more rapid weight gain of breastfed compared to formula-fed infants. Alternatively, it may be because breast milk is digested more quickly than formula and milk volume is regulated by infant suckling [93], causing breastfed infants to exhibit more cues of hunger to initiate feeding than formula-fed infants. A large longitudinal study of 30,466 Norwegian mothers found negligible effects of breastfeeding on later temperament or difficult temperament on later breastfeeding [95].

Although the literature to date does not show any lasting association between breastfeeding and infant temperament, prospective evidence suggests that breastfeeding may offer children some long-term protection against mental health disorders. Oddy and colleagues followed 2,900 infants from birth to 14 years of age, noting obstetric risk factors for mental illness (preterm birth, advanced maternal age), exposure to early life stressors, mother's mental health status postpartum, and changing family composition and income [96]. After accounting for these confounding variables, children that had been breastfed for more than 6 months were less likely to experience internalising mental health problems (e.g., being withdrawn, anxious/depressed, or having somatic complaints) and externalising mental health problems (delinquent or aggressive behaviour) at 14 years old, than children that had been breastfed for fewer than 6 months.

Additionally, emerging research suggests that exposures to bioactive hormones through breast milk may shape infant temperament. Breast milk contains a number of hormones that may program infant psychological development [97], [98]. As such, lactation may be regarded as a fourth trimester during which time breast milk provides a direct biological connection between the endocrine systems of the mother and infant.

Human infants exposed to higher levels of cortisol in their mother's milk scored higher in negative affect than infant's exposed to lower levels, although this correlation was stronger in girls than in boys [99]. Neither environmental factors (e.g., maternal education, age, and social economic status) nor negative maternal affect (e.g., depression and perceived stress) at 3 months postpartum accounted for this correlation. Similar results have been reported in rhesus macaques [100]. Specifically, higher levels of milk cortisol in macaques predicted more confident temperaments in both sons and daughters, independent of available milk energy. Another study in humans found that the circulating cortisol levels in mothers and infants were more closely correlated in breast-fed mother-infant pairs compared to formula-feeding mother-infant pairs [101].

Together, these findings suggest that exposure to elevated cortisol levels in breast milk may shape infant temperament in humans, and that mothers have the ability to tune their infant's temperament through transmission of biologically active components in milk.

8.4 Psychological Barriers to Breastfeeding

A mother's decision to breastfeed or not is a topic of great interest to both family and non-family members. Determining which feeding method to use involves interacting social, psychological, emotional, and environmental factors [9].

Mothers in the United States (US) most often cited the following five considerations as reasons to breastfeed [9]:

1. Infant health benefits
2. Naturalness of breastfeeding
3. Facilitating infant bonding
4. Convenience
5. Maternal health benefits.

Conversely, the chief factors cited as reasons to formula-feed were [9]:

1. Father's objections
2. Fear that the baby would receive insufficient nourishment
3. Career/job demands
4. Physical discomfort of breastfeeding
5. The belief that lactation adversely affects breast appearance.

Although the vast majority of mothers now acknowledge that "breast is best" for their child, there are a number of psychological variables that impact a women's decision to breastfeed. This section discusses the barriers to breastfeeding mother's face, which range from societal stigma to their partners fears that breastfeeding will cause the breasts to sag.

8.4.1 Societal Pressures

Although breastfeeding is receiving increasing societal recognition and support in most countries around the world, there are often social costs. For instance, babies need to be fed while mothers are out in public, and mothers in many western countries report feeling awkward or embarrassed about breastfeeding in public. Currently, in the US, breastfeeding in public is illegal in five states. In Missouri, low-income pregnant women reported feeling that it was less acceptable to breastfeed in public than in the presence of visitors in one's home, but that attempts to preserve modesty by covering the breasts should be made in both circumstances [102]. Mothers also report feeling vulnerable and prone to negative feedback when breastfeeding in public [103]. Mothers embedded in cultures stigmatising breastfeeding may confront ongoing pressure to use formula in public, lack confidence in their decision to breastfeed, and feel ashamed to breastfeed in the company of others [104].

These uncomfortable social perceptions can not only deter breastfeeding in public, but also undermine breastfeeding mothers at work. For example, breastfeeders were evaluated as both less competent and less likely to be hired in a hypothetical job search in comparison to women without children or non-breastfeeding mothers [105]. Remarkably, the negative effects of breastfeeding were perceived by raters to be as deleterious to professional success as to deciding to purposefully sexualise one's breasts, and this sentiment was shared by both men and women [105].

Much of the taboo surrounding breastfeeding in public appears related to assumptions that bare breasts are sexually evocative or indecent [106]. The sight of a breastfeeding mother is regarded as obscene in societies where the breast is primarily regarded as sexual. Albeit an anecdotal illustration, Facebook prohibited users from posting images of breastfeeding mothers on the grounds that such images violated their decency code [107].

The extent to which breastfeeding is socially taboo, tolerated, or encouraged varies not only geographically but also by ethnicity [108]. Immigrants from societies in which breastfeeding is the norm demonstrate higher breastfeeding rates than the native population. Thus, Black immigrants from West Indian societies where breastfeeding is typical are more likely to express the intention to breastfeed exclusively than African American women [109]. The influence of prior culture on immigrant mothers appears to diminish with time; length of residence in the US was negatively correlated with initiation of breastfeeding in Puerto Rican mothers [110].

Societies also substantially vary in attitudes regarding the normal age of weaning, and mothers who transgress these expectations can suffer negative social consequences. For example, many mothers in western countries who breastfeed longer than the first few months of their child's life report adverse social feedback [111]. In the US, approximately one third of mothers who breastfed for longer than 6 months reported perceiving negative social feedback about their breastfeeding practices [111]. This number climbs to three fifths among mothers breastfeeding for 2 years. The US and most western nations deviate from what may be considered to be the normal human breastfeeding duration. Mothers in traditional societies typically breastfeed for an average of approximately 2.5 years [112]. While there are potential social and interpersonal costs associated with breastfeeding, it is also important to acknowledge that there are also social costs associated with formula-feeding [113].

Due to the consensus by health professionals that breast milk is the ideal source of nutrition for infants, mothers often face enormous pressure to breastfeed. Mothers who cannot or chose not to breastfeed fear they will be labelled as "bad mothers" by health professionals, family members, or other mothers in their communities [114]. New mothers report that where the expectations of others do not match their child feeding decisions, they can feel palpable guilt, self-doubt and confusion [113]. There have even been reports that guilt and shame associated with breastfeeding failure in mothers who intended to breastfeed can be a precursor to postpartum depression [115].

Whether a mother breast or formula feeds is often framed by academics and health care professionals as a purely personal choice made by the mother. In reality, many mothers desperately want to breastfeed, but are unable to meet their breastfeeding goals for a variety of reasons unrelated to choice. Although approximately 96% of mothers can physically lactate [116], mothers who do not receive proper breastfeeding education and professional lactation support may produce insufficient milk to nourish their infant. Women lacking access to skilled breastfeeding professionals are much more likely to experience painful breast infections (e.g., mastitis), engorgement, or cracked and bleeding nipples [3]. Additionally, many workplaces deny mothers the physical space necessary to pump and store their milk, and fail to provide convenient or flexible breaks to express milk by pump. In these circumstances, mothers have to work to financially support their child's needs. In the US, there is also evidence that women of some racial and ethnic groups are less likely to receive essential breastfeeding support while in hospital. African American mothers are nine-times more likely to be given formula while in hospital than white mothers, and this practice explains much of the shorter duration of breastfeeding observed in African American mothers compared to white mothers [117]. These examples highlight the role that structural barriers to breastfeeding play in mothers' feeding behaviours. No amount of pressure or guilt associated with breastfeeding will help mothers surmount these very real breastfeeding hurdles. Therefore, while educating mothers about the benefits of breastfeeding is essential, health care professionals must be sensitive in their approach and recognise that breastfeeding may not be possible or practical for women in certain circumstances.

Research tells us that educating mothers alone is not sufficient to bring about breastfeeding promotion. Education efforts targeted towards partners and families, and social support networks must also be part of any comprehensive breastfeeding promotion programme. Societal shifts in the value of infant health and the right to breastfeed are also necessary to bring about regulations that mandate employers to provide the resources for mothers to both work full time and breastfeed.

8.4.2 The Mother's Partner

Mothers who deliberate over whether to breastfeed often consider the potential effects on their personal relationships. Breastfeeding is an intimate experience shared between a mother and baby, leaving some partners feeling excluded. Some fathers report feeling that their partner's breastfeeding activities interfere with their own ability to bond with the baby [118], and even fathers who encourage breastfeeding sometimes acknowledge feelings of jealousy [119]. Qualitative insights from interviews indicate that such feelings can delay fathers' inclinations to actively develop a relationship with the baby until after weaning [120]. Feelings of exclusion related to breastfeeding may generalise to include families in which two women co-parent, but only one breastfeeds.

Such negative partner reactions can sometimes be ameliorated if breastfeeding is reframed as a joint effort, if non-breastfeeding parents are provided better education about the benefits of breastfeeding, and by highlighting opportunities for non-breastfeeding parents to participate in other supportive activities while breastfeeding occurs, such as entertaining visitors [120]. Likewise, in families using a breast-pump to express milk, non-breastfeeding parents can feed breast milk to the child.

The impact of breastfeeding on mothers' sexuality can also decrease partner support for breastfeeding [119]. Breastfeeding can diminish sexual desire in mothers, and cause vaginal dryness and painful sex [121] by lowering oestrogen levels early after birth [7]. Consistent with this early suppression of oestrogen, breastfeeders report experiencing greater vaginal pain during intercourse at 3 months after giving birth but not at 6 months [122]. In convergent evidence, breastfeeding at 3 months following birth predicts reduced reported frequency of intercourse, sexual satisfaction, and desire for sex in comparison to formula-feedering at this time point, with no difference between the two groups by 6 months post-birth [123]. While it seems that breastfeeding mothers experience diminished sexuality for the few months postpartum, the reduction is not large and, for most, has no major effect on their sexual relationship with their partner [124].

A common reason for women choosing not to breastfeed is the belief that it will adversely affect breast appearance [9]. Partners also worry about this effect, leading some to discourage their partners from breastfeeding [118]. These concerns are not supported by empirical evidence. A study of 93 women seeking plastic surgery to improve the shape of their breasts found no significant relationship between ratings of breast ptosis (drooping or sagging) and breastfeeding initiation or duration [125]. The notion that breastfeeding makes breasts sag likely comes from the fact that pregnancy leads to changes in breast tissue. This study also found that number of pregnancies, age, body mass index, larger pre-pregnancy bra cup size, and smoking history were positively related to breast ptosis. Similarly, a prospective Italian study found that mothers frequently reported changes in the size and shape of their breasts after childbirth, but these changes were not different as a function of infant feeding behaviours [126].

8.4.3 Mental Health Barriers

There is overwhelming evidence that women with depression in pregnancy or in the first weeks postpartum are less likely to initiate breastfeeding and to breastfeed for shorter durations [82], [83]. Mothers with postpartum depression report experiencing breastfeeding as more difficult [127], [128], have a higher incidence of failed attempts to breastfeed [129], and perceive themselves as less capable of effectively breastfeeding [130]. For example, women who self-report depressive symptoms at 2 weeks postpartum are more likely to wean by 2 months postpartum [131]; and depressive symptoms reported 7 weeks after giving birth predict higher rates of weaning by 6 months postpartum [132]. Similar patterns seem to uphold in women with depression prior to giving birth. Expectant mothers who report depression during pregnancy are less likely to initiate breastfeeding after giving birth [133] and, in one study, weaned 2.3 months earlier than mothers without prenatal depression [87].

It seems plausible that common symptoms of depression, such as negative mood, poor self-esteem, and anxiety, could lead women with depression to perceive common breastfeeding problems (such as pain, latching, or milk insufficiency worries) as less surmountable or more serious than their non-depressed peers [90]. Likewise, anxiety can interfere with milk supply and the milk letdown reflex [134], which could lead mothers with depression to have more breastfeeding problems [135]. In addition, mothers with depression tend to be less sensitive to infant cues [136], which may lead to problems in infant latching and the establishment of breastfeeding routines.

Finally, many antidepressant and psychiatric medications are not recommended for breastfeeding mothers, prompting some women with depression or other serious mental illnesses to choose to formula feed to enable them to receive medical treatment. The mediators that underlie the association between depression and breastfeeding outcomes should be examined in future research.

Overall, research suggests that identifying and treating mothers with prenatal or postpartum depression may encourage breastfeeding. Likewise, depressed mothers may need extra support from family members and health care professionals to meet their breastfeeding goals.

8.5 Conclusions

Breastfeeding triggers a unique psychological and physiological period that has many benefits for both mother and infant. There is strong evidence that breastfeeding alters a mother's stress physiology, bolstering the parasympathetic nervous system, leading to lower levels of self-reported stress in breastfeeding compared to formula-feeding mothers.

There is also emerging evidence linking breastfeeding to reduced risk of postpartum depression. Some studies have found that breastfeeding may have a dose-response effect on depression risk, with increased breastfeeding frequency or intensity providing mothers more protection. The relationship between breastfeeding and postpartum depression is complex as depression can also interfere with a women's ability or motivation to breastfeed for both psychological and biological reasons.

Markedly fewer studies have directly addressed the question of whether breastfeeding promotes maternal bonding. Despite this, there is good indirect evidence indicating that breastfeeding should promote maternal bonding, foremost that showing the association between breastfeeding hormones (oxytocin and prolactin) and parenting behaviour. However, experimental studies examining breastfeeding and maternal-bonding are difficult to carry out, and correlation studies have been confounded by the fact that maternal bonding may also engender higher breastfeeding rates.

Additionally, compared to formula-feeding mothers, breastfeeding mothers have longer slow wave sleep time, greater brain activation in response to infant cues, and may have heightened defensive aggressiveness when they or their infants are threatened.

Research in infants has focused on the physical health benefits of breastfeeding, leaving many topics on the psychological impact underexplored. Breastfeeding engages the infant's sucking reflex, triggering relaxation and decreased activity during feeding sessions. Whether breastfeeding causes greater levels of infant relaxation than bottle-feeding or pacifiers merits research attention. Studies relying on maternal reports find that breastfed babies are fussier than formula-fed infants, while large longitudinal studies report no such differences or less negative affectivity in breast fed infants.

Although data supporting a link between breastfeeding and infant temperament are generally weak, one large prospective study reported that breastfeeding for a minimum of 6 months protected children from mental health problems in adolescence. The relationship between breastfeeding and infant temperament is complicated by research showing that maternal hormones are passed from the mother to the infant through breast milk, and breast milk composition varies from mother to mother. Infants exposed to higher levels of the hormone cortisol in breast milk have more fearful temperaments than infants exposed to lower levels. There are many bioactive components in human breast milk and the combination unique to each mother may calibrate her infant's temperament in ways that could promote greater mother-infant synchrony.

Breastfeeding promotion efforts need to be sensitive to the many psychological and social barriers to breastfeeding faced by new mothers. Socially, some mothers feel confined to their homes because they are uncomfortable breastfeeding in public. Additionally, breastfeeding becomes less likely when people close to the mother discourage breastfeeding, and where there are challenges in the workplace. Thus, while the evidence is robust that promoting breastfeeding will have psychological benefits for mothers, their children and society as a whole, the needs and individual circumstances of mothers must be respected and addressed.

8 Key Points

- In mothers, breastfeeding is associated with increased maternal sensitivity, reduced reactivity to stress, enhanced slow wave sleep, and reduced risk of postpartum depression. Stress and depression in mothers can also interfere with breastfeeding.
- For infants, breastfeeding is associated with relaxation and components in milk likely shape infant behaviour and temperament.
- A mother's decision to breastfeed is often heavily influenced by those closest to her, exerting both negative and positive impacts

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9 Sociological and Cultural Influences upon Breastfeeding

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Expected Key Learning Outcomes

- The social and cultural factors affecting maternal attitude towards breastfeeding and its success
- The different influences in high-income and low/middle income countries
- A key factor to empower mothers to make an informed choice in relation to socio-cultural issues
- Other influencers in enabling a positive socio-cultural environment for breastfeeding

At first glance, breastfeeding could be perceived to be principally a biological issue. Indeed, earlier research in this area often focused primarily on understanding factors, such as milk production, latch, and pain. Much of this initial research was conducted in or around hospital settings by those with a background in medicine or nursing. Such research is paramount, but it neither provides the full picture nor on its own enables addressing the significant issues of breastfeeding rates or sub-optimal practices in many countries.

Breastfeeding is a biological act and breast milk production is hormonally driven. Milk starts to be produced in small amounts from mid-term pregnancy, with production of greater volumes once the placenta is removed after birth. A rise in prolactin and oxytocin post birth trigger this rapid increase in milk volume, and these hormones continue to play an important role in ensuring sufficient breast milk is produced throughout the breastfeeding period. Each time the infant sucks, a rise in prolactin is seen [1]. Meanwhile, breast milk supply is generally matched to the needs of the perceived infant; the more milk that is removed from the breast, the more milk is made and vice versa [2].

Research suggests that the majority of mothers should be able to produce breast milk for their infant, although some will experience impediments or have contraindications for breastfeeding [3]. For example, infants with galactosaemia (where infants lack the enzymes needed to digest lactose and galactose in milk) need specialist formulas. Mothers with active tuberculosis should be separated from their infant, although transmission in milk is low, and mothers with active herpes lesions around the nipple should not breastfeed. Some medications such as lithium, atropine, and iodides are contraindicated, but usually a safe alternative can be found [4].

The most common but relatively rare condition, affecting around one in 1,000 mothers, is insufficient glandular development [5]. This typically presents as little change to the breast during pregnancy or after birth. Breasts lack fullness vertically and horizontally, and are widely spaced with enlarged areola. Women often have low milk production despite frequent feeds after birth. In one study, 85% of mothers with the condition produced less than half of the milk needed for their baby during the first week, although it did improve. By one month, 55% produced less than half the milk needed and 39% produced the full milk requirement for their baby [6]. Other disorders, such as gestational diabetes [7] and polycystic ovary syndrome [8] may require more support in helping mothers achieve a full milk supply.

These data suggest that from a physiological perspective, the majority of women should be able to breastfeed their baby. In her reflections of time spent as a lactation consultant in Zimbabwe, Morrison found that less than 0.1% of the thousands of mothers she met could not produce sufficient breast milk [9]. This reflects the expected occurrence of insufficient glandular development. In many regions of Africa and Asia, it mirrors the high numbers of women who initiate breastfeeding at birth, which is similar to the numbers breastfeeding at six and 12 months.

However, these figures do not reflect the breastfeeding experiences of many women in Western cultures. In many Western countries, rates of both initiation and continuation are far lower. For example, while breastfeeding initiation is almost universal in African, Asian and some South American regions, only 81% of mothers in the UK and 77% in the USA initiate breastfeeding. Disparities also occur in duration of breastfeeding. At six months postpartum, virtually all women in African and Asian regions are breastfeeding while only half of mothers are breastfeeding in the USA and Australia, and one-third of mothers are breastfeeding in the UK [10]. There is no plausible, physiological reason why this variation should happen. This is not to say that women in these regions do not have physiological issues. In fact, the majority cite reasons of insufficient milk supply, pain, and difficulties with latch as reasons for stopping [11].

Conversely, issues such as pain, difficulty, and breast milk insufficiency are rarely given for breastfeeding cessation in cultures where breastfeeding knowledge, acceptance, and support is high. Anthropological research exploring influences on breastfeeding in a rural tribe in East Africa found that all infants were breastfed for at least six months, 90% for at least a year, and 75% until two years. Reasons for stopping breastfeeding before two years included maternal illness, pregnancy or the child being able to eat the diet of the tribe. Insufficiency or insurmountable difficulties were simply not a concept [12].

Firstly, it might be suggested that breastfeeding difficulties are a Western phenomenon — that Western women have lost the ability to breastfeed their babies. However, this shift is relatively recent in terms of history. Only 150 years ago, breastfeeding was still very much the norm. Infants were breastfed by their mother or a wet nurse, or neither. However, with the advent of the formula industry and the first formulas made at the end of the 19th century, behaviours started to change [13]. Physiological evolution does of course happen but slowly, while social evolution can progress at a much faster pace. Attitudes, norms and knowledge can change and be lost very quickly.

Secondly, this pattern of low rates of breastfeeding does not exist across the entire West. In Nordic regions, breastfeeding initiation remains almost universal, with around three-quarters of mothers continuing to breastfeed until six months postpartum. Differences in breastfeeding rates also occur within regions, in a pattern that cannot be explained by any geographical phenomena. In the UK, variation is seen in initiation and duration between the four countries: in England 83% of mothers breastfeed at birth compared to 74% in Scotland, 71% in Wales, and 64% in Northern Ireland [11].

Finally, rates of breastfeeding also differ between groups even within a country. Mothers who are older are more likely to breastfeed and for longer. In the UK, 87% of mothers aged over 30 years breastfeed at birth whereas only 20% of those under the age of 20 years do so [11]. This pattern repeats itself around the globe. Even when breastfeeding rates in a country are almost universal, those who are more likely to stop at a comparably earlier time point are more likely to be younger mothers [14]. From a biological perspective, the ideal time for a woman to have a baby is when she is younger, whereas you might expect older mothers to struggle more with breastfeeding as their fertility declines and other complications arise. Biology is therefore not responsible for this difference.

Breastfeeding rates also differ strongly by maternal education. The longer a mother spends in education, the more likely she is to initiate and continue breastfeeding. In the UK, 91% of mothers who leave full time education over the age of 18 years start breastfeeding compared to 63% of those who left at 16 years or younger. A similar pattern is also seen for occupation; 90% of women in managerial and professional jobs begin breastfeeding compared with 74% of those in routine and manual occupations, and 71% of those who have never worked [11]. These are global patterns. Education is also predictive of early initiation and exclusive breastfeeding in developing countries [14]. Education does not affect a woman's physiology.

Patterns of breastfeeding go deeper than that, however, with significant differences seen in ethnic groups, even within countries. In the UK, women from non-white British backgrounds are significantly more likely to breastfeed than those from white backgrounds [11]. Conversely, in the USA, women from white backgrounds are significantly more likely to breastfeed than women from black backgrounds [15]. This is further affected by degree of acculturation and we will consider this later in the chapter.

What these statistics show is that breastfeeding cannot simply be a physiological issue if such extensive variation is seen between and within countries. Consensus is growing to the importance of taking a systems level, public health approach to breastfeeding, recognising the importance of the society, culture, and environment in which breastfeeding occurs. Breastfeeding is not simply a physiological process — the psychological, social, and cultural aspects can directly affect ability to breastfeed through influencing maternal behaviour and opportunity. As Victora et al. 2016 [10] state:

> *'The reasons why women avoid or stop breastfeeding range from the medical, cultural, and psychological, to physical discomfort and inconvenience. These matters are not trivial, and many mothers without support turn to a bottle of formula. Multiplied across populations and involving multinational commercial interests, this situation has catastrophic consequences on breastfeeding rates and the health of subsequent generations.'*

These social and cultural issues are numerous and complex but can broadly be split into two themes: 1) direct negative attitudes about breastfeeding and its impact and 2) more subtle factors that despite intention and desire to breastfeed, erode maternal ability to do so. Some of these influences are overt; negative attitudes to breastfeeding in public, beliefs that formula fed babies are more content, and pressure from family members to take part in the feeding. More covertly, a lack of understanding of how breast milk production works, a desire to manipulate infant feeding patterns, or religious and cultural influences can all lead to a low milk supply through practices that discourage either exclusive and/or responsive breastfeeding.

Although ultimately breast milk supply is determined by hormonal levels, the frequency of feeding is critical to a good milk supply with infant sucking triggering a rise in prolactin [1]. Responsive feeding, e.g., when the infant signals to be fed, is associated with the best outcomes. The volume of breast milk produced is predominantly affected by how much and how frequently breast milk is removed from the breast, either through a baby feeding directly or through milk expression. The more milk removed from the breast, the more breast milk produced by the body. Less milk is produced if demand declines, e.g., through bottle feeding with formula or lengthening the time between feeds [16]. The body is therefore adept at adapting milk production to meet the perceived needs of the infant. Infants who are breastfed responsively, e.g., whenever they signal hunger, are more likely to continue to be breastfed [17].

Although this mechanism between frequency of feeding and milk supply is physiological, societal and cultural norms play a significant role in determining whether this is successful. This is because responsive feeding is heavily embedded in the knowledge, attitudes, and norms of a society. In Western culture, many new parents and those supporting them either do not understand the importance of responsive feeding or are dissuaded from doing so by the environment in which they live. This dissuasion can be deliberate and direct or more subtle, with individuals not recognising the damage that is occurring. It is this environment that affects how responsively an infant is fed and consequently, how much breast milk is produced.

Breastfeeding is therefore the end point of a physiological issue, but many social and cultural issues determine the success of that physiology. Over time, societies and cultures build the breastfeeding environment that new mothers will adopt, and the resulting attitudes and norms can be very influential on new mothers. However, they are not fixed, and can and have been changed as we will see. Identifying and understanding these issues is crucial to being able to support new mothers to breastfeed to the very best of their ability. As Rollins (2016) [18] states:

> *'The success or failure of breastfeeding should not be seen solely as the responsibility of the woman. Her ability to breastfeed is very much shaped by the support and the environment in which she lives. There is a broader responsibility of governments and society to support women through policies and programmes in the community.'*

9.1 Societal Attitudes Towards Breastfeeding

A significant indicator for any health behaviour is the attitude that both an individual and their society hold towards the value and significance of that behaviour. The same is very much true for infant feeding. Individuals may hold beliefs that are different to the norm in their society, but they still formed that belief while being part of that society. They are very likely aware of how their attitude and decision compliments or contrasts with the opinion of the many.

The dominant attitude towards breastfeeding matters in a multitude of ways; whether it is through information sharing, reactions or ability to support. Breastfeeding in a community of peers with positive attitudes to breastfeeding is easier than when their attitudes differ, even if they do not overtly share their differing beliefs. Mothers who feel they are part of a supportive community where their peers breastfeed and honour their decision, are more likely to breastfeed, even if they are younger [26]. Conversely, many mothers, especially those living in areas of deprivation, talk about communities where formula feeding is the norm [19].

In Western culture, a number of attitudes towards breastfeeding are often known to, if not widely held, by communities. These are based around attitudes to breast milk itself, the breast, and to the act of breastfeeding. In addition, attitudes about formula milk directly affect attitudes towards breastfeeding, as they are often considered two opposing choices. These attitudes affect women's decisions about breastfeeding directly or her decisions about when to breastfeed, potentially impacting upon formula milk feeding. Unsurprisingly, negative views towards breastfeeding are associated with formula use [20].

9.1.1 Perceptions of the Breast

As soon as the words 'breast milk' are uttered, many are drawn immediately to the word 'breast' and its connotations. For some, breastfeeding and the sexual nature of the breast are deeply intertwined and inseparable. The breast has become so highly sexualised by the media (and accepted as such) that it automatically triggers sexual connotations for many. There is nothing wrong with this; breasts are a sexual part of the body and many women take pride in their appearance.

However, it is the singular connotation of acceptable use of the breast that damages the image of breastfeeding. This is partly due to exposure. Whereas images of breasts in their sexual form are in every magazine and on every corner, the breast in its nurturing sense is rarely seen. This seeks to strengthen the automatic connotation of the breast as sexual, while reducing its connection with feeding [21]. Those who hold the highest attitudes about the breast as sexual, are those who are most intolerant to breastfeeding [22] and those who feel generally uncomfortable around sexual stimuli, feel significantly more uncomfortable around breastfeeding [23].

The sexual connotation of the breast is in part due to the lack of visibility of breastfeeding in society. In one study, only a quarter of adolescents had ever seen anyone breastfeed [24], yet it could be assumed that they had been exposed to many, many images of breasts in a sexual form. Representations of breastfeeding in the media are scarce, and mainly focused around newborn infants of white, educated, older women. Extended breastfeeding is not visible; it is seen as socially unacceptable and made others feel uncomfortable [25]. Additionally, of the references to breastfeeding, many make a play on the sexual nature of breastfeeding, using inappropriate humour [26].

Focus on the sexual nature of breast increases issues with maternal body image, affecting breastfeeding decisions. A common concern, especially for younger mothers is that breastfeeding will ruin the appearance of the breast, or that clothes needed for breastfeeding are unattractive [27]. Research shows that those women who are pregnant and worried about the potential impact of breastfeeding on their breast shape and volume, are unlikely to even plan to breastfeed [28]. However, despite research showing that it is pregnancy and not breastfeeding that affects breast shape [29], such myths perpetuate.

9.1.2 Perceptions of Breast Milk

Often intertwined with the view of the breast as sexual, the negative connotations of breast milk are associated with negative attitudes towards breastfeeding. A view that breast milk is a bodily substance and must therefore be dirty or contaminated is common, and held subconsciously by some. Many claim that breast milk is normal and healthy, but squirm if offered some to drink. Others are more overt in their disgust, comparing breastfeeding in public places to urinating, as if the two were somehow equal in their intent.

Breast milk is a unique substance in terms of bodily secretions. Other secretions may carry disease, signify ill health, or have the potential to cause harm, whereas breast milk does not. However, some group all bodily fluids together, thus viewing breast milk as a contaminant. Generally, people hold the view that bodily fluids should be controlled and contained, but breastfeeding is a visible sharing of those fluids [30]. An interesting statistic emerged from YouGov polled research in response to a news story that a woman had breastfed her baby in a swimming pool. They survey found that while 65% of responders thought it appropriate to breastfeed when sitting beside a pool, only 36% believed it appropriate to breastfeed in the pool. This suggests a fear that breast milk would in some way contaminate the individual [31].

These attitudes contribute to the negative societal connotations of breastfeeding and thus upon breastfeeding itself. Women can feel that they should be hiding their milk; they are taught to feel ashamed of and hide other bodily fluids, such as menstrual blood [30]. Others feel uneasy that such a potential contaminant (e.g., to their eyes) should be present in food settings, creating unease for mothers trying to breastfeed their baby. Education is key; after all, many of those who hold negative views about breast milk are more than happy to have the milk of another species in their tea.

9.1.3 Attitudes to Breastfeeding in Public

The previous sections explore the concept of the breast as sexual and breast milk as a contaminant, factors that contribute directly to the issue of negative societal attitudes to breastfeeding in public. In the UK, under the 2010 Equality Act for England and Wales, a woman must not be treated unfavourably because she is breastfeeding. More specifically, in Scotland, a person must not be prevented from breastfeeding her child (if under two years of age) in a public place. Similar laws occur globally, including some regions of the USA, Canada, Australia, and Europe. However, individuals often consider public areas to be “their” space and feel that they can directly or indirectly dictate what happens in them [32].

However, protection by law does not prevent many from holding the negative attitude that women should not breastfeed in public. A global survey found that most members of the public agreed that babies should ideally be breastfed but simultaneously, between one-third and half believe women should not breastfeed in public, with the USA having the most negative views, followed by France. Others are more supportive of breastfeeding, but thought that bottle-feeding was more acceptable in public [33].

Likewise, in research that has compared attitudes across different countries, significant variation is seen in rates. In one study exploring rates in European countries, 56% of respondents in Italy and 42% in Spain thought breastfeeding in public was wrong, whereas only 8% in Sweden thought it inappropriate [34]. In the USA, only 43% of those surveyed believed that women had the right to breastfeed in public [35]. This reflects the breastfeeding rates of the country; Sweden has some of the highest rates in the West, whereas the USA has some of the lowest.

Others do not disapprove of breastfeeding, but report that it makes them feel uncomfortable [36]. Some add provisos that breastfeeding in public is acceptable as long as the woman is discrete and respects the feelings of others [37]. Ultimately, many appear to view the situation as their wish versus the wish of mothers, when in reality it should be considered as their wish versus that of infants.

Finally, some feel breastfeeding in public is unavoidable and should be tolerated, but are unhappy with it being depicted ‘unnecessarily’. For example, only one-quarter of the public in the USA believe it is suitable to show a mother breastfeeding on television [35]. Another study found that only 48% of men felt it was appropriate to show a woman breastfeeding on a magazine cover, 37% felt it was appropriate on a billboard or poster, and 46% felt it was appropriate on a family television show [38]. Media representations of breastfeeding often play to these views. When breastfeeding is shown on television, it is often shown in the context of the home, with cues depicting that this was a private activity, e.g., mothers wearing a nightgown while feeding their infants, rather than being out in public [39].

Most studies find breastfeeding attitudes vary with age. The most open to breastfeeding in public are those who have young children themselves, and older people. However, adolescents and university age students typically have the most negative views. In a Canadian study, nearly 80% of college students believed breastfeeding was an intimate act that should be kept private [37], while in America only one-third of undergraduate students believed it was acceptable to breastfeed in public [40]. In Quebec, a quarter of adolescent girls believed that breastfeeding in public showed a lack of respect for others, and one-third believed that it was important not to see the breasts if a woman was breastfeeding in public [41]. Attitudes also differ by gender. In general, men are actually a little more supportive of breastfeeding in public than women [35], and men who are fathers are more likely to have supportive views compared to men without children. A study in the USA showed that only 16% of fathers expressed an issue against women breastfeeding in public [38].

Why do the public hold negative views about breastfeeding in public? The view of the breast as sexual and of breast milk being potentially contaminating is common, but views about the function of the female body also play a role.

In Western culture women are required to look attractive and be perceived to be available. Their bodies are frequently used in popular culture in a sexual way, surrounded by misogynistic messages around ownership and consent [42]. For some, the sight of a woman breastfeeding provokes anger; the woman is using a part of her body to nurture a baby that they expect to see for themselves only, suggesting her attention will not be directed towards them [43]. Others feel anger towards women who break away from the mould of a "good woman", labelling them (especially those who draw attention to breastfeeding through protests and celebrations) as silly, irritating and obnoxious [44].

This may seem far-fetched, but close links are seen between sexism and dislike of breastfeeding in public. When male sexism is high, men are less likely to approve of a photograph of a woman breastfeeding in public [22]. Two broad types of male sexism occur. The first is hostile sexism, which is a direct dislike of women and belief in masculine ideologies. The second is benevolent sexism, where men like women but believe they must be protected and cannot achieve the same things as men. Men with high levels of hostile sexism hold negative views of childbirth and breastfeeding [45]. However, although men with high levels of benevolent sexism are supportive of breastfeeding, because it suggests that a woman is a good, traditional female [23], they dislike a woman to breastfeed in public, because this signifies that she is breaking away from her 'good woman' role [22].

Public attitudes to breastfeeding do affect maternal decisions. Countries where attitudes to breastfeeding in public are the most positive tend to have the highest breastfeeding rates. This has a cyclical impact. The more breastfeeding is seen in public, the more normal and accepted it becomes, and vice versa. Research shows that experiencing negative attitudes towards breastfeeding in public is common amongst new mothers. In the UK, a large survey by a parenting magazine found that 60% of mothers felt that the UK was not breastfeeding friendly, 65% found breastfeeding in public a stressful experience, and 54% had directly received negative comments or actions [46]. Additionally, the UK Infant Feeding Survey 2010 found that 85% of breastfeeding mothers felt that society frowns upon mothers who breastfeed, and 68% believed it was the cultural norm to bottle feed babies [11].

Understandably concerns around breastfeeding in public – whether these are based on embarrassment, shame or fear – are associated with a shorter breastfeeding duration. Fear of being approached is common amongst new mothers. Others fear the silent disapproval and stares of others. Findings from the UK Infant Feeding Survey 2010 showed that only 8% of breastfeeding mothers felt comfortable breastfeeding wherever they wanted, and the majority felt self-conscious. As such, only around half of women breastfeed in public by six weeks in the UK compared to 80% of mothers in Sweden. Feeling uncomfortable breastfeeding in public is a common reason for not doing so [11].

Other women feel that they must practice “socially sensitive lactation”, where despite protection under law, mothers feel hesitant breastfeeding in public and try to do so covertly or use a private room [47]. Some may express milk to avoid breastfeeding in public. However, expressing can be time consuming and difficult, with some women finding they can only express a small amount [48]. Moreover, infants may not accept a bottle as it is shaped differently to the breast [49]. Finally, others may try to extend the time in between feeds, which can negatively impact milk supply [16].

9.1.4 Attitudes Towards Formula Milk

Interlinked but separate to attitudes towards breast milk, are perceptions of formula, particularly around its perceived impact on infant sleep. A very common perception is that formula fed babies are more content and settled, need to feed less often, and will sleep better at night [50]. This ties strongly into Western cultural norms, that infants should be quiet, settled and “good”. These beliefs are reflected in media representations of formula feeding; whereas breastfeeding is often presented in television shows as being difficult, formula feeding is typically presented as normal, problem free and something that others, particularly the father, can join in with [26].

In general, breastfed babies will feed more frequently, irregularly, and for longer from the first week of life than formula fed infants [51]. Formula fed infants typically have more defined feeds rather than tending to cluster feed [52]. Breastfed infants tend to feed around 8–12 times per 24 hours, whereas formula fed infants may feed 6–8 times [53]. Breast milk is not a uniform product, changing in energy density during the course of a feed and at different times of the day [54]. Growth spurts can also lead to a change in feeding patterns, with more frequent feeding before and during a growth spurt [51]. Indeed, in cultures where carrying and sleeping with infants is the norm, infants will feed up to several times an hour and throughout the night [55].

These differences can in part be explained by the significantly faster rate of digestion of breast milk compared with formula milk [56]. However, formula fed infants consume a greater volume of milk per feed [57], feeding more quickly, consuming milk at a faster rate, and having fewer sucking pauses [58]. Differences in the feeding mechanism contribute to this. Formula feeding works by a simple sucking action whereas breastfed infants must latch onto the breast [59]. This makes persuading a bottle fed infant to take more milk easier than with a breastfed infant, with research showing that with encouragement, bottle fed infants will consume on average a further 10% more milk [60].

Notably, a major difference between breast and formula feeding is the need for breastfeeding to be responsive to these frequent needs, to ensure sufficient milk supply. Missing or replacing breastfeeds, or extending the time between feeds, can lead to a reduction in milk supply. This issue does not arise with formula milk. Responsive feeding is associated with a faster production of mature breast milk [61], less weight loss after birth [62], and greater breast milk supply [63]. Conversely, attempting to reduce feeds or feed to a set schedule can lead to a reduction in milk supply [64], breastfeeding difficulties [50], and breastfeeding cessation [65].

In terms of sleep, waking at night is normal throughout the first year and beyond, despite significant social beliefs that it is not. Between 30–80% of babies continue to wake up at night throughout the first year, with an average frequency of 1–2 times per night [66], [67]. In most non-Western cultures, mother and baby sharing a sleeping surface is normal [68]. Sleeping alone is a Western concept and is rare from a global perspective. Waking at night may be protective against sudden infant death syndrome [69]. Sleeping close to their mother impacts on infant behaviour and physiology. Infants who sleep next to their mother in hospital are more relaxed in their sleep than those placed in a nursery [70]. Sleeping next to their mother regulates the infant's temperature control [71], heart rate [72], and breathing [73].

Feeding at night is also normal from an anthropological perspective. Observational studies in rural cultures show that infants (who typically co-sleep) breastfeed on average four times a night [12]. Infants can take up to half of their milk at night [74], with the amount increasing as they become toddlers, and more active and distracted during the day [75]. This is perceived as normal and not something that would be measured or considered an issue [55].

In Western culture, many do not understand that frequent feeding and waking at night is normal, thus worrying that something is wrong if breastfed infants feed in this normal pattern. Others perceive it to be inconvenient or incompatible with lifestyle, or believe that infants should be placed in a maternal-led schedule [50]. There is also the notion that formula milk and an early introduction to solid foods will promote deeper sleep. In early infancy, infants who are formula fed do start sleeping for longer periods and have fewer night feeds at an earlier age [76]. However, this pattern does not last. Research with slightly older infants shows that how babies are fed, both in terms of milk type and frequency of solid foods, does not impact on how often babies wake at night [66].

Infant waking is not the only predictor of maternal sleep. Research examining sleep duration in mothers who are breast or formula feeding shows that mothers who breastfeed get more sleep overall. Formula fed infants may wake less frequently, but the time taken for a mother to prepare a bottle and resettle the infant leads to greater sleep deprivation [77].

Breastfed infants are also less restless at night. Breastfed babies were less likely to snore, wheeze, cough or have breathing problems during their sleep, making maternal sleep easier [78]. Co-sleeping and breastfeeding are closely linked. In one study, twice as many co-sleeping infants were breastfeeding at 3–4 months than those who slept alone [79]. This may be partly because infants who co-sleep feed twice as often at night than those who sleep separately [80]. However, this does not stop beliefs that infants should be encouraged to develop a stricter pattern for feeding and sleep. Unfortunately, attempting to encourage breastfed infants into a routine is associated with a shorter breastfeeding duration [65] and attempts to feed to a routine are associated with difficulties [50] and cessation [17].

We also known that responsive care for infants plays a crucial role in infant development [81]. When babies feel secure in the care of a primary caregiver, they go on to have better outcomes socially, educationally, and emotionally in childhood and later life than those who do not have such security [82]. Mothers who respond sensitively and promptly to their infants' signals have more positive attachment bonds [83], with infants recovering more quickly from stressful events [84]. Conversely, allowing an infant to cry for an extended period of time can raise stress hormone levels [85], which may impact negatively on the developing brain [86]. These early experiences are critical. Increased and prolonged levels of stress in early infancy programme the nervous system to be over stimulated [87].

Attitudes that infants should be settled and that formula will remedy this are deeply embedded in the broader ideas of how babies should be fed, family traditions, and perceptions of the visibility of breastfeeding and breast milk. They are also tied into the wider notions about how we view, care for, and value our new mothers.

9.2 Societal Attitudes Towards Mothering

The decision to breast or formula feed is not made in isolation; it is made as part of a mother's wider experience of how she cares for her infant. The attitudes towards breastfeeding, breast milk, and formula described above all affect her attitudes and choices, but so does her experience of being a mother.

Experience of mothering in modern Western culture is inherently different to that seen in previous generations or in other cultures. Typically, modern mothers are isolated without a support system in place. Many have moved away from their original family and, with the trend to have fewer children later in life, are not exposed to caring for newborn infants until they have their own. In one study exploring the experiences of young women without babies, three had never held a newborn and only one-fifth had ever babysat a very young baby, bottled fed or changed a nappy [88].

Becoming a mother can therefore be real culture shock. New parents often must move from a position of low-caring responsibility and independence to one of responsible 24/7 infant care. Older and more educated mothers feel this shift most harshly. Many report loving their children but not loving the loss of their former identity and lives [89]. Some stop working, and mourn the loss of their working identity and financial security; others attempt to juggle their former working lives with caring for an infant. Copious research articles and headlines talk about this issue, and the high levels of stress, anxiety, and exhaustion whatever the decision taken.

Unsurprisingly, many new mothers feel overwhelmed by this change in circumstance, reporting that they feel shocked, unprepared, and anxious about their new lifestyles [90]. Fathers feel this too, but typically not to the extent of mothers who shoulder most of the responsibility [91]. Maushart (2006) [92] describes this transition to motherhood as 'the most powerful of all biological capacities and among the most disempowering of social experiences'. It should not be a shock that many do not feel happy with their change of circumstances, with some slipping into postnatal depression because of this.

9.2.1 Postnatal Depression

Postnatal depression is increasingly common in Western culture. Data suggest that around 15% of new mothers experience postnatal depression, but this is likely to be an underestimation. Many do not seek contact with health services because they are concerned about the implications or do not feel that they will be supported. Physiological explanations for postnatal depression are unclear and many models of the illness focus on psychological, social, and cultural factors. Lack of family support, relationship dissatisfaction, and isolation are key contributors to low maternal wellbeing, alongside the culture shock of the new responsibility and lifestyle change of becoming a new mother. Grief can play a central role, as the mother has to adapt to leaving her former life for a new intense responsibility for another. When mothers are isolated in doing this, risk of postnatal depression is higher [93].

The concept of postnatal depression is predominantly a Western infliction. Although episodes of postnatal illness do occur in many cultures across the world, their frequency is much lower. Societal and cultural reaction to these mothers is also different. In Western culture postnatal depression carries stigma, with mothers worrying that they will be perceived as "bad mothers". Treatment often focuses on pharmacological treatment and counselling approaches, rather than addressing many of the social and cultural factors that increase postnatal depression risk. It could be argued that much of postnatal depression in Western cultures can be attributed to a normal reaction to the lack of emotional and practical support that new mothers need [94]. For example, sleep deprivation [95] and infant crying [96] is linked to an increased risk of postnatal depression, alongside feelings of loss of identity [97]. Mothers should be supported to care for their new infant rather than left to experience exhaustion.

The relationship between postnatal depression and breastfeeding is complex. Mothers who breastfeed for the longest duration have the lowest levels of postnatal depression. It is possible that being able to breastfeed for longer enhances maternal wellbeing. Conversely difficulty breastfeeding and feeling unable to do so may increase the risk of postnatal depression. Pain and difficulties with latch are associated with an increased risk of postnatal depression [98]. However, infant feeding is often blamed for these negative emotions. Numerous perceptions are held in Western culture about the impact of breastfeeding upon infant behaviour. Breastfeeding can often be perceived as the root of issues, as formula fed infants are perceived as more content [50]. Infant feeding in general, whatever the method, takes up considerable time in infancy and it is easy to place blame on this [99].

However, it could also be that wider circumstances increase the likelihood of both postnatal depression and a short breastfeeding duration. Infant temperament is one key area. Mothers with postnatal depression are more likely to have an infant with a difficult temperament; for some, this could be based on perception rather than actual infant behaviour [100]. Mothers with postnatal depression are more likely to perceive their infant as crying excessively and find it more difficult to regulate infant behaviour than those who do not have symptoms [101].

The symptoms of postnatal depression may also make breastfeeding more difficult. Mothers with postnatal depression interact with their baby differently, particularly with regard to responsivity. Mothers with depression have poorer interactions with their newborn compared with non-depressed mothers, with low rates of touching, less sensitivity to their needs, and reduced skin-to-skin contact [102]. They are also more likely to be less intuitive with holding their baby, and more likely to report latching issues and consequently a poor milk supply [103].

Chronic pain is more widely linked to a risk of depression via physiological pathways [104]. Other factors can further increase the risk of depression through an effect on the immune system. Cytokines rise in response to sleep deprivation, stress, and pain, which in turn increase the likelihood of depression from a stress hormone perspective [105]. Stress hormones can inhibit prolactin, which can interfere with milk letdown [106]. Experimental studies of breastfeeding women placed in stressful conditions (subjected to mental puzzles and noise) show that the oxytocin levels in these stressed women are half those of women without the stressful conditions [107]. However, supporting mothers with relaxation interventions leads to an increase in expressed milk output [108].

Expectations also play a major role. Mothers who believed that breastfeeding would be easy and straightforward were at an increased risk of postnatal depression compared to those who perceived it might be more challenging [109]. Indeed, it is intention to breastfeed that predicts postnatal depression more strongly than duration itself. Mothers who want to breastfeed but cannot are at an increased risk compared to mothers who did not want to breastfeed. Notably, antenatal education often significantly lacks the much needed information about what breastfeeding is like and how to overcome difficulties, leading many women feeling unprepared [110].

9.2.2 Work

Alongside caring for an infant, many new mothers also have the additional pressure of returning to work. Whether this is through choice or necessity, many face juggling competing responsibilities. In the UK, around 50% of women return to work when their baby is aged 6–9 months old [111] but in the USA, most women returning to work do so by the third month due to the absence of statutory maternity leave [112]. This is in contrast to the extended, well paid maternity and paternity leave allowances of Nordic countries where maternity leave paid at 80% extends into the second year.

Employment can impact on breastfeeding success in a number of ways. Firstly, it can stop women initiating breastfeeding at all, through the belief that their infant will not adapt to a bottle when they need to return to work. It is also a significant reason given for why women stop breastfeeding, particularly when infants are over the age of 3 months. In the UK, one-fifth of women who stop breastfeeding at 4 months cite a return to work as the main reason, with return to work rising to the predominant reason for stopping breastfeeding between 4 and 6 months postpartum [113]. This pattern is reflected around the Western world with similar findings in the USA, Europe, South America, and South East Asia [114].

Unsurprisingly, a sooner return to work is associated with a shorter breastfeeding duration. A return in the first 3 months is associated with an average one-month shorter breastfeeding duration than if return to work is after 3 months [115]. In the USA, women who received paid leave were more likely to start breastfeeding and still be breastfeeding at 6 months than those who were not [116].

Ability to continue breastfeeding on return to work is context dependent. Some mothers are able to visit their infant at an on-site nursery and breastfeed them directly. However, others will need to express milk and if they want to give it to their infant, they will need to store it. Not all mothers find expressing breast milk simple, and many find they cannot express a significant amount despite being able to produce a good supply when feeding their infant directly.

Employers do have some obligation to support breastfeeding, but guidance is unclear. In the UK, employers are not permitted to refuse to support breastfeeding, but there are no requirements around what that support entails. Mothers should have somewhere safe and appropriate to rest, including a space to lie down, and should be risk assessed. There is guidance that women should have access to a private room in which to express and a fridge in which to store milk. However, these are guidelines and not laws and many employers do not follow them.

Conversely, in the USA, many states have issued legislation making it mandatory for employers to provide breaks for women to express, and breastfeeding rooms in which they can do so. However, research has shown that many pregnant and new mothers are unaware of company policies around breastfeeding [114]. Providing good quality breastfeeding support has a positive impact for the organisation. In the USA, it can reduce the premiums that organisations pay for employee health care cover. Increased breastfeeding rates are associated with reduced rates of infant and maternal illness, and reduced rates of absenteeism. When support for breastfeeding is strong, maternal moral increases [117].

However, not all organisations understand the importance of supporting breastfeeding for both population health and for themselves. In a study exploring breastfeeding support and attitudes across 157 businesses, most had little understanding of how breastfeeding could benefit the business or why it might be important to support breastfeeding mothers [117]. Conversely, organisations may state that they support breastfeeding in principle, but few can explain why this is important [118]. Many women feel uncomfortable in telling their employer that they will be breastfeeding on return to work, or raising the need for specific facilities or breaks. Returning to work after maternity leave can be daunting for new mothers, and many feel that discussing breastfeeding will be an additional challenge. Others worry that they are vulnerable on their return and do not wish to ask for additional support [119].

Additionally, organisations may express embarrassment at discussing breastfeeding or in some cases feel offended by it [120]. In a world where business settings are predominantly male dominated, breastfeeding is seen as a bizarre request and at odds with how the typical employee acts in the workplace [121]. Perceptions of the breast as sexual – whether it be an explicit or implicit view – can increase these reactions, particularly when the context of breast milk as a bodily fluid is included. In general, many are uncomfortable with bodily fluids, including breast milk. This, combined with the perception of the breast as sexual, can lead some to view breast milk as a sexual fluid [122].

From looking at the experiences of women who do feel supported to continue breastfeeding when they have returned to the workplace, a number of common factors appear to enable this. Mothers value flexibility, particularly in terms of working hours or break times to express when they need to. Paid lactation breaks are appreciated, albeit fairly rated, and private rooms again are appreciated, but rare. More broadly women value support in their decision, both from their employers but also their partner and wider family [45].

Facilities on site to support breastfeeding can increase breastfeeding duration. When workplaces have breastfeeding rooms and breast pumps, employees breastfeed for longer [123]. Some organisations go as far as offering breastfeeding education classes during pregnancy, and access to a lactation consultant after the birth, which is associated with increased breastfeeding rates at 6 months [124].

9.3 Familial Influences

Significant predictors of many psychological models of behaviour are the attitudes and behaviours of those around an individual. Research has shown that the attitudes of a woman's partner and her own mother predict her attitudes towards breastfeeding and whether she is likely to initiate or continue to breastfeed. In short, positive attitudes and support are protective of breastfeeding, while negative attitudes can be significantly anxiety provoking and damaging.

9.3.1 Fathers/Partner

Key influences on breastfeeding success are the attitudes and behaviours of a woman's partner. When fathers are supportive of breastfeeding, a mother is far more likely to initiate and continue breastfeeding [26]. Moreover, the majority of fathers state that they want their baby to be breastfed or at least respect their partner's decision to do so [125]. The most supportive fathers act in ways that boost maternal confidence, providing both practical support and emotional assistance [126]. Fathers who can act as an advocate for the mother are important to breastfeeding success [127]. However, attitude and behaviour are not necessarily linked, and not all fathers want or are supportive of their infant being breastfed.

Fathers who themselves were breastfed are significantly more likely to be supportive of breastfeeding, perceiving it to be normal, and more likely to have had experience of breastfeeding in their wider family. Those who were breastfed are more likely to hold positive attitudes of breastfeeding in public and do not feel embarrassed when their partner breastfeeds in front of others [128]. Some however, are disinterested or have no opinion, particularly if they are younger fathers [129].

However, although many fathers state that they want to support breastfeeding, many struggle with how to do this, feeling helpless and unprepared. Others fear doing the wrong thing or take control, wanting to fix the problem rather than supporting the mother emotionally [128]. Despite wanting their infant to be breastfed, many feel unsettled by the reality reporting that they feel excluded, voicing concerns over bonding. Some report feeling jealous of the mother and her perceived bond with the infant [130]. Others feel embarrassed or unsettled at the mother breastfeeding in public, particularly in front of friends and family [128].

Often fathers are excluded from breastfeeding antenatal education, fuelling feelings of being left out and resulting in them having a poor understanding of breastfeeding and its mechanisms. Many report wanting this additional information so that they can support their partner with issues that arise [131]. This lack of understanding about the wider role of breastfeeding support can increase the likelihood of fathers wanting to specifically fix issues rather than support the mother more broadly [132].

9.3.2 A Woman's Own Mother

Infant feeding decisions are significantly affected by familial patterns and traditions. One of the biggest predictors of both breastfeeding initiation and continuation is whether a woman was herself breastfed. If a mother herself was not breastfed, the amount of contact she has with her mother predicts her breastfeeding duration; more contact and she is less likely to breastfeed [133]. This is in part due to the knowledge and experience the grandmother would have gained. Grandmothers who themselves have breastfed will be more able to offer support around feeding patterns and issues such as latch [134]. However, it is also linked to attitudes. Mothers value acceptance and encouragement from their mothers [135].

Unfortunately, due to low breastfeeding rates in the 60s, 70s, and 80s, many of today's mothers were not breastfed themselves. When a grandmother only has experience of using a bottle, it is easy to suggest that as a solution to her daughter's problems. A lack of understanding around how breastfeeding works and the damage non-responsive feeding can do, may lead to grandmothers suggesting a bottle if a baby feeds frequently, does not sleep, or simply as a means to give the daughter some time away from feeding. These additional bottles can however damage mothers' milk supply [135].

Families are, however, not always supportive of breastfeeding. Many studies suggest that grandmothers will actively try and dissuade their daughter from breastfeeding if they don't agree with her decision [136]. This impact is most strongly seen for younger mothers who are likely more reliant on their own mother, potentially financially as well as emotionally. Challenging negative attitudes towards breastfeeding can seem impossible to mothers who are not independent, and younger mothers do often listen to the advice of their own mother rather than to that of health professionals [137]. This can have a direct impact; a study which used a counselling intervention to support younger mothers to initiate and continue breastfeeding worked well as long as the mother was living independently. When she was still living with her own mother, the intervention failed [138]. Interventions that target the wider family are therefore critical.

9.4 Ethnicity, Acculturation, and Religion

Much of the above discussion has focused on the issue of low breastfeeding rates in Western countries in predominantly white communities. However, breastfeeding rates, practices, and attitudes are significantly intertwined with ethnicity, the degree of acculturation to a country, and religious practices. Breastfeeding rates might be optimal in terms of duration in many non-Western regions, but practices are not always so. Significant sociocultural barriers within these communities contribute to perceptions around breastfeeding and breast milk.

9.4.1 Ethnicity in Western Regions

An interesting pattern can be seen in breastfeeding rates between different ethnic groups, dependent on the country in which they live. In the UK, White British women have the lowest levels of breastfeeding, with women from European, Black, Asian and Chinese families initiating breastfeeding at higher rates and doing so for much longer durations. For example, in the UK, 97% of women from a Chinese background initiated breastfeeding, 96% from a black background, and 95% from an Asian background compared to 79% of White mothers [11]. Similarly, in Ireland 49% of mothers from White Irish backgrounds initiated breastfeeding at birth compared to 86% of those from other White backgrounds. African or black women had a 92.5% initiation rate while Chinese and Asian women a 91.5% rate. Irish born mothers were significantly less likely to initiate or continue breastfeeding compared to those who were born outside of Ireland. Only 50% of Irish born mothers initiated breastfeeding compared to 89% of those born outside of Ireland. Again, the longer a mother lived in the country, the less likely she was to breastfeed [139].

Why do these differences occur? One reason is a strong family history of breastfeeding, particularly if women were born in a country where breastfeeding is the norm. There are also ties with religious practice, which we will consider in the next section. In an earlier version of the infant feeding survey, mothers from Indian, Pakistani, and Bangladeshi felt that they would have breastfed for longer if they had given birth in their home country. Reasons given included cultural norms, greater knowledge, and increased exposure to breastfeeding for both mothers and fathers [140]. Moreover, mothers who move to another country but keep ties to their heritage, have stronger breastfeeding rates. In Australia, Arabic and Chinese speaking women were more likely to initiate and continue breastfeeding than English speaking women [141].

A woman does not have to belong to an ethnic group with high breastfeeding rates to be influenced by practices. In the UK, White women who have a partner from a different ethnic group are more likely to breastfeed than if their partner was also White. Breastfeeding rates were also higher among White single mothers, when they lived in high ethnic communities [142]. This suggests that community norms – whether that is an ethnic community or a physical one – impact on attitudes and support to breastfeed. Conversely, in the USA, women from Black American backgrounds are significantly less likely to initiate or continue breastfeeding than both White Americans and Hispanics [143]. This leads to significant health disparities between Black and Hispanic groups, despite having significant poverty levels. Health outcomes for Hispanics are significantly better than their income levels would predict. Known as the "Hispanic paradox", this can at least in part be explained by long durations of breastfeeding in infancy [144]. Mothers born in the USA are also significantly less likely to initiate or continue breastfeeding compared to foreign-born mothers. In fact, the odds of an American-born mother initiating breastfeeding are reduced by 85% compared to those born outside the USA [145].

Why do women from Black American backgrounds have lower breastfeeding rates? In the US, women from African American groups report different levels of engagement with Women, Infant, and Children services compared to White women, with lower rates of breastfeeding advice received [146]. Other research with Black mothers reveals that they felt that unless they initiated a conversation with health professionals about breastfeeding, no one would talk to them about it under the presumption that they would not want to do it. Others felt that the image of the strong Black woman meant that African American women treasured their independence and did not want to ask for help with problems [15]. Racially biased healthcare, whereby Black Americans do not get access to the same support or quality of information compared to women from other ethnic groups, is an issue across the healthcare system particularly in America [147].

In an in-depth study of African American mothers, a common theme was that of not viewing other Black women breastfeeding. They were not exposed to positive photos or other images of Black women breastfeeding in the literature or on the Internet. Black women are also more likely to be in lower paid jobs with long hours, returning to work within 6 weeks after the birth. They were worried about raising legal rights because they feared losing their job. Historical issues with slavery play a major role, particularly for older generations. It was not so long ago that Black women were required to nurse White women's babies, and the connotation between breastfeeding and slavery has remained. Grandmothers in particular, some of whom may have been wet nurses themselves, hate the idea of breastfeeding and see formula feeding as a freedom [15]. Black women are also more likely to experience a series of health problems that can make breastfeeding more difficult. These include an increased risk of poor perinatal health, chronic illness, depression and stress, all of which can make the experience of breastfeeding more difficult [148]. Poverty also plays a major role [149].

9.4.2 Acculturation

Acculturation occurs when immigrants to a country start to adopt the practices, attitudes, and beliefs of the country they have moved to. This can be positive or negative, but for many women moving to a Western country, the impact on breastfeeding rates is typically damaging. For example, although those born outside of the USA have higher breastfeeding rates than those mothers born in the USA, the odds of a foreign-born mother breastfeeding decrease by 4% for each year she lives in the USA. Notably, a similar pattern was seen for every year an immigrant father lived in the USA [145].

Why does living in another country affect breastfeeding rates? Firstly, acculturation can mean that the mother adopts the negative breastfeeding practices of the country or experiences the same barriers as those of women born in the country. Secondly, they can be exposed to new negative beliefs and start to become anxious that these are true. In a study of Somali women in Norway, one mother noted that the concept of not having enough milk was alien back in Somalia, but that this worried many of her new peers. Finally, the stress of being in a new environment can make breastfeeding challenging, particularly if a mother is taken from the support systems in her home country [150].

9.4.3 Religious and Cultural Beliefs

Cultural beliefs and normative behaviour have a very powerful impact on human behaviour, particularly in relation to nutrition [151]. References to breastfeeding are present in many historical and religious texts. For example, the UK and USA could very much be seen as a formula feeding cultures today, although historically, views around breastfeeding and breast milk have not always been this way in these countries. In England and America, in the 18th century, breast milk was seen as a medicine, having restorative powers for adults who were sick or older. Breast milk was believed to cure infections and references are often made to its power to cure eye infections, something still used today. Breast milk from another woman was thought to speed up childbirth. Writing in early texts romanticised breastfeeding as the ultimate expression of love [152].

References to breastfeeding as something to be treasured and protected also occur throughout the texts of the major religions. References to breastfeeding are made throughout Christian religious texts, and it is mentioned throughout the bible in reference to love, calmness, and security. Religious imagery often showed infants being nursed [152]. However, references to breastfeeding in Hindu and Muslim texts are of considerably greater depth.

In Hinduism, the primary sacred texts are the Vedas (1800 BC), which consists of four texts: Rig Veda, Sama Veda, Yajur Veda, and Atharva Veda. Alongside this, ancient Ayurvedic writings are followed, including writings from paediatricians, surgeons and Acharya Charak considered the Father of Medicine [153]. There are no references in these texts to bottle feeding, although wet nurses are often referred to. Throughout these writings breast milk and the breast are mentioned in terms of longevity and sweetness, describing the breast as a pitcher full of nectar. Breast milk is life giving; when the Goddess Parvati, wife of the Hindu God Shiva, creates the baby boy Ganesh out of her dress, Ganesh comes to life only when she puts him to her breast [154]. Reference is also made in Hinduism to the importance of caring for the mother after birth. In Hindu culture, a mother is protected to rest for 40 days after the birth. During this period, she is excluded from housework to recover from the birth and care for her newborn. She will be offered regular meals, but also special foods that are believed to increase the quantity and quality of her milk, including dried fish, dahl, and eggplant [154].

In Islam, the Koran states that mothers should breastfeed for two years. Breast milk is seen as God's gift for the baby, so the mother has an obligation to God to breastfeed. Breastfeeding is seen as passing the mothers wealth onto the baby. Most Muslim women believe they will be punished if they do not breastfeed and fulfil this obligation [155]. Muslims are required to fast between the hours of sunrise to sunset during the month of Ramadan. Exceptions are made, including for breastfeeding women. However, many who are exempt still fast; one study found that around 50% of breastfeeding women still fast. Notably, one-third of those who said it was acceptable for breastfeeding mothers not to fast were still fasting [156].

Religious texts are therefore generally very positive about breastfeeding, seeing it as something to be protected and encouraged. This may in part explain the higher levels of breastfeeding among communities that have high adherence to Islam and Hindu beliefs and practices. However, breastfeeding practices are not optimal despite the fact that in many African, Asian, and South East Asian communities, breastfeeding rates are almost universal and long term, with little use of formula milk. The World Health Organization (WHO) recommends that babies are exclusively breastfeed, with breastfeeding starting within the first hour of life. Initiating breastfeeding after the first hour doubles the risk of mortality [157]. However, only 41% of babies in South Asia are breastfed within one hour of birth [14]. In Ethiopia, children who receive prelacteal feeds are nearly twice as likely to be stunted (low height-for-age) compared to those who do not receive them [158]. Non-optimal breastfeeding practices are often embedded in religious or cultural practices, or norms of the community in which a woman lives.

Firstly, delaying breastfeeding until after a certain event or number of days is common. Some Hindu medical literature suggests that breastfeeding should not be started until the third day, although others recommend feeding on the first day [154]. In rural Ghana, first time mothers must go through a cultural cleansing process before they can breastfeed. This involves pouring warm herbal water over the mother, for three days if the baby is male and for four days if the baby is female. The baby will either be wet nursed or fed herbal tea while this occurs [159]. In the Haryana tribe in India, a common practice is not to initiate breastfeeding until stars have been seen in the sky. If a baby is born in the morning, the mother should not breastfeed until that evening but if the birth is at night, breastfeeding can start sooner [160]. Muslim societies hold a call to prayer ("Adhan") five times a day. It is believed that breastfeeding should be started after three Adhan calls. This means that babies will not be breastfed for 8–16 hours after the birth. Waiting until this time means that babies will be patient and more resistant to hunger [161].

Secondly, many cultures particularly in Africa and Asia, discard colostrum despite its immune properties, believing it is dirty or too thick based on its colour and consistency [162]. Others believe colostrum holds no nutritional value, may make babies sick or even bring bad luck [163]. Some cultures believe that colostrum has been stored in the breast for the entire pregnancy and is therefore unsafe or "dirty water". In Turkey, older generations particularly recommend a mixture of butter and sugar water that is thought to prevent vomiting [161]. Some believe colostrum may kill the newborn because it has been stored for 9 months in the breast and is dirty [164]. Similarly, in Indonesia, around one-fifth of mothers' discard colostrum, believing it to be indigestible, "cheesy" or dirty; children who drink it will suffer from stomach ache or be "stupid" [165].

A study in rural Northern Ghana highlighted a practice of expressing colostrum and putting black ants in it to test for bitterness. If the ants crawl out, the breast milk is considered acceptable; if the ants die, the breast milk is considered bitter, dirty and poisonous, and could make the baby ill or even die. Before she can feed her baby, the mother must go through a ritual to purify the milk. This involves using herbs or shea butter to wash her breasts. The ritual lasts three days if the mother has a boy, and four days if the mother has a girl [159]. A lighter version in Hindu literature suggests that the mother should express a few drops at the beginning of each feed to purify the tubules [154].

Thirdly, prelacteal feeds are common in many African, Indian, and South East Asian regions. Estimations range from around 60% in Nigeria [166] to 27% in Nepal [167]. Perceptions that infants are born hungry and need immediate feeding can lead to prelacteal feeding, with foods such as porridge, salt or sugar often given in many African and Indian communities. Prelacteal feeds may be given because of rituals that delay breastfeeding until a certain time or discard colostrum. They are closely tied to religious practices, and those who follow the religion of Islam are more likely to give prelacteal feeds than those who follow Christianity [166].

However, prelacteal feeds are often given for other reasons. Different prelacteal foods are perceived to have different benefits, such as honey and ghee that are believed to help the infant pass meconium [154]. Others believe that these feeds can cleanse the infants stomach [168]. In Pakistan, prelacteal feeds are often given via a finger of an elderly person and believed to clean the stomach and strengthen the newborn [169].

Prelacteal feeds are frequently part of religious ceremonies. In Hinduism, the child is welcomed into the family during a traditional ceremony called Jatakarma. Here, a family member who is seen to have "virtuous qualities" writes the word 'Om' onto the infant's tongue using jaggery (unrefined brown sugar) dipped in ghee. This is believed to pass the person's good qualities on to the baby. Additionally, the father uses his fourth finger and a gold rod to give the baby honey or ghee. If the baby is a boy, the father uses a golden spoon. This ritual is believed to give wisdom, longevity, and protection from the gods [154].

Cultural beliefs also exist as to when it is appropriate to breastfeed, and these can be very different to those in Western culture. In Kenya, some mothers fear breastfeeding in public, although this is not due to societal beliefs around its acceptance. Some believe that breastfeeding in public might lead to people with an 'evil eye' watching them. The evil eye represents a malevolent gaze, which passes on a witchcraft curse and leads to milk drying up or breast sores. Actions and emotions are also believed to affect breast milk. Research in two slums in Kenya found that women talked about how milk can become "unclean" if a woman has an extramarital affair. Such affairs lead to the curse "chira", which may cause the infant's death. Some perform cleansing rituals to clean the mother (and her milk), but a community stigma still exists that if a woman has sex with multiple men her baby will die. Mothers should not breastfeed if they have an argument with their spouse, family or other community members until they have performed a cleansing ritual. This often involves eating herbs in a special remedy known as "manyasi" [162].

Finally, beliefs around the impact of breast milk sharing can affect decisions about breast milk donation. In Islam, children who are breastfed by the same women are considered milk siblings. Under consanguinity laws this means that they are unable to marry. Mothers must therefore be known to each other to prevent such marriages. There has been considerable discussion over just how many feeds a baby must receive before they are considered milk siblings; some suggest just one, while others suggest at least five or up to ten times. Others suggest to consider feeds over a sustained period, such as for ten consecutive feeds or all feeds over a 24-hour period [170].

A further debate is how breast milk is given. Some suggest that if milk is expressed and given in a bottle or cup then this milk-sibling relationship does not occur. This has considerable implications for donated breast milk for premature and sick babies. Some suggest that sufficient milk must be given from one mother to 'build flesh and bone'; donated breast milk from a breast milk bank is therefore acceptable, because the milk given is from a mixture of milks from different women, so no one woman's milk would contribute sufficiently to the infant's growth. However, others see this as unacceptable, because it is not possible to trace who the milk came from [171].

This concept is not constrained to religion. In many cultures, those who have fed from the same mother are believed to have a special bond [170]. Some hold the same view that marriage should be avoided between those who have received milk from the same mother, and have customs that wet nurses should therefore only nurse a child of the same gender to avoid this [172]. Others are more relaxed, seeing instead only a special bond. In Turkey, for example, those who have shared the milk of one woman are considered to be friends for life. Among older generations in Poland today, men who have been breastfed by the same woman consider themselves milk brothers [156].

9.5 The Way Forward

The attitudes and beliefs of societies and cultures, both towards breastfeeding and wider connotations of motherhood, therefore have a significant impact on breastfeeding initiation and continuation. These show that breastfeeding is not simply a biological issue that can be fixed with practical support. Yes, good quality hospital and community support with breastfeeding are important, but at the same time, we must change the environment in which a woman breastfeeds. As UNICEF Baby Friendly UK note in their Call to Action:

> *'It is time to stop laying the blame for a major public health issue on individual women, and instead work together to build a supportive, enabling environment for women who want to breastfeed.'*

Specific interventions that might work should focus on educating the society around the mother, rather than the mother only. Further legislation is needed to support women to breastfeed on return to work. Ideally, maternity leave would be extended to the levels seen in Nordic regions, including paternity leave. Mothers should not need to return to work for financial reasons when they are predominantly breastfeeding their baby and sleep deprived. Particular focus should be given to the disparity between ethnic groups in the USA, protecting those women with very low incomes, especially those from Black backgrounds, enabling them to spend longer with their infants rather than returning to work in the early weeks after birth.

Public health campaigns should focus on promoting women's legal protection to breastfeed making public spaces more breastfeeding friendly. Further imagery is needed of breastfeeding – in the media, literature, and public spaces. If we want the breast to be associated with breastfeeding as well as its sexual function, it must be shown this way. Moreover, showing breastfeeding is the only way to make it more acceptable and normal [110]. Seeing breastfeeding works. In one study, young mothers were encouraged to look through a photo album containing photographs of mothers breastfeeding and interacting with their babies. After viewing these, the mothers were more likely to state that they planned to continue breastfeeding [173].

Fathers and grandmothers should be included in breastfeeding education. In Australia, attending antenatal and postnatal breastfeeding classes increased breastfeeding at six weeks [174]; teaching fathers to identify and manage breastfeeding problems increased breastfeeding rates at six months [175]. Another study saw a rise in exclusive breastfeeding rates when fathers attended antenatal classes with their partner [133]. Educating grandmothers about breastfeeding has been shown to increase their knowledge of breastfeeding but not change their attitude [176]. However, caution is warranted as some research has suggested that paternal involvement in infant care can lead to lower breastfeeding rates [177] and that grandmother's own preference dictates whether she will be supportive [176]. Criticism has also been raised in that men and women often have different preferences in learning style and approach, so messages can be interpreted differently. Additionally, some women may feel uncomfortable discussing breastfeeding when men are present, due to cultural and societal connotations of the breast [178].

In terms of religious and cultural beliefs, these are a sensitive issue. However, in terms of non-optimal feeding practices, education is key. Prelacteal feeds and discarding of colostrum are particularly related to the attitudes and presence of grandmothers and traditional birth attendants [179]. Fathers are also a major influence. In rural Ghana, attitudes of the father strongly predict breastfeeding; over 98% of babies are breastfed when the father approves, but only 27% when he does not [180]. Educating the wider community will help to support more optimal practices. Meanwhile, home deliveries make it particularly likely that these feeding practices will be adopted. Helping more women to access healthcare may reduce occurrence [181]. For example, a lack of understanding about the risks of prelacteal feeding significantly increases the likelihood that infants will receive these feeds. A study in Ethiopia found that mothers who had not heard of the risks of prelacteal feeding were 3.7 times more likely to give such feeds [168].

On a wider note, prelacteal feeds, delaying the first feed, and discarding colostrum are all reduced when mothers have a higher level of education [166]. Wider education for all in the community, alongside greater access to healthcare services may reduce these practices. Finally, exposure to formula advertising, which can have a devastating impact in developing countries, is also related to giving prelacteal feeds. Ensuring adherence to the WHO code may protect more families from this practice [182].

Brazil is an excellent example of how implementing such a society-wide approach significantly increases breastfeeding rates. In 1986, median duration of breastfeeding was 2.5 months, but by 2006 had risen to 14 months. Exclusive breastfeeding rates to four months also increased from 4% to 48%. To make this happen, the government invested heavily in promoting breastfeeding at the societal level, including multi-organisation working, media campaigns, training of health workers, and the development of mother-to-mother support groups. Policy wise, a strict enforcement of the International Code was introduced, maternity leave was extended to six months and more than 300 maternity hospitals gained Baby Friendly Hospital Initiative certification. Investment in over 200 human milk banks led to Brazil having the highest number of milk banks in the world. The combination of these interventions led to their success, along with the fact that they did not focus solely on maternal knowledge but focused on the mother's wider environment and support system, enabling her to breastfeed her baby [183].

In summary, interventions to raise breastfeeding rates in Western cultures and improve breastfeeding practices in developing regions are desperately needed. These should however focus not only on practical support with physiological issues, but look to the wider societies, cultures, and communities in which breastfeeding occurs. Governments must invest in breastfeeding to support mothers, babies, and future population health. The return will be priceless.

9.6 Summary

Breastfeeding cannot be considered as simply a physiological issue; numerous social and cultural factors affect both maternal attitude towards breastfeeding and its success. Breastfeeding works on a demand and supply basis, and responsive feeding enables the best possible milk supply, infant weight gain and ease of experience. However, numerous socio-cultural factors affect knowledge, desire, and ability to breastfeed responsively, leading to its discontinuation.

In Western culture, attitudes towards breastfeeding are often adverse. Sexual connotations surrounding the breast, fears of breast milk as a bodily fluid, and poor acceptance of breastfeeding in public lead to formula use. Interventions must target public health promotional messages and create “safe” spaces for women. Wider pressures on mothers in modern society can make them feel that breastfeeding is impossible. A lack of care for new mothers and dispersed families can lead to maternal exhaustion and the cessation of breastfeeding. Similarly, a need or desire to return to work can result in the avoidance of breastfeeding, as it is perceived as being too difficult to juggle both. Greater investment in mothers is needed in terms of healthcare and extended leave.

Breastfeeding attitudes and norms are strongly tied to ethnicity. In the UK, white British mothers have the lowest breastfeeding rates; both initiation and continuation are far higher in women from Black, Asian, and Chinese backgrounds, predominantly due to cultural norms and support in their communities. Conversely, in the USA, women from Black American backgrounds breastfeed for significantly shorter durations, affected by historical norms around slavery, poorer healthcare and poverty.

Although breastfeeding duration is optimal in developing countries, many sub-optimal breastfeeding practices, such as delaying the initial feed, discarding colostrum, and giving prelacteal feeds, place the infant at risk. These practices are strongly tied to religious and cultural norms and must be treated sensitively. However, greater access to healthcare and education, particularly for older women in the community, help reduce their occurrence.

Overall, governments must recognise the importance of creating environments that are conducive to breastfeeding. Practical support is not enough. Investment works; countries that have adopted a systems approach to raising breastfeeding rates have seen increases in breastfeeding and thus in population health.

Key Points

- There is indication that several socio-cultural themes influence a mother’s decision to breastfeed. Initial understanding shows that in high income societies, sexual connotations, fear of breast milk as a bodily fluid, and poor acceptance of breastfeeding in public seem to play a key role in choosing to use formula. Whereas in low/middle income countries cultural/religious beliefs seem to be more important. Family influence and work-related issues play an important role irrespective of geography
- Education needs to focus on all factors to assist mothers to make an informed choice
- Governments must recognise the importance of creating breastfeeding-friendly environments by implementing practical support, investment, and a multilevel, multidisciplinary approach to increase breastfeeding rates

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10 Breastfeeding Promotion: Politics and Policy

Ashley M. Fox, PhD, MA

Expected Key Learning Outcomes

- The key political discussion points in relation to breastfeeding
- The main women's rights issues facing mothers wishing to breastfeed
- How focusing on the rights of the child can have a negative impact
- The effect human rights campaign has had on breastfeeding
- The political actions that could support breastfeeding promotion

10.1 Introduction

To assess the barriers to more widespread adoption of breastfeeding promotion policies internationally, this chapter approaches the issue of human lactation from a political perspective. Research has shown the benefits to infant survival of early and sustained breastfeeding, particularly in low- and middle-income countries (LMIC), as well as sustained benefits throughout the life cycle. UNICEF has boldly declared that 'breastfeeding saves more lives than any other preventive intervention' and the World Health Organization (WHO) recommends exclusive breastfeeding for the first six months of life. In spite of the purported health benefits of breastfeeding, policies that protect and promote breastfeeding vary widely across countries and breastfeeding promotion efforts face a number of obstacles.

This chapter reviews the literature on breastfeeding politics and policy. The paper suggests that breastfeeding promotion policies have not been more widely adopted because of the different ways in which breastfeeding has been framed, and its degree of contentiousness, at specific time points in its history. Drawing on Stone's concept of "causal stories", the chapter argues that the success of breastfeeding advocacy groups at raising attention to breastfeeding will hinge on the way the problem is framed, successful identification of "villains", and matching of solutions to the problem. As Stone [1] tells us:

> *'Problem definition is a process of image making, where the images have to do fundamentally with attributing cause, blame, and responsibility. Conditions, difficulties, or issues thus do not have inherent properties that make them more or less likely to be seen as problems or to be expanded. Rather, political actors deliberately portray them in ways calculated to gain support for their side. And political actors, in turn, do not simply accept causal models that are given from science or popular culture or any other source. They compose stories that describe harms and difficulties, attribute them to actions of other individuals or organizations, and thereby claim the right to invoke government power to stop the harm.'*

The chapter identifies three primary causal stories that have been used to frame breastfeeding as a problem; each causal story describes different primary causes of the problem, which imply different potential policy solutions. These include framing the problem from the angles of "women's rights", "children's rights", and "global human rights". Breastfeeding promotion has passed through several "frame contests" (i.e., contested understandings of the nature of the problem) that have at times advanced the issue dramatically, and at other times led to conflict. It is important to understand these different frames because knowing what factors draw attention to an issue, and which factors make the issue contentious and less attractive, can influence the degree of traction the issue receives from governments and the success of breastfeeding promotion activities.

These frames each place blame, cause, and responsibility on different actors (including the so-called villains – ▶ Table 10.1). When framed as a women's rights issue, gender inequality, patriarchal culture, and prudish Western attitudes towards breasts and women's bodies become the principle source of contention. Breastfeeding advocates look to work-related policies and protection in public spaces to normalise the act of breastfeeding and link it more broadly to gender equality and equal participation in society.

By contrast, in the children's rights frame, mothers who choose to work or to bottle feed rather than breastfeed for reasons of convenience are considered the principle reason for low breastfeeding rates. Thus, efforts are targeted at making replacement feeding less convenient and harder to

▶ **Tab. 10.1** Summary of characteristics of different breastfeeding issue frames.

Issue frame	Villain	Causal story	Policy solutions	Tensions/trade-offs
Women's Rights	Patriarchal/ puritanical/ male-dominant culture	Women would breastfeed more but male-dominant, corporate culture restricts their ability to do so; women's breasts have been sexualised; breastfeeding represents a woman's re-appropriation of her body	Work-related policies (e.g., paid maternity leave, flex time, pumping breaks); reform of indecency laws and the creation of a supportive culture and environment for breastfeeding; re-normalise breastfeeding	Women may not want to take time off to breastfeed; breastfeeding reinforces gendered division of labour; it assumes all women have equal choice
Children's Rights	Mothers who do not breastfeed	Women choose to work for "convenience" rather than to breastfeed; women may underestimate their ability to breastfeed	Fear-factor approach, i.e., scare women into breastfeeding; exaggerate research claims; promote breastfeeding in hospitals; limit access to feeding alternatives	Privilege the child's welfare over the mothers; use of shame and fear to motivate action; research on the benefits of breast vs bottle is weak, and is based more on ideology and cultural assumptions than on solid evidence
Global Human Rights	"Greedy" transnational formula companies	Under the guise of helping women that cannot breastfeed and their babies, greedy transnational companies spread their "lethal" wares (formula) on unsuspecting mothers. They are directly responsible for millions of deaths globally that result from unsafe use of replacement feeding	Global Policy Agreements (e.g., International Code on the Marketing of Breast Milk Substitutes); Innocenti Declaration; Baby-Friendly Hospital Initiative	Ignores the underlying problem of lack of clean water and sanitation but instead scapegoats formula companies; glosses over the reality that women in LMICs may also experience trouble breastfeeding and that low rates of exclusive breastfeeding may be due to causes other than formula; neglects the difference between urban, affluent women (whose risks are closer to those in the global North) and poor, illiterate, rural women; creates a double standard, i.e., the risk to babies in HICs is not equivalent to the risks to babies in LMICs

HIC = high-income countries; LMIC = low- and middle-income countries accomplish by policies that include prescriptions for formula, and restricting the point of sale and advertising of formula.

In the global human rights frame, "third world" women are depicted simultaneously as "good" mothers for their relatively higher breastfeeding rates and as "victims" of greedy transnational corporations seeking profit at the expense of the health and wellbeing of infants. Policies to promote breastfeeding in this context include limiting the availability of substitute feeding, implementation of "baby-friendly" hospitals, and development of the International Code of Marketing of Breastmilk Substitutes. However, this framing of the problem may not be sufficiently attentive to the needs of women in LMICs. For these women, replacement feeding is not merely a question of convenience or autonomy. It may be a matter of life and death for their infants due to conditions of extreme poverty. Wider attention to policies that confront these conditions of poverty and adapt pro-breastfeeding messages to the social context may be warranted.

Across all three frames, the corporate villain is an easy and ready target, putting profit above the health and welfare of mothers and babies, and aligns these three perspectives. The marketing, advertising, and promotion of formula are targeted as a convenient scapegoat. However, this villain identification may also gloss over important differences in the problem definition and policy responses between high and low income settings.

This chapter provides a critical viewpoint on these three frames – women's rights, children's rights, and global human rights. It suggests that the breastfeeding advocacy movement adopt more of a "harm reduction" approach to breastfeeding, balancing the benefits of exclusive breastfeeding against the real-life challenges of breastfeeding that make bottle-feeding appealing and sometimes necessary.

10.2 The Three Frames of Breastfeeding Politics

10.2.1 Breastfeeding as a Women's Rights Issue

When framed as a women's rights issue, gender inequality, patriarchal culture, and prudish Western attitudes towards breasts and women's bodies become the principle arguments around breastfeeding. Radical feminist thinking has embraced breastfeeding, and considers it as a means of reappropriating and desexualising women's breasts, representing women's rights to control their bodies (Attar, 1988, cited in Carter 1995 [2]). Van Esterik's tome on breastfeeding of 1989 [3] embraces this framing. She refers to notions of "mother power" in reclaiming natural womanhood of which women have been deprived as the cultural context has shifted towards greater acceptance of bottle over breast. Likewise, Marxist feminists have focused attention on the ways in which capitalist development has led to commercialisation of breast milk products that devalue natural products like mother's milk. Changing production modes have contributed to the devaluation of women's unpaid work within the home (including child care responsibilities and breastfeeding) as compared with paid work in the private sphere. Breastfeeding has thereby come into conflict with male-dominant workplace environments with little work-life flexibility or private space for women to express milk. To gain acceptance and equality in the workplace, and to keep up with the declining value of men's paychecks, women are increasingly torn between employed work and family demands while workplace policies have not evolved to meet this new reality [4].

This framing views breastfeeding politics as an expression of women's empowerment and breastfeeding promotion policies. Such politics are essential to giving women choices over how to use their bodies, with milk substitutes providing an "illusion of liberation" only [5]. For breastfeeding rights activists, or "lactivists", breastfeeding represents a protest against a culture that is friendly towards bottle feeding and hostile towards breastfeeding; it also represents a reclaiming of public spaces to make them less hostile towards infant feeding [6]. According to Hausman [7], lactivist feminists tend to see a culture that favours infant formula and is beset by barriers to breastfeeding, be it in homes, workplaces, or in public spaces where the women's right to feed their infants is frowned upon [8].

Moreover, in this framing of the problem, mothers making decisions about infant feeding or breastfeeding their newborns are faced with dissonant messages. On the one hand, they recognise the medical benefits to breastfeeding and desire the opportunity to provide this benefit to their infants but, simultaneously, face the reality of social structures that erect barriers to its practice. The choice to breastfeed is in this frame may therefore be viewed as a form of protest that seeks to redefine women's bodies and the lines between public and private spaces.

Though often treated as separate from the natural childbirth and "back to nature" movements, the choice to breastfeed can similarly be viewed as a rejection of the medicalisation of childbirth [2]. The women's liberation movement encouraged women to gain knowledge and power, and avoid unnecessary childbirth interventions. Resistance to formula feeding by lactivists has also been seen as a means to avoid unnecessary medicalisation of their infants and thereby reclaim breasts for their "primary" physiological function (as opposed to their secondary function as sexual objects) [2].

The "breastfeeding as a woman's right" frame also points to the benefits of breastfeeding not only for the baby, but for the mother. Breastfeeding advocacy movements employ a series of instrumental arguments to convey breastfeeding benefits for both infants and mothers. For example, such benefits include weight loss, uterus contraction for faster postpartum recovery, cost-effectiveness, promotion of infant bonding, and a possible risk reduction for breast and cervical cancer. (See, e.g., WebMD's description of the benefits of breastfeeding for women: http://www.webmd.com/parenting/baby/nursing-basics). Breastfeeding is also framed in some circles as a form of activism against a bottle-dominant, capitalist, convenience culture. In short, in this framing of the issue, breastfeeding is consistent with, and can be used to elevate and advance, women's autonomy.

The women's rights frame blames a male-dominant, patriarchal culture that sexualises women's breasts, and the insufficient action by governments to promote and normalise breastfeeding. The causal story views declining breastfeeding rates as emanating from effective marketing campaigns, workplace norms that lack accommodation for breastfeeding mothers, and cultural ambivalence about maternal bodies [7]. The locus of blame in this framing is on the government and their complicity in failing to bring the state's regulatory framework to take action, such as compelling employers to offer maternity leave and provide private space for breast milk expression, and reform public decency codes to create areas for breastfeeding.

Available solutions therefore focus on efforts to provide breastfeeding-friendly public spaces, workplace accommodation for pumping, paid maternity leave, and subsidies for breast pumps. Each of these solutions are considered to advance women's rights and autonomy, and foster an environment that goes beyond equality and include women's "capabilities" to breastfeed [9]. Cook (2015) argues against a women's "right to breastfeed", noting that legal rights alone may be inadequate to counteract cultural attitudes against breastfeeding without an understanding of the lived experience of breastfeeding mothers. She argues instead in favour of a liberal "capabilities" approach, drawing on the work of Martha Nussbaum.

10.2.2 Breastfeeding as a Children's Rights Issue

A second framing of breastfeeding focusses on the baby. This framing is often written from the perspective of the medical community and organisations dedicated to improving child health such as UNICEF. It emphasises the health benefits of breastfeeding for infants and children throughout the life span. Policy actors operating in this frame build their case for breastfeeding on literature reciting the purported health benefits associated with breast over bottle feeding. These include the prevention of dermatitis, allergies, sudden infant death syndrome, respiratory illnesses, malnutrition, colic, eczema, Crohn's disease, and asthma, and general strengthening of the immune system (thus reducing, for example, ear infections). Mothers who breastfeed will allegedly have more intelligent children than mothers who bottle feed, and exclusively breastfed infants may benefit from lower rates of future obesity and diabetes. These claims can be found in various official documents on infant feeding, for example: UNICEF (2011a, 2011b) [23], [24]; UK NHS (2011a, 2011b) [25], [26]; Stockholm Health Care Guide (2011a, 2011b) [27], [11]; La Leche League (2006) [28] and are more closely scrutinized by a set of critical literature presented later in the chapter.

Evidence for the superiority of breast milk over bottle feeding also relies on "naturalising" breastfeeding. According to proponents of the children's rights frame, breastfeeding fulfils nature's intended purpose for the female breast, providing the perfect food that 'emanates on demand from the breast and is continuously changing to meet the exact needs of both mother and child' [10]. By contrast, proponents of the children's rights frame denaturalize "artificial" bottle feeding as 'giving a child a processed fluid through a piece of rubber' [10].

The benefits of breastfeeding for the child identified in the biomedical literature have been distilled into official state policy at both national and global levels. The WHO and UNICEF promote breastfeeding, declaring that 'exclusive breastfeeding for 6 months is the optimal way of feeding infants', and that 'thereafter infants should receive complementary foods with continued breastfeeding up to 2 years of age or beyond'. (See WHO website on Exclusive Breastfeeding: http://www.who.int/nutrition/topics/exclusive_breastfeeding/en/). Moreover, to enable mothers to achieve this goal, WHO and UNICEF recommend 'breastfeeding on demand — that is as often as the child wants, day and night', and 'no use of bottles, teats or pacifiers'. The 'Breast is Best' slogan is a social marketing tool that has been used to promote breastfeeding in the USA and the UK. The official Swedish policy is that breastfeeding is the best option for babies and that formula should only be given if there is a problem [11]. Packages of formula in the Netherlands are required to carry a message that 'breastfeeding is the best for your baby' [12].

In this framing, mother's needs and constraints are secondary to that of the child's. Breastfeeding has declined because women have prioritised convenience, work, or "household orderliness" over the maternal-child dyad. For instance, in early La Leche League publications, The League's advocacy of breastfeeding was full of advice about why household orderliness was less significant than meeting children's needs. J. Law remarks upon a Chicago-area bumper sticker that advertised 'affordable healthcare begins with breastfeeding' [13]. The statement suggests that a woman's decision to breastfeed has implications well beyond her own infant's health, and more broadly attributes blame for wider societal issues including rising health care costs to non-breastfeeding mothers. In this framing, mothers' decision to breastfeed becomes transformed from an individual decision to a civic duty, responsible for ensuring not just the health of individual infants but the health of the next generation [14].

Solutions that address breastfeeding as a children's rights issue include policies that prioritise the rights of the child, such as laws banning pacifiers, prohibiting the advertising and distribution of breast milk substitutes, and incentivising baby-friendly hospitals. There have even been discussions about whether breastfeeding may be considered as part of children's civil rights, which could lead to putative actions against mothers who fail to breastfeed [2]. As expressed in the following post in the Wall Street Journal by Erica Jong (2010), 'mandatory breast-feeding isn't imminent, but it's not hard to imagine that the 'food police' might become something more than a punch line about overreaching government. Mothers, after all, are easy scapegoats' (cited in Hausman 2013 [7]). The ever-changing recommendations about what women should and should not eat and drink while breastfeeding, along with other disputed activities like hair dying, are additional examples of how the children's rights framing places the locus of control and blame on the shoulders of mothers and focusses attention on the impact of their actions on infants.

In this regard, the children's rights framing and protection policy that it implies may conflict with the promotion of women's autonomy, since such policies may inconvenience working mothers and work against women's equal participation in society. Moreover, a focus on the mother as the central "actor/villain" in this policy narrative tends to individualise the problem, distracting from the broader structures that result in declining breastfeeding rates.

10.2.3 Breastfeeding as a Global Social Justice Issue

A third framing of the problem has focused attention on the contribution of bottle feeding to infant mortality in LMICs. The blame in this frame has been placed on the global formula industry, epitomised by the Swiss-based Nestlé corporation, which came to be the focus of a global boycott. To increase profits after saturating markets in developed countries post World War II, infant formula companies began to expand their products into developing countries, where the goal was to make bottle feeding the norm there as well [10].

To sell their products to this new consumer base, formula companies turned to colonial imagery, portraying bottle feeding as "modern", and breastfeeding as "primitive" and associated with peasant life [10]. In addition to direct advertising, radio spread the word to the illiterate while doctors and hospitals were bombarded with free samples and gifts. Formula companies also utilised "milk nurses", i.e., trained nurses employed by the infant food industries to visit new mothers to sell formula. By associating medical authority with bottle feeding, these practices further contributed to the "medicalisation of formula" or to the idea that it was superior to breast milk for child health. The fact that formula is used for infants with low birth weight who are too weak to suckle only further reinforced the image of infant formula as having medicinal qualities.

Soon after formula sales started to increase, a new "disease" emerged in many low-income countries known as "bottle-baby disease". This encompassed the rapid onset of diarrhoea, dehydration, and malnutrition, resulting from exposure to water- and food-borne pathogens from unsafe water and poor hygiene, respectively. Rates of infant mortality were already high in developing countries, primarily due to these same causes, and breastfeeding practices that had sheltered many newborns from exposure to these pathogens were declining as replacement feeding caught on.

Throughout the 1970s, the international health community, including physicians in developing countries, became increasingly concerned about these marketing practices. They eventually launched one of the most successful global social movements in history against the practices of formula companies. A key tactic of this anti-formula social movement, initiated in 1977 by the US-based Infant Formula Action Coalition (INFACT), was to expose the practices of formula companies and equate their actions (in no uncertain terms) to murder in the highest degree. Nestlé in particular became the focus of the global campaign and the campaign did not mince words. One documentary, simply entitled "The Baby Killer" (originally released in 1974 and translated into multiple languages), made explicit the connection between the products of formula companies and infant death. A Swiss activist group retitled the documentary even more explicitly as 'Nestlé kills babies' [10]. The campaign was at least in part successful due to the easy identification of an irredeemable villain, the formula industry, and the facile association of their marketing practices with a reprehensible wrongdoing (namely, the wilful murder of babies).

The culmination of this global action against formula companies and their marketing tactics was the adoption of the International Code of Marketing of Breast-Milk Substitutes, approved by the World Health Assembly in 1981. Later reinforced by the Innocenti Declaration in 1990,[1] the Code was the international community's policy response to formula manufacturers' marketing practices in the developing world. The Code makes several recommendations, including instructing health care workers to promote breastfeeding. It

1 The Innocenti Declaration, which was drafted by WHO and UNICEF in 1990, restates WHO's recommendation for breastfeeding duration and calls upon member countries to promote a "breastfeeding culture" rather than a "bottle-feeding culture". The Declaration recommends creating national committees in member countries that bring together government agencies to coordinate their breastfeeding promotion efforts. It asks member nations to fully implement the International Code of Marketing of Breast-milk Substitutes to enact legislation promoting breastfeeding rights, to collect data and monitor national breastfeeding trends, and to promote the Baby-Friendly Hospital Initiative (BFHI). The BFHI was launched by UNICEF and WHO in 1991 and implements10 steps that can lead to an official designation as "baby-friendly". These include allowing women to initiate breastfeeding within the first 30 minutes of birth, "rooming in" between child and mother as soon as possible, not feeding babies formula or water, not using pacifiers, and training staff to provide support to breastfeeding mothers. According to UNICEF, some 15,000 hospitals in 134 countries have earned baby-friendly status since 1991.

clearly states the hazards associated with use of formula; banning the distribution of free formula samples to new mothers and the use of aggressive marketing practices; prohibiting the use of "milk nurses"; and prohibiting formula company salespersons from providing instruction on infant care to new mothers. Several countries acted immediately to implement the provisions of the Code, and formula companies came under significant pressure to conform to these international standards.

The clear villain in this global social justice framing is powerful multinational corporations with an economic incentive to push their products on unsuspecting low-income mothers in resource poor settings. This then becomes a larger issue of corporate ethics and also a story of inequality between the global North (where breast milk substitutes are not ideal, but are not deadly) and the global South, where it infant food source is a life or death issue. Given the inequality in outcomes faced by mothers in the global North and global South, policies to address this framing might be different between developing and developed countries. Policies in developing countries might include specific attention to international regulations on multinational corporations and their activities in LMICs, and particularly focus on how conditions of extreme poverty significantly raise the stakes in the breast versus bottle debate.

Human immunodeficiency virus (HIV) has further complicated the politics of breastfeeding in LMICs. Competition between the HIV community and child health community resulted in different standards for women in resource poor contexts. When HIV emerged as a major global epidemic in the early 2000s, tensions arose between advocates and physicians in the HIV community who recommended that HIV-positive women should not breastfeed and the child health community that recommended exclusive breastfeeding despite the small risk of HIV-infection [15]. As many women living with HIV are only diagnosed following routine HIV testing during childbirth, with the expansion of services to prevent mother-to-child transmission during childbirth came recommendations in some acquired immunodeficiency syndrome (AIDS)-affected countries to formula feed rather than breastfeed. Early in the 2000s, UNICEF developed a programme to distribute free packs of formula in AIDS-affected countries [15].

Eventually, in a situation of inadequate sanitation, the scientific community agreed that the large risks of not exclusively breastfeeding on infant mortality outweighed the more moderate risk of HIV infection. Guidelines from WHO, UNICEF, and UNAIDS provided a reasonable framework within which to make choices on infant feeding appropriate to their socioeconomic circumstances. Formula feeding was recommended for HIV-infected women only when the practice would be "culturally acceptable" (i.e., not raise stigma regarding HIV status) and where it would be possible to prepare artificial milks hygienically. However, the guidelines stated that where formula feeding was not "acceptable, feasible, affordable, sustainable, and safe", HIV-infected women were recommended to breastfeed exclusively for the first few months. The statement was based on evidence from randomised trials that promotion of exclusive breastfeeding was estimated to prevent 13% of current child deaths whereas use of Nevirapine and replacement feeding would only prevent 2% of current global child deaths [16]. UNICEF eventually ended its formula programme, but not before significantly impeding breastfeeding promotion efforts in countries heavily affected by HIV [15]. Representatives in developing countries raised concerns about whether there should be two sets of policies: one for developed countries and another for areas where clean water for formula feeding was scarce and if a 2% transmission rate of HIV was an acceptable trade-off.

These events are important on a broader scale in that they raise questions about the degree of risk posed by the failure to breastfeed exclusively in the global North versus the global South. In developed countries, breastfeeding is largely a luxury that is enjoyed by women of adequate means who can afford to take time off of work while bottle feeding is more concentrated in lower income groups. Moreover, the choice to bottle-feed in developed countries, while perhaps less than ideal, does not carry deadly consequences with it. However, in LMICs, where many households have inadequate access to improved water and sanitation, breastfeeding exclusively can literally be a matter of life and death. For example, UNICEF estimates that bottle-fed babies are as much as 25 times more likely to die in childhood than infants that are exclusively breastfed in the first 6 months of life (UNICEF 1990, cited in Carter 1995 [2]). Evidence of the more minor morbidities associated with bottle feeding in industrialised countries (as previously discussed) is too easily joined with these dire statistics from low-income countries. Putting these two very different breastfeeding contexts on the same scale diminishes the substantial difference in the magnitude of risk between these two settings.

This situation puts the magnitude of risk implied by a failure to breastfeed exclusively in perspective globally and highlights the potentially skewed risk framing in late industrial "risk societies". Late industrial risk societies are marked by the continuous production of data to support or revise risk determinations leading to a "culture of fear". As Joan B. Wolf describes, 'everyday people are bombarded with advice about how to reduce their risk of everything from cancer to kidnapping' [8]. That bottle feeding may be less risky for infant health than living in a polluted urban environment in a high income country, illustrates the successful risk framing of breastfeeding promotion campaigns at engendering fear more than promoting a rational benefit-to-risk assessment [8].

Moreover, concerns have been raised by environmental activists about the potential for environmental pollution of breast milk, which theoretically could amount to a greater risk to infants than formula [17]. The relative balance in the degree of risk in different situations is rarely assessed or articulated in breastfeeding discussions.

While there is an unequal degree of risk from bottle feeding in low versus high income countries, some scholars suggest that the politics of breastfeeding in developed and in developing contexts are not clear cut. For instance, Van Esterik advocates to apply the same rubric in developed and developing countries to analyse how mothers' "choices" must be placed in context to historical events that have transformed the landscape of mothering for all women [3]. Placing an emphasis on the singularity of the problem in low-income countries also effaces the barriers to breastfeeding that are shared between women of the global North and of the global South, such as how to balance work and breastfeeding. The image of "third world" women homebound with ample time for suckling conflicts with research that shows women engage in informal and formal labour inside and outside the home in various developing country contexts. Furthermore, all women in low-income countries are assumed to have poor sanitation when in reality there is great diversity in the experiences and social conditions of these women (i.e., not all women in poor countries are poor). Instead, Van Esterik proposes that breastfeeding advocates examine four issues that influence infant feeding paradigms in any given national or local situation: poverty environments, empowerment of women, medicalisation of infant feeding, and the commoditisation of food [3].

In sum, the global human rights framing of the breastfeeding issue has perhaps been the single most successful breastfeeding promotion campaign. It constitutes a broader example of how a compelling causal story can bring policy attention and action to bear on an issue. The campaign achieved this success mainly through clear identification of a highly culpable villain (the profit-seeking formula industry) that is easy to despise in the context of its victim (innocent, defenceless baby). The equation was simple and policy reform ensued. However, the corporate villain frame may oversimplify the complex factors driving women to bottle-feed in both developed and developing country contexts.

10.3 Critiques and Tensions in the Three Frames

While each of the three frames — the mother's rights, children's rights, and global human rights frames — may offer compelling causal stories to advance breastfeeding policy on national and international agendas, the frames (and the policy communities that support them) also conflict with each other in unproductive ways. This is demonstrated by a recent landscape analysis of the global breastfeeding promotion efforts conducted by UNICEF [18]. This analysis found that a lack of cohesion over a common agenda with a shared vision of change is constraining the breastfeeding community's ability to influence policy makers and raise resources. Discussed below are several tensions (conflicts) in each of the above framings regarding the problem of low breastfeeding rates.

10.3.1 Tension 1: Trade-offs Between Mothers' Rights and Children's Rights Frame

The breastfeeding promotion literature is careful to recommend promoting policies that are "mother-centred" (See Alive and Thrive website: http://aliveandthrive.org/). However, breastfeeding promotion efforts have at times applied unsubtle social pressure to shame bottle-feeding women is applied to denormalise bottle feeding by making formula difficult to access, banning pacifiers, and unequivocally advocating "breast is best". Taylor & Wallace note that while studies often focus on maternal "guilt", shaming is a more appropriate descriptor of the emotions that women experience in their choice of breast over bottle [19]. They suggest that women should not be shamed for either choice. Proponents of a women's rights frame also suggest that breastfeeding promotion campaigns focus on promoting women's autonomy and on providing honest information on risks and benefits [20]. This, they propose, is preferable to reiterating scientific evidence that "breast is best", especially since this evidence in developed countries is considered to be of dubious quality [8], [14].

Efforts to normalise breast feeding may not be particularly harmful. However, an abundance of critical literature on the politics of breastfeeding has indicated the various ways in which the children's rights frame has led to overemphasis on the benefits of breastfeeding for children with little attention to balancing these benefits with the needs of mothers. This literature recognises that there are often trade-offs between what is best for mothers and what is best for babies (i.e., what is good for the goose is not always good for the gander).

This conflict is most evident in the US Department of Health and Human Services sponsored National Breastfeeding Awareness Campaign (NBAC). Their warning was that women who did not breastfeed put their babies at risk of various health problems; not to breastfeed was equated to a variety of risky practices, such as logrolling and riding a mechanical bull when pregnant. Based on messages of fear and blame, this social marketing campaign directed at mothers precipitated a wave of controversy and negative feedback [8], [21]. This extreme version of the children's rights frame scapegoats women, and downplays the significant structural and social challenges women face in their capabilities to breastfeed.

More broadly and surprisingly neglectful of the breastfeeding issue overall, feminist literature centres around two visions of breastfeeding – with breastfeeding viewed from one standpoint as a reclamation of women's bodies and identities, and from the other as undermining women's equality by assigning a laborious, gender-specific task [4], [2], [7].

This conflict epitomises the "central dilemma of feminism": on the one hand to minimise gender differences and foster androgyny between the sexes, and on the other to embrace and enhance gender difference and fight to remove constraints and transform patriarchal cultures [2]. Early liberal and Marxist feminist thinking on breastfeeding viewed breastfeeding as a barrier to gender equality, with breastfeeding naturalising the sexual division of labour within the home [4]. Milk substitutes levelled the playing field in the sexual division of labour by enabling men to attend to infants equally and women to participate more equally in the job market. However, recent feminist work has returned to the paternalistic, patronizing, and naturalising views on lactation in medical literature, which acts as a form of control over women, their bodies, and their reproductive choices.

Recent feminist work tries to resolve these two poles by turning the focus from individualised mother shaming tactics to how structural constraints inhibit women's capabilities to make informed, autonomous decisions [7]. For example, the American Academy of Pediatrics suggests exclusive breastfeeding for the baby's first six months and then complementary feeding accompanied by breastfeeding for at least the baby's first year or "as long as is mutually desired" [22]. However, there is little logic in this recommendation. Most American workplaces offer either no paid maternity leave or 6–8 weeks only and lack support mechanisms for breastfeeding mothers. This situation makes it difficult for the majority of mothers to combine paid employment with lactation. The contradictions between the scientific advice and absence of institutional supports to realise this goal produces concerning dissonance.

In this way, the frames of maternal and child rights can and do collide. Policies that fail to take into account women's needs, and play on feelings of maternal guilt and shame, draw on fear and overstate the degree of risk and implore women to breastfeed without providing the necessary structural conditions to achieve this goal, can lead to dissonance and be counterproductive to efforts to promote breastfeeding. On the other hand, policies that are too pro-formula slip easily into a hegemonic bottle-feeding culture.

10.3.2 Tension 2: Different Standards for Developed and Developing Countries?

The global human rights frame has been very successful at galvanising international attention and outrage towards formula companies. However, this successful framing of the issue has glossed over the important issue of why breast is so much better than formula in low-income country settings — namely, the role of contaminated water in infant death. It is the unclean water used to mix the formula that is killing babies rather than the formula *per se*. If the goal is to improve child health and reduce child mortality (children's rights frame), then a priority must also be to attend to the conditions that give rise to contaminated drinking water and unsafe complementary feeding.

Furthermore, while it is true that "third world" women breastfeed much more than their "first world" counterparts, the global formula villain frame ignores the reality that this may be the result of a lack of alternatives [2]. What tends to be glossed over in overly naturalised discussions is that poor women in poor countries breastfeed largely out of necessity, because they have little other means by which to nourish their infants. In reality, women in low-income countries face similar challenges to breastfeeding to those of women in developed countries. Such challenges include sore nipples, flat or inverted nipples impeding adequate breastfeeding, time pressures, the need to work to survive, and exhaustion. Additional to this, many breastfeeding women in low-income countries are themselves malnourished. Studies in the child health frame report that malnourished women are able to produce adequate amounts of milk of reasonable quality to sufficiently breastfeed, but pay little attention to the cost to the mother's health. R. Kukla raises questions about the increased risk of osteoporosis from breastfeeding in developed countries [14]. The risk of malnutrition and immune system weakness in malnourished breastfeeding women should be an additional consideration for a more balanced approach to the women's rights and children's rights frames. Appreciation of these challenges may also partially explain why exclusive breastfeeding rates and durations remain so low in much of the developing world where there are much higher rates and durations of mixed feeding (i.e., breastfeeding as well as feeding with water and foods). While "traditional practices" and overbearing mothers-in-law are frequently the scapegoats in these discussions, women's everyday realities and the simple inconvenience of breastfeeding may play an underappreciated role in the practice of supplementary breastfeeding.

Persistent promotion of exclusive breastfeeding without attention to everyday challenges to realise this ideal may undermine efforts to reach this goal. An alternative framing from this "breastfeed or bust" approach could be to take a "harm reduction" approach. This might include making bottled water and disposable bottles more widely available for women who do not breastfeed, much in the same way as clean needles are distributed to injection drug users. Thus, the means to bottle feed safely could be made more widely available in resource-poor settings where there is substandard sanitation. Additionally, single-use premixed formula that does not require mixing with water and that can be stored unopened without refrigeration could be sold. For women who wish to breastfeed exclusively, the provision of accurate information about the challenges that this might entail should support their decision.

Indeed, harm reduction approaches are in line with current language. This approach to breastfeeding could help to equalise the stakes in the breast versus bottle debate between high-income and low-income settings, fostering women's autonomy and balancing the women's rights frame more evenly against the children's rights frame. A harm reduction approach can simultaneously advocate for changes in structural conditions impeding breastfeeding (e.g., workplace policies) while by acknowledging the role of everyday constraints on the practice of exclusive breastfeeding [6].

10.4 Conclusion

Balancing women's rights, children's rights, and global human rights in making ethical and evidence-based breastfeeding policy recommendations

We began this chapter suggesting that policy issues and their solutions are driven by the concept of causal stories, i.e., the attribution of cause, blame, and responsibility on different actors. Stone reminds us that there are many strategies for pushing responsibility onto someone else [1]:

> *'Books and studies that catalyse public issues have a common structure to their argument. They claim that a condition formerly interpreted as accident is actually the result of human will, either indirectly (mechanical or inadvertent cause) or directly (intentional cause); or they show that a condition formerly interpreted as indirectly caused is actually pure intent'.*

The breastfeeding community has drawn mainly on three causal stories or "issue frames" to advance breastfeeding promotion policy, namely, the women's rights frame, the children's rights frame, and the global human rights frame. The global human rights frame has been the most successful at painting a clear story of an intentional cause to the problem of declining breastfeeding rates and its dire consequences. By contrast, the children's rights frame has struggled because an overemphasis on children's rights implies an insensitivity or inattention to women's rights and needs. Portraying mothers as villains even if indirectly has not been a successful strategy for breastfeeding promotion and is likely to prompt negative reactions. Likewise, an overemphasis on the joys of breastfeeding and its association with women's rights that assigns blame to patriarchal norms ignores other feminist views that pro-breastfeeding culture shames women that cannot or will not breastfeed and inflates the benefits of breast over bottle.

Moreover, the global human rights frame has simplistically outlined the problem as formula promotion by corporate villains without adequate attention to the broader underlying cause of "bottle-baby disease", which is unclean water and lack of sanitation. Reframing the issue of bottle feeding in developing countries that focusses attention on unsafe water would implicate a broader set of villains – governments, global development agencies, and perhaps even global capitalism that keeps poor countries poor. While this framing is likely to be less effective because the villain or cause is too diffuse, a harm reduction approach to breastfeeding could focus attention on how to bottle feed safely when breastfeeding is not an option.

A harm reduction approach to breastfeeding promotion suggests that advocates of breastfeeding should acknowledge that the risks of bottle feeding are not equivalent between developed and developing countries. They should more directly target the mechanisms in developing countries that are making babies sick. This includes increasing the availability of safer tools for replacement feeding and addressing feeding practices that undermine exclusive breastfeeding, such as giving water to breastfeeding infants not in the context of bottle feeding.

In sum, efforts at breastfeeding promotion are hindered by specific politics of breastfeeding policy. Recognition of the trade-offs in the different framings of the issue and identification of who is to blame can assist in developing more effective breastfeeding promotion campaigns.

Key Points

- Political discussions follow three frameworks – women's rights, children's rights and global human rights. Each requires clear policy focus if breastfeeding rates are to increase
- Mothers recognise the medical benefits for breastfeeding, but often face the reality of gender in-

equality, patriarchal culture, work-place conflict and negative societal attitudes

- The focus for children's rights campaigners on the long-term health benefits of breastfeeding is often viewed as pressuring mothers who cannot, or choose not to breastfeed, likely prompting negative reactions
- The success of global human rights campaigns in galvanising international attention and outrage towards formula companies as the main culprit for low breastfeeding rates is too simplistic
- The focus needs to shift towards a differentiated set of government led policies to create a more positive societal attitude to breastfeeding

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11 Human Milk in Economics Context

Subhash Pokhrel, PhD, MSc

Expected Key Learning Outcomes

- The economic considerations for mothers
- The impact of breastfeeding on health systems
- Analysis of how far breastfeeding promotion and support interventions offer good value for money
- Effective ways to invest in breastfeeding promotion
- Outline of a business case made for breastfeeding promotion and support in the absence of robust economic evaluation

Human milk has several implications. Depending on what perspective one chooses, the use of alternatives to human milk for feeding infants has attracted enormous debate in the past. This chapter surveys contemporary literature around the economic value of breastfeeding and presents an example analysis to show how a business case for breastfeeding support could be made.

11.1 Economics of Lactation

What economic value may human milk have? This question has featured in both academic and political debates for a long time. For some, human milk is protective against certain disease conditions and therefore it can provide substantial economic benefits. Breastfeeding is beneficial not only to the health and wellbeing of a child and their mother, but it also generates substantial cost savings to the national health services. Health services would have to treat fewer infant, childhood, and maternal diseases with increasing breastfeeding prevalence [1], [2]. In addition, some authors argue that women who choose to breastfeed actually produce and supply breast milk and therefore contribute significantly to the national economy [3], [4]. When costs of implementing breastfeeding support policies are considered, society is more likely to get a positive return on investment (ROI) from breastfeeding [2].

The other side of the argument positions breastfeeding as a costly enterprise to women because, if they chose to breastfeed their babies, they would be required to incur substantial private costs to enable milk expression [5]. Like formula feeding, breastfeeding is also associated with private costs. In addition, breastfeeding may have implications for earnings and productivity of working women, potentially requiring a longer maternity leave, working part time, or missing opportunities for promotion [6], [7], [8]. It also takes a substantial amount of a mother's time to breastfeed her child [9]. Therefore, both the private costs and the forgone opportunities women may experience by choosing to breastfeed can be considerable.

Underneath these individual benefit-cost arguments rests a question that has probably the most profound implications for any breastfeeding support policy. Can a health system ask women to initiate breastfeeding, and breastfeed for longer and exclusively, particularly when we, as a society, recognise that it is up to women themselves to make those explicit choices? What determines a woman's decision to initiate (or cease) breastfeeding and how those factors relate to the thinking of a healthcare system appear to be central to this question [10]. Therefore, it is important to consider whether breastfeeding is in fact an "economic" decision for women as well as for other stakeholders.

11.1.1 Breastfeeding as an Economic Decision

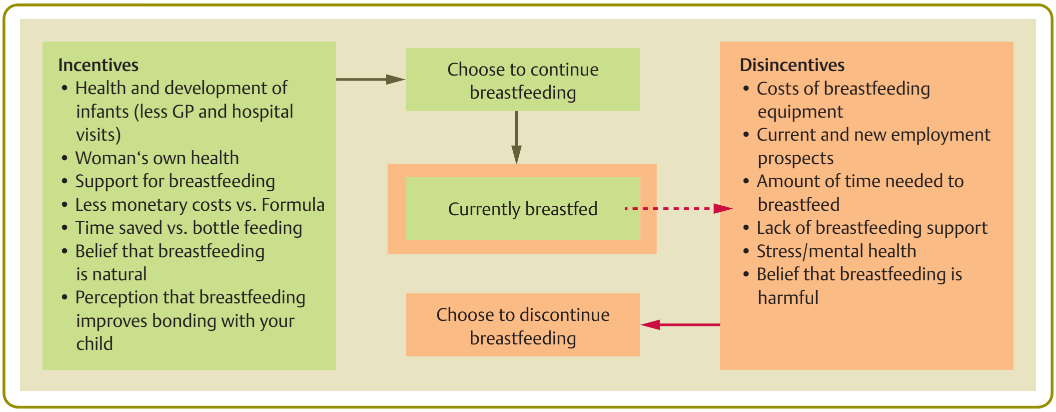
Breastfeeding is an economic decision but its nature varies according to the perspective taken. Working women may consider the consequences of breastfeeding (i.e. opportunities foregone and/or monetary costs of breastfeeding relative to formula feeding) when deciding whether to breastfeed their babies, while employers and health systems may consider the need to support breastfeeding women through maternity pay and by creating baby-friendly workplaces and hospitals [11].

Maternal employment appears to be negatively associated with breastfeeding initiation and duration [12]. This is particularly relevant since exclusively milk-feeding mothers would have to spend much more time every week on feeding their baby compared with other mothers [9]. Understanding incentives or disincentives facing women that may influence their choices regarding initiation and duration of breastfeeding (any or exclusive) is therefore critically important.

Economic theories help us to understand what those incentives and disincentives might be, and how these may determine a women's choice to breastfeed or formula feed and for how long. One such theory is that of individual net-benefit (utility) maximisation; in this case, individuals are assumed to make a choice (e.g., to initiate breastfeeding) that is perceived to benefit them and adhere to their decision until the benefits outweigh the costs [10]. In this framework, any factor that is perceived as a barrier or disincentive by a mother, e.g., money, time, and negative feedback from friends or family, is a cost. Likewise, any factor that is perceived as a facilitator or incentive, e.g., money saved by not buying formula, better health of the child, bonding with their child, and access to breastfeeding support, is a benefit. The model also assumes that the incentives and disincentives to breastfeeding may change over time.

▶ **Fig. 11.1** depicts this notion of the decision making process proposed by Racine and colleagues [10]. In this construct, the decision is an economic choice; the postpartum women weigh the benefits of breastfeeding against the costs of continuing or discontinuing breastfeeding. Some factors that are incentives for health systems (e.g., the health benefits of breastfeeding for infants/children and for mothers) are also incentives for women. Although provision of breastfeeding support requires health systems to cover costs, this support is also an incentive for women encouraging them to choose to breastfeed.

Racine and colleagues implemented this model in a sample of 1,595 low-income families in the US, and found that the decision to discontinue breastfeeding was significantly associated with a number of disincentives: the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) participation at 2–4 months, mothers returning to work for 20–40h per week, mothers not attending a postpartum doctor's visit, fathers not being in the home, a smoker in the household, no receipt of breastfeeding instruction at the paediatric office, the doctors not encouraging breastfeeding, and the mother experiencing depressive symptoms [10]. The main implication of this finding is that any breastfeeding promotion programme will need to address disincentives associated with breastfeeding cessation. Understanding the economics of breastfeeding decisions is therefore helpful for policymakers.



▶ **Fig. 11.1** A schematic representation of the Net-Benefit (utility) Maximisation model of breastfeeding decision proposed by Racine et al. (Reproduced from [10])

Although the Net-Benefit (utility) Maximisation model is a valuable way to identify determinants of breastfeeding decisions that women may take (i.e. initiate, continue or discontinue; any or exclusive breastfeeding), the decision itself is complex. The decision not to breastfeed infants is also the decision to formula feed (i.e. use infant food or breast-milk substitutes). Infant food is often allocated by markets. If we were to rely on markets to allocate resources efficiently, consumers (i.e. postpartum women) would have to make informed (rational) choices. These choices require that postpartum women themselves are responsible for the full costs and benefits of their infant food purchase decisions. Much cultural knowledge of health risks of formula feeding is based on inaccurate or biased information and this, coupled with commercial vested interests, may not enable women to make an informed (rational) decision [13]. It is known that not choosing to breastfeed leads to a decrement in infant and maternal health, thereby costing health systems millions of dollars [1], [14]. Those health systems costs are usually borne by taxpayers (as in the British National Health Service [NHS]) or others (e.g., social/private insurance) and not by women who make consumption decisions (purchase of breast-milk substitutes), a phenomenon known as externalities (an attribute of market failure). This is particularly important as the extent to which the women who choose to use breast-milk substitutes are willing to bear this cost is less understood. In this instance, the market price of artificial infant food becomes much lower than its true economic costs to women who want to purchase it, making breastfeeding a less attractive option [13].

Another linked issue around the use of markets to allocate infant food efficiently is that of agency. In the case of infant feeding, one could argue that the infants are the actual consumers and not their mothers. Mothers make decisions on behalf of their infants – a classic principal-agent problem in economics [15]. While agents (mothers) make decisions on behalf of their principals (infants), it is likely that agents are acting in their best interests rather than in the best interests of their principals. It is argued elsewhere that given the difficulty to accommodate the needs of the breastfeeding mother in the context of institutional frameworks, it is likely that the interests of the mother and the infant may not always align [13].

Whether to breastfeed is thus a complex decision that postpartum women have to make by weighing the incentives (benefits) and disincentives (costs) of breastfeeding relative to that of formula feeding. Breastfeeding is not a binary choice; it is rather a set of complex choices around initiation, duration, and exclusivity. What women decide to do on infant feeding may have far reaching implications beyond their families.

11.1.2 Private Costs of Breastfeeding and Formula Feeding

One of the economic disincentives (costs) associated with women's infant feeding decisions is private costs [10]. Despite breast milk being considered as the best form of nourishment for infants and usually in sufficient supply for the first few months of life, it is not free for women who choose to breastfeed. There are private costs associated with breastfeeding. Two types of private costs are prevalent: monetary costs and time costs.

In a study conducted in Liverpool, England 149 women between the age of 18 and 43 were asked to report the purchases associated with their infant feeding practices (mean age of infants: 13 weeks) [5]. The study identified a number of equipment items needed to enable women to breastfeed. This included nursing bras, nightshirts, breast pads, antiseptic nipple spray, breast cream, breast shells, nipple shields, breast pump, breast-milk storage bottles, breast-milk freezer bags, steriliser, and support pillow. Two separate models (high costs and low costs) were used to estimate the average costs of purchasing the equipment. A set of breastfeeding equipment was purchased for £34.60 per week (high-cost model) or £2.40 per week (low-cost model). Likewise, formula feeding mothers had bought bottles, teats, steam steriliser, formula, bottle warmer, bottle carrier, powder dispenser and bottle/teat brushes. A set of formula-feeding equipment including the food was purchased for £31.43 per week (high-cost model) or £6.30 per week (low-cost model).

On average, breastfeeding cost women £11.58 per week compared with £9.60 per week for formula-feeding (2002–2003 prices). However, the study found that women, particularly the first-time mothers, in both groups, 'spent money on items that were not needed or used only once or twice' [5]. Higher spending was characterised by education, socio-economic status and age. Although women included in the study spent more per week on breastfeeding compared with formula feeding, provision of better support (information) could have led the women to avoid purchasing items that were unnecessary or to go for cheaper alternatives where available.

Depending on the healthcare context, there may be other forms of private monetary costs associated with infant feeding. Frick and colleagues identified food for the mother herself and medical care use for herself or her child (in non-NHS/insurance settings) as potential private costs required to enable mothers to breastfeed [16].

The choice of infant feeding is also associated with time costs. In particular, 'exclusive breastfeeding is time intensive, which is economically costly to women' [9]. In an Australian survey (2005–2006), 139 new mothers were asked to report their average weekly time spent on feeding (milk or solids), feeds preparation, and the total of the two. Mothers who were exclusively breastfeeding spent on average 7 hours extra per week on milk feeding their infants compared with other mothers. This difference was statistically significant and implied that premature weaning was probable 'for women who are time-stressed, lack household help from family, or cannot afford paid help' [9].

The time costs of breastfeeding have wider implications. As exclusive breastfeeding is associated with substantial time commitment, working women in particular may have to compromise on their earnings and productivity as choosing to breastfeed means choosing to take longer maternity leave or work part time and potentially miss promotion opportunities [6], [7], [8]. For others, the time spent on breastfeeding could have other usage [10]. The opportunities forgone by choosing to breastfeed may therefore be considerable. Breastfeeding promotion policies must therefore subsidise/share these costs through provision of various services, e.g., childcare, help with housework, prolonged maternity leave, and if mothers decide to return to work, the provision of breastfeeding breaks at the workplace [13].

11.1.3 Supporting Women who Choose to Breastfeed

As seen above, breastfeeding is an economic choice that women make. Therefore, it is important to support women to breastfeed for as long as they choose to. It appears that most women who stop breastfeeding don't want to and often consider getting the help and support that would keep them breastfeeding for longer and exclusively [17]. Supporting women who choose to breastfeed would therefore help align interests of the mother, the baby, and the health services. As breastfeeding (exclusive and/or longer duration) becomes more common as the result of this support, this will lead to wider economic benefits too [2], [14].

Central to any policy debate around breastfeeding should be the recognition that to breastfeed is an exclusive choice of a new mother. Any breastfeeding support policy therefore must acknowledge that new mothers who have chosen to breastfeed are well informed, well trained and well supported for however long they choose to breastfeed (exclusively or partially). It is possible that a breastfeeding promotion policy may help new mothers initiate breastfeeding; support thereafter enabling women to breastfeed for longer is what generates health and economic benefits to the mother, the baby, and the health services.

11.2 Economics of Breastfeeding Support

Having established the notion that supporting women who choose to breastfeed makes an economic sense, it is important to look at the evidence base to see what health benefits breastfeeding may offer to mothers and their babies. How would the positive health effects of breastfeeding translate into economic benefits both to national health systems and to wider society? At the micro level, do breastfeeding support interventions offer good value for money?

11.2.1 Benefits to Infants and Children

Breastfeeding has been found to be protective against a number of health conditions in infants and children. However, the strength of evidence varies by health conditions. For gastrointestinal infections, lower tract respiratory infections and acute otitis media in infants, and necrotising enterocolitis in pre-term babies, convincing evidence exist to suggest that breastfeeding prevents the incidence of those conditions [2]. ▶ **Table 11.1** provides a summary of this evidence.

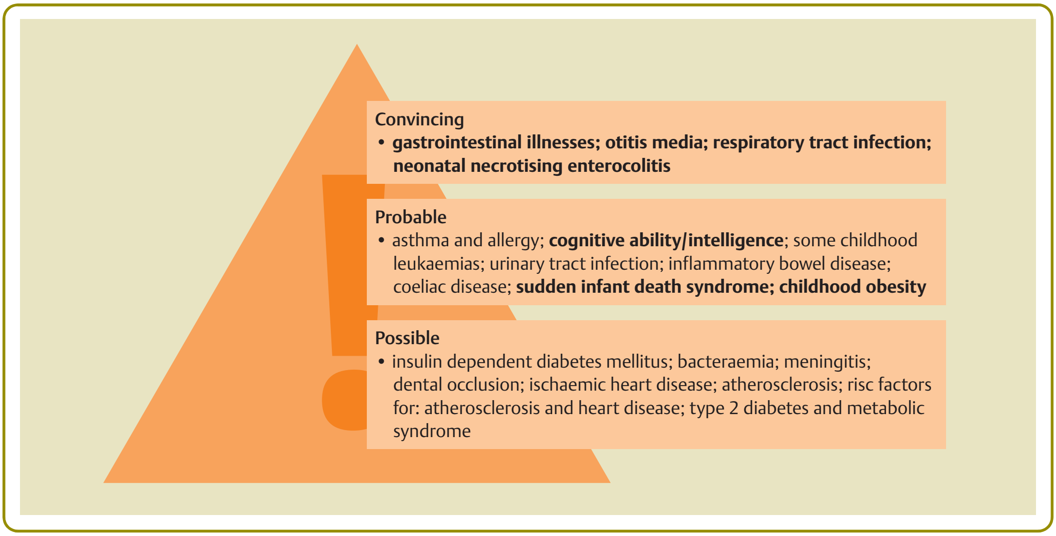
A previous review of the benefits of breastfeeding identified evidence according to three categories: convincing (significant relationship established by systematic reviews/meta analyses), probable (association found in several studies but more evidence is needed), and possible (association found in few studies of less good quality) [18]. A large number of disease conditions where breastfeeding could be protective were identified according to this evidence hierarchy (▶ **Fig. 11.2**).

More recent systematic/evidence reviews have corroborated these findings [2], [19]. As more studies are conducted, clearer pictures of the association between breastfeeding and these health outcomes will emerge. Of particular note are the three conditions (cognitive outcomes, sudden infant death syndrome, and childhood obesity) where studies increasingly indicate a negative correlation between breastfeeding and the incidence of these outcomes [2].

▶ **Tab. 11.1** Disease conditions where breastfeeding was convincingly found to be protective for the United Kingdom population. [1], [2]

Disease condition	Population	Risk measure* Mean value (95% CI)	Source
Gastrointestinal infection	Infants	• Exclusive breastfeeding: – Hospitalisation: **0.39** (0.18–0.85) – GP visits: **0.28** (0.11–0.69) • Any breastfeeding: – Hospitalisation: **0.52** (0.30–0.87) GP visits: **0.36** (0.18–0.74)	[20] [21] [20] [21]
Lower respiratory tract infection	Infants	• Exclusive breastfeeding: – Hospitalisation: **0.70** (0.49–0.98) – GP visits: **0.69** (0.47–1.0) • Any breastfeeding: – Hospitalisation: **0.67** (0.52–0.88) – GP visits: **0.65** (0.43–0.96)	[20] [22] [20] [23]
Acute otitis media	Infants	• Exclusive breastfeeding: – GP visits: 0.50 (0.37–0.70) • Any breastfeeding: – GP visits: 0.40 (0.21–0.76)	[24] [23]
Necrotising enterocolitis	Infants	• Any breast milk: **0.19** (0.05–0.73)	[25]
Maternal breast cancer	Mothers	• Ever breastfeeding vs never breastfeeding: **0.96** (0.92–0.99) • Breastfeeding for < 6 months vs never: **0.98** (0.95–1.01) • Breastfeeding for 7–18 months vs never: **0.94** (0.91–0.97) • Breastfeeding for 18 + months vs never: **0.89** (0.84–0.94)	[26]

CI = confidence interval, GP = general practitioner
* Odds ratio (OR) or relative risk (RR) measuring how likely a disease condition listed above is in breastfeeding group compared to non-breastfeeding group. Mean values are reported in bold. A ratio of less than 1.0 indicates breastfeeding is protective. Both values less than 1.0 in the parenthesis provide confidence that the reported mean value of the risk measure was not observed by chance.



▶ **Fig. 11.2** A schematic of evidence hierarchy on benefits of breastfeeding to infants and children in industrialised countries based on Allen & Hector [18]. Corroborated conclusions by Renfrew et al. [2] are shown in bold.

Thus, we see that existing evidence does support the notion that breastfeeding is beneficial to the health of infants and children. The disagreement, if any, is around the degree to which the association is likely to be causal for many of these conditions as, despite best efforts, individual studies might not have been able to fully remove the effect of existing confounders [19]. Nevertheless, the state of the knowledge in this area should provide enough grounds for policy makers to develop evidence-based strategies in supporting women who have chosen to breastfeed to improve the health of infants and children.

11.2.2 Benefits to Mothers

Whilst the benefits of breastfeeding to infants and children are well established, the literature as to what extent breastfeeding may benefit women themselves is emerging. There is convincing evidence that breastfeeding and maternal breast cancer are negatively correlated. Breastfeeding for 18 + months over the lifetime of a woman (which may include breastfeeding more than one baby) is associated with significantly decreased risk of having breast cancer, compared to a woman who has never breastfed. A study conducted in the US has found that nearly 5,000 excess cases of breast cancer were associated with suboptimal breastfeeding durations [14]. In the UK, optimal breastfeeding durations could have led to 865 fewer breast cancer cases for 313,000 first time mothers or a gain of 512 quality-adjusted life-years [2].

Apart from maternal breast cancer, there seems to be a lack of good quality evidence on the link between breastfeeding and other maternal outcomes. Breastfeeding is *probably* associated with ovarian cancer and rheumatoid arthritis, and *possibly* with several other health outcomes, e.g., maternal depression, endometrial cancer, osteoporosis and bone fracture [18]. A relatively recent review finds studies that support the link between breastfeeding and Type 2 diabetes, breastfeeding and hypertension, and breastfeeding and coronary heart disease [19]. Putting this evidence into perspective, optimal breastfeeding in the US could have averted an additional 8,500 myocardial infarction cases and an extra of over 36,000 hypertension cases [14].

It is important here to note that absence of good quality evidence does not necessarily imply that there is no association between breastfeeding and the above conditions. While we wait for more methodologically sound studies in the future to corroborate whether the *probable* and *possible* links are definitive ones, the current state of the knowledge appears to be enough for policy makers to develop and implement breastfeeding support strategies to improve maternal health outcomes.

11.2.3 Benefits to National Health Systems

How would reductions in the incidences of the above health conditions, as more women initiate, continue and exclusively breastfeed their infants, translate to benefits to national health systems? A systematic review of the evidence in this area found that increased breastfeeding rates were associated with potential cost-savings to the national health systems across a range of countries [2]. Although the studies included in this review reported the impact of optimal breastfeeding differently (▶ **Table 11.2**), the conclusion was robust: There is an economic case for breastfeeding support.

More economic studies have evolved since 2012 when the above review was published. ▶ **Table 11.3** summarises a cross-section of new studies (where more than one country is included) showing the economic benefits of optimal breastfeeding. Although each study has included different outcomes, employed different assumptions to model the cost savings, and used slightly different underlying methods, all studies highlight the economic loss currently observed due to suboptimal breastfeeding. In other words, if breastfeeding rates were increased at a level deemed appropriate or realistic in countries where breastfeeding rates are low, this would generate substantial cost savings to the respective national health system in each of these countries.

▶ **Tab. 11.2** Economic impact of suboptimal breastfeeding reported by Renfrew et al. 2012. [2]

Study	Country	Reported economic impact
Ball and Wright 1999 [27]	USA	Excess costs of US $331 per not-breastfed infant for a year
Barton et al. 2001 [28]	USA	Mean difference of US $3,366 between breastfed and non-breastfed infants during neonatal unit stay for that year
Buchner et al. 2007 [29]	Netherlands	A saving of Euro 250 per newborn per year on best case scenario of 100% breastfeeding for 6 months or more
Cattaneo et al. 2006 [30]	Italy	Mean difference of Euro 160 per infant per year
Wight 2001 [31]	USA	Mean difference of US $200 per infant in the first 6-months of life; extra cost of US $9,669 per infant for not using human milk in a neonatal unit or a savings of US $11 per US $1 spent on human milk
Bartick and Reinhold 2010 [32]	USA	US $3.35 billion savings in treatment costs and US $13 billion including the value of premature deaths, at 90% breastfeeding rates
Drane 1997 [33]	Australia	Australian $9 million in treatment costs and Australian $11.5 million including special education costs, at 80% breastfeeding rates
Riordan 1997 [34]	USA	Between US $1.2 and 1.3 billion in treatment costs attributable to formula feeding
Weimer 2001 [35]	USA	US $3.6 billion savings including the value of premature deaths, at 75% breastfeeding rate
Smith et al. 2002 [36]	Australia	Australian $1.5 million in treating four diseases – gastrointestinal infections, respiratory illnesses, eczema, and NEC – in children aged 0–4 in Australian Capital Territory alone
Hoey and Ware 1997 [37]	USA	$200 per infant savings compared to bottle feeding

▶ **Tab. 11.3** New evidence on the economic impact of suboptimal breastfeeding

Study	Country	Reported economic impact
Pokhrel et al. 2015 [1] Renfrew et al. 2012 [2]	UK (covering 4 home countries)	• Optimal breastfeeding (45% exclusive breastfeeding at 4 months, 75% babies in neonatal units breastfed at discharge) would lead to over £17 million cost savings annually through: – 3,285 fewer gastrointestinal infection-related hospital admissions and 10,637 fewer GP consultations (£3.6 million saved) – 5,916 fewer lower respiratory tract infection-related hospital admissions and 22,248 fewer GP consultations (£6.7 million saved) – 21,045 fewer acute otitis media (AOM) related GP consultations (£750,000 saved) – 361 fewer cases of NEC (over £6 million saved) • Optimal breastfeeding (cumulative breastfeeding of 18 months over the lifetime in half of currently not breastfeeding) in each annual cohort of 313,000 first-time mothers could save £31 million through: – 865 fewer breast cancer cases (over £21 million saved) – 512 quality-adjusted life-years gained (over £10 million gained) • A 1% decrease in never breastfed infants would lead to 8,000 fewer children with cognitive impairment (£278 million gained) • A modest increase in exclusive breastfeeding for more than 2 months would lead to prevention of 3 cases of sudden infant death syndrome annually (£4.7 million loss prevented) • A modest increase in breastfeeding rates would lead to 16,300 fewer obese young children (£1.63 million saved)
Rollins et al. 2016 [38]	96 countries	• Optimal breastfeeding (every infant breastfeeding until at least 6 months of age) could have avoided $302 billion (0.49% of gross national income) globally in economic losses from cognitive deficits through: – $70.9 billion (0.39% of gross national income) in low- and middle-income countries – $231.4 billion (0.53% of gross national income) in high-income countries
Walters et al. 2016 [39]	7 South East Asian countries	• Optimal breastfeeding [100% of children receive some breast milk up to the age of 6 months (cognitive outcomes), 100% of children are exclusively breastfed to age 6 months and then continue to receive some breast milk to age 2 years (health outcomes), and 90% of women breastfeed cumulatively for 2 years over their lifetime (maternal outcomes] could have avoided US$1.9 billion a year across the seven countries through: – $1.63 billion savings via better cognitive outcomes – $294 million savings via healthcare cost savings

One of the methodological issues in the analysis of economic impact of suboptimal breastfeeding has been the uncertainty around the estimated impact. Most studies have relied on point estimates, but it is a well-known fact that several assumptions would have to be made in order to model such an impact under any employable method. These assumptions may in turn introduce uncertainty around the predicted impact. Some researchers [1], [14] have looked at this important methodological issue. In the US, the most recent estimates put direct medical costs of suboptimal breastfeeding at $2.6 billion (95% confidence interval: $2.3, $2.9 billion), 79% of which are maternal [14]. Having taken into account the uncertainty around various assumptions, their findings do not alter what has long been shown to be the case — that there are substantial costs associated with suboptimal breastfeeding to the national health services. Rather, the uncertainty analyses have provided decision makers with reasons to be confident about these findings and develop and implement breastfeeding support policies and strategies.

11.2.4 Benefits to Wider Society

If breastfeeding improves 'the quality of life for women through the reduction in incidence of breast cancer and for children through reducing acute and chronic diseases' [2], it is reasonable to expect that this benefit may translate to wider societal impact. A healthier population with a better quality of life may be economically and socially more productive. More research is needed to explore this wider societal impact of improved breastfeeding rates.

Some evidence does exist to support the notion that the economic benefits of breastfeeding are wider. In a recent study, Rollins and colleagues found the optimal breastfeeding scenario in which every infant was breastfed until at least 6 months of age could have avoided $302 billion (0.49% of gross national income) globally in economic losses from cognitive deficits [38]. Most of this economic cost was in high income countries ($231.4 billion or 0.53% of gross national income compared to $70.9 billion or 0.39% of gross national income in low- and middle-income countries). Another recent estimate by Walters and colleagues for seven South East Asian countries also shows that the economic loss due to cognitive deficit in suboptimal breastfeeding populations is high (US$1.63 billion) [39] corroborating similar estimates by Renfrew and colleagues for the UK [2] (▸ **Table 11.3**).

Premature death is another wider outcome of suboptimal breastfeeding. The most recent estimate from the US shows that 3,340 premature deaths (between 1,886 and 4,785) could have been averted through optimal breastfeeding [14]. Importantly, 78% of these deaths were maternal (986 due to myocardial infarction, 838 due to breast cancer, and 473 due to diabetes). Of the 721 excess deaths in children, sudden infant death syndrome claimed 492 lives and necrotising enterocolitis 190 lives.

Whether one should put a monetary value on premature deaths to reflect this aspect of societal impact is a contentious issue. Bartick and colleagues have used a method to assign a monetary value against their estimated premature deaths due to suboptimal breastfeeding [14]. They find that the total cost of premature deaths was $14.2 billion (between $8.8 and $19.6 billion) and that the costs were evenly distributed between maternal and child population.

It has been argued that women who choose to breastfeed actually produce and supply breast milk and therefore contribute significantly to the national economy [4]. Current human milk production levels exceed $3 billion annually in Australia and potentially $110 billion a year in the US, but premature weaning means nearly two thirds of this value may have been lost [3]. Smith therefore argues that 'failure to account for mothers' milk production in GDP and other economic data has important consequences for public policy' [3].

The other side of the coin is the negative impact of breastfeeding. Breastfeeding is associated negatively with labour market outcomes, particularly for working women's own earnings, work productivity and promotion prospects [6], [7], [8], [12]. The opportunities forgone by choosing to spend longer time breastfeeding may be considerable for some women [9], particularly when emerging evidence does not support the perception that their breastfed babies may have better future-earning prospects than non-breastfed children [40]. It is important to consider these negative implications of breastfeeding. However, the current state of the knowledge strongly implies that, on balance, optimal breastfeeding could potentially lead to substantially more societal benefits than societal costs.

11.2.5 Cost-Effectiveness of Breastfeeding Promotion/Support Interventions

The health, economic and societal benefits described above are "potential". In other words, if we as a society were able to increase current breastfeeding rates (initiation, duration, and exclusivity) to an optimal level (e.g., all babies exclusively breastfed for 4 months), this increase in breastfeeding prevalence would generate those benefits. However, increasing breastfeeding rates would require health services to implement breastfeeding promotion and support interventions that are effective. Implementing effective breastfeeding promotion and support interventions will require upfront investment and the size of this investment may be considerable. Then the question is: Would we still get the substantial benefits described above after we have taken in to account the cost of implementing the interventions? In other words, do breastfeeding promotion and support interventions provide "value for money"? This is exactly the sort of question decision makers often ask because, in their role as public health investor, they will need to justify whether the benefits described above outweigh the costs required to implement breastfeeding promotion and support programmes.

What does the evidence say? A summary of a cross section of published studies that looked at the cost-effectiveness of breastfeeding interventions is provided in ▶ **Table 11.4**. Rice and colleagues find that enhanced contact with specially trained staff who provide education, support and a care plan for mothers is a cost-saving (cheaper and more effective) intervention, compared with usual care [41]. Likewise, proactive telephone support where a feeding support team calls women daily for one week following hospital discharge of-

▶ **Tab. 11.4** Cost-effectiveness of breastfeeding interventions.*

Study and Context	Intervention	Comparator	Cost-effectiveness
Rice et al. 2010 [41], UK hospital (neonatal unit)	Enhanced contact with specially trained staff. Staff provided education, support and a care plan for mothers.	Normal staff contact. Staff were not specifically trained to support breastfeeding mothers	• Intervention arm: – Costs: between £47,228 and £86,759 – QALYs: between 14.70 and 21.92 – depending on infant weight • Comparator arm: – Costs: between £47,294 and £87,345 – QALYs: between 14.45 and 21.91 – depending on infant weight • Intervention was cost-saving (more effective and cheaper) for all weight groups
Hoddinott et al. 2012 [42], Scotland (postnatal ward)	Proactive: Feeding support team called women daily for one week following hospital discharge. Whether to receive calls and with what frequency in the second week was chosen by women.	Reactive: Women could telephone the feeding team anytime over the two weeks following hospital discharge	• Intervention arm: – Costs: £41.25 per woman – Effects: 69% any breastfeeding at 6–8 weeks • Comparator arm: – Costs: £21.13 per woman – Effects: 46% any breastfeeding • Incremental cost = £87 per additional woman who was breastfeeding • Intervention was "promising" as a cost-effective intervention
Hoddinott et al. 2009 [43], UK, primary care	Breastfeeding groups (BIG) for pregnant and breastfeeding women in a deprived area. Included weekly group meetings facilitated by a health professional.	Usual care	• Intervention arm: – Costs: £36 per attendance – Effects: 26% (± 3%) breastfeeding at 6–8 weeks • Comparator arm: – Costs: £31 per attendance – Effects: 30% (± 7%) breastfeeding • Intervention did not provide good value for money

* A cross section of studies included in the UK National Health Service Economic Evaluation Database (NHS EED) (www.crd.york.ac.uk).

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fers some promise to be a cost-effective intervention, compared with reactive telephone support where women have to call the feeding team for any breastfeeding support [42]. However, breastfeeding groups (BIG) for pregnant and breastfeeding women in a deprived area with weekly group meetings facilitated by a health professional is not cost-effective, as this intervention is unlikely to increase breastfeeding rates among women but costs similar compared to usual care (home visits) [43].

It seems that good quality economic evaluations in this area are sparse. Paucity of good quality studies evaluating cost-effectiveness of breastfeeding interventions does not necessarily mean that breastfeeding interventions do not provide good value for money; this simply shows current lack of good quality evidence in this area. However, many interventions aimed at promoting and/or supporting breastfeeding are found to be effective. In their scrutiny of breastfeeding or feeding with breast milk interventions for infants admitted to neonatal units, Renfrew and colleagues found a number of interventions to be effective despite limitations in the evidence base [44]. These interventions include: kangaroo skin-to-skin contact, peer support, simultaneous breast milk pumping, multidisciplinary staff training and the Baby Friendly accreditation of the associated maternity hospital [44].

More scrutiny elsewhere finds counselling (peers or health personnel), Baby-Friendly Hospital support, and community mobilisation approaches do improve breastfeeding prevalence, but higher impact can be achieved via running the interventions concurrently in a combination of health system, home, and community settings [45]. Likewise, another systematic review finds that breastfeeding education/support generally increases the rates of exclusive breastfeeding and decreases no breastfeeding at birth, 4 weeks, and 60 weeks, but combined individual and group counselling seems more effective than individual or group counselling alone [46]. Importantly, breastfeeding education/support interventions and peer support interventions in low- and middle-income countries have greater impact than those in high-income countries [46], [47].

Thus, breastfeeding support interventions exist in different guises and may include peer support, support units/teams, antenatal education, counselling, staff training, or school education but, whatever form it takes, providing breastfeeding support means scarce resources are utilised [48]. As 'many of these interventions inter-relate, it is unlikely that specific clinical interventions will be effective if used alone' [44]. More cost-effectiveness studies are therefore needed to help policy makers decide whether the overall benefits of these effective interventions, preferably implemented as a package, are worth their costs.

11.3 Making the Business Case for Breastfeeding Promotion and Support

So far, we have seen that good quality evidence exists to demonstrate the scale of potential health, economic, and societal benefits that optimal breastfeeding (i.e. increasing breastfeeding initiation, duration and exclusivity) may generate, even after considering any negative impact of breastfeeding. However, it is unlikely that these potential benefits can be reaped without putting significant, upfront investments in breastfeeding promotion and/or support interventions. Also, many breastfeeding interventions are found to be effective in increasing breastfeeding initiation, duration, and exclusivity with varying degree of impact for low/middle-income and high-income countries. However, we do not seem to have sufficient good quality economic studies evaluating the cost effectiveness of those interventions. In the absence of many good quality economic evaluation studies in this area, how can business cases be made for breastfeeding promotion and/or support? In particular, can the implementation costs of those effective breastfeeding interventions be justified?

11.3.1 Return on Investment (ROI) Analysis

Building a business case often means we provide a single metric that tells us the extent to which current investment will generate an economic return within a defined time horizon. Expected rates of return (RR) from any money invested in an economic activity (e.g., provision of breastfeeding support) would help us decide whether to undertake that investment. Thus, RR can help us compare investment priorities; the portfolio with higher RRs is prioritised over the ones with lower RRs [49]. Variants of RRs exist in public health; the most common being a benefit-cost ratio [50]. Public health investors can use information such as the benefit-cost ratio to make their case for investment or disinvestment explicitly. In the field of tobacco control, for example, it has been shown that every £1 invested in Stop Smoking Services in England leads to a return of £2.82 after 10 years [51]. The National Institute for Health and Care Excellence (NICE) in England has developed a number of decision support tools, known as the return on investment (ROI) tools, to help public health investors build their business cases [52]. A number of other decision support tools exist, including the one to estimate the value for money of social marketing campaigns to support breastfeeding, but a more comprehensive ROI tool for breastfeeding support interventions may be developed in the future [53].

Until there is a comprehensive tool exclusively developed to estimate the ROI of breastfeeding promotion and/or support interventions, we have to rely on published data to build business cases for breastfeeding promotion/support. One such example is presented below based on published data available for the UK setting [2].

11.3.2 The ROI from Breastfeeding Promotion/Support Interventions: an Example

Before embarking on a business case for breastfeeding promotion/support programmes, it is important to consider what evidence exists on effective interventions and what national guidance and strategies are in place in a particular context. As discussed earlier, breastfeeding promotion and support programmes work more effectively when they are delivered concurrently in a combination of different settings. This idea has been reflected in several key documents, such as the UNICEF Baby Friendly Initiative [54] and the NICE guidance on maternal and child nutrition [55].

Building a business case for breastfeeding promotion and support is usually achieved in several steps:

Step 1: Define intervention Usually, the intervention is 'a multifaceted programme of interventions across different settings, including staff training, peer support, and activities to raise awareness and overcome barriers to breastfeeding, ensuring peer supporters are part of a multidisciplinary team and receive appropriate training' [2].

Step 2: Identify and cost intervention components Once the intervention is defined, the next step is to identify individual components of the multifaceted package of interventions and cost them. Renfrew and colleagues present one such example for the region of Lancashire, UK (▶ **Table 11.5**).

Step 3: Estimate the consequence of implementing the intervention To estimate the consequence of implementing the intervention, it is important to make three key assumptions:

Firstly, decide how much improvement in currently observed breastfeeding rates this multifaceted intervention is likely to bring. In the Lancashire example, it was assumed that implementing the above intervention would improve exclusive breastfeeding rates at 6 months from the current 0.5% to 7% (lower estimate) and exclusive breastfeeding rates at 4 months from the current 7% to 65% (higher estimate) [2]. Note that the target rates are the ones currently observed for 4 months and at birth, respectively. Therefore, the intervention was assumed to support women who were exclusively breastfeeding at birth to continue until 4 months (lower estimate) and those who were exclusively breastfeeding at 4 months to maintain that until 6 months (higher estimate).

Secondly, decide how many infants will benefit from this intervention. Usually, this is the number of newly born babies who will survive in the current year (in the Lancashire example, n = 13,785 infants).

Thirdly, select the relevant "potential cost-savings (mean)" estimate provided by Renfrew and colleagues and summarised here in and multiply that figure by the number of infants expected to

▶ **Tab. 11.5** Example incremental costs for Lancashire region (UK) of implementing multifaceted breastfeeding interventions as reported by Renfrew et al. [2]

Intervention component	Cost one-off (2012 prices)	Costs recurring (2012 prices)	Total costs (2012 prices)
UNICEF Baby Friendly Initiative accreditation for maternity units	£0	Assumed to be in the budget already*	£0
UNICEF Baby Friendly Initiative accreditation of universities	£0	Assumed to be in the budget already*	£0
Peer support services (priority national recommendation)	£0	Assumed to be in the budget already	£0
Neonatal networks training	£117,000**	£0	£117,000
Provision of donor milk	£0	£13,300**	£13,300
Support service to filter harmful advertising	£0	£57,000**	£57,000
Strategic leadership	£0	£259,000**	£259,000
Breastfeeding-welcome employers and public space*	Assumed to fall outside of the health sector	£0	£0
Support to formula-feeding mothers	£0	Included in current services, assumed no additional costs	£0
Schools programmes	Assumed to fall outside of the health sector	£0	£0
Total	£117,000	£329,300	£446,300

* It costs maternity/community units approx. £16,000 and universities £4,000 to go Baby Friendly. **See [2], Appendix p. 202–203, for detailed costing.

benefit from the interventions. In the Lancashire example, £9.93 (higher estimate) multiplied by 13,785 infants equates to approximately £136,891 (higher estimate) as the potential cost savings from gastrointestinal illnesses ("approximately" because the figures reported in ▶ **Table 11.6** are slightly different from the results of this simple calculation due to rounding).

This process is repeated for all other health outcomes, i.e. lower respiratory tract infection and acute otitis media in infants (n = 13,785 infants in Lancashire) and necrotising enterocolitis in preterm babies (n = 1,383 neonatal admissions in Lancashire).

Step 4: Estimate return on investment Fourthly, estimate the benefit-cost ratio by dividing the potential cost savings (incremental benefits) by the incremental costs of implementing the intervention. In this case, assuming that the benefits of breastfeeding are limited to the savings in treatment costs of acute diseases in children only (i.e., ignore maternal breast cancer benefits as reported by Renfrew et al 2012 [2]):

Potential cost savings per annum **(B) = £82,667** (lower estimate) or **£553,454** (higher estimate – ▶ **Table 11.6**)

Incremental costs of implementing the intervention per annum **(C) = £446,300** (▶ **Table 11.5**)

▸ **Tab. 11.6** Potential cost-savings in the Lancashire region (UK) reported by Renfrew et al. [2]

Health outcome	Potential cost savings			
	Mean (lower estimate)	**Mean (higher estimate)**	**Total (lower estimate)**	**Total (higher estimate)**
Gastroenteritis in infants	£1.11	£9.93	£15,341	£136,891
Lower respiratory tract infection in infants	£1.81	£16.12	£24,898	£222,168
Acute otitis media in infants	£0.17	£1.49	£2,296	£20,491
Necrotising enterocolitis in neonatal units	£29.02	£125.75	£40,132	£173,904
Total potential cost savings from acute diseases in children (annual, 2012 prices)	–	–	£82,667	£553,454

Benefit-cost ratio for the current year = **B / C** = £82,667 / £446,300 = **0.19** (lower estimate) or = £553,454 / £446,300 = **1.24** (higher estimate)

Now, assume that the size of the birth cohort for the next year is similar to this year but the incremental cost of intervention is lower (£329,300) as the health system would have to pay just the recurring costs from second year onwards. Recalculate the benefit-cost ratio (discounting for the second year could be ignored as the effect is relatively small).

Benefit-cost ratio for the next year = **B / C** = £82,667 / £329,300 = **0.25** (lower estimate) or = £553,454 / £329,300 = **1.68** (higher estimate)

Step 5: Interpret results with caveats The final step involves interpreting the benefit-cost ratio and acknowledging that the interpretation comes with some caveats.

The above benefit-cost ratios suggest that a multifaceted evidence-based breastfeeding support intervention as defined above is likely to be cost effective. The most conservative estimate (i.e. benefits limited to acute childhood diseases with lower estimates) suggests that there would be a net loss (£1 investment gives a return of £0.19 this year) but if considering higher estimates of the same benefits, the intervention is good value for money (£1 investment gives a return of £1.24 this year). As incremental costs of implementing the intervention decline in the following years as a result of not having to pay for one-off costs, the returns will increase.

Several caveats are worth mentioning here. The benefits of breastfeeding support interventions are wider than just the cost savings in the acute childhood disease area. As discussed previously, good quality evidence consistently implies that breastfeeding-support interventions have potential to increase breastfeeding rates and such an increase generates wider benefits. The most obvious is the value of benefits from the treatment of fewer maternal breast cancer cases, which in the case of Lancashire could range from £399,000 to £724,000 over the lifetime of each annual cohort of first-time mothers [2]. Once this benefit, together with the benefits coming from savings incurred elsewhere (e.g., fewer cases of sudden infant death syndrome and childhood obesity, and better cognitive outcomes) is included in the above calculation, a significant proportion of the investment is likely to be offset by the returns, even in the short term.

Over time, as members of staff providing breastfeeding support become more skilled, resulting in reduced additional training and leadership costs, the investment required to implement the intervention will fall from the initial level. This will make the investment generate a more favourable ROI. It is important, however, to recognise that it may take several years before a return on investment is seen from a breastfeeding-support intervention [48], but the estimates presented above suggest that evidence-based multifaceted support intervention is likely to result in a positive net benefit within a much shorter period.

11.4 Summary

The use of alternatives to human milk for feeding infants has attracted enormous debate within health economic literature. The answer to the question – what economic value may human milk have – varies depending upon what perspective is taken. Convincing evidence exists to support the viewpoint that breastfeeding is protective against a number of illnesses, in particular gastrointestinal illnesses, lower tract respiratory infections and acute otitis media in infants, necrotising enterocolitis in pre-term babies, and breast cancer in mothers.

Choosing to breastfeed is a complex economic decision that women have to make; the complexity is further aggravated by three key attributes: initiation, duration, and exclusivity. Women often weigh the benefits (incentives) of choosing to breastfeed, how long to breastfeed, and whether to breastfeed exclusively, against the costs (disincentives). Breastfeeding is often associated with significant private costs, in both money and time. In addition, maternal employment is negatively associated with breastfeeding durations, and the impacts often extend to wider labour market outcomes, such as prolonged maternity leave and limited prospects for promotion and productivity.

The current breastfeeding rates are suboptimal and increasing breastfeeding prevalence in those women who choose to breastfeed could bring substantial benefits to women themselves, to their children, to the national health systems and to the wider society at large. Women and children could enjoy better quality of life through reduction in their risk for certain diseases. To the national healthcare system, having to treat fewer cases of certain health conditions in a breast/milk feeding population means substantive cost savings. To the wider society, benefits accrue over time due to fewer premature deaths, coupled with lower prevalence of cognitive impairment and childhood obesity, in the breast/milk feeding population.

Good quality evidence on both the impact of breastfeeding as well as the effectiveness of breastfeeding promotion/support interventions is evolving. The current state of the knowledge clearly implies that promotion of breastfeeding on all three aspects (initiation, duration, and exclusivity) could lead to much more societal benefits than societal costs. It is therefore important to make a business case for breastfeeding promotion and support.

Whilst the evidence on economic impact of suboptimal breastfeeding is robust, the cost-effectiveness evidence of breastfeeding support interventions is relatively sparse. More research is therefore needed in this area. One way to make the economic case for breastfeeding promotion/support is to combine published robust studies around "what works" for increasing breastfeeding rates with other studies around the impact of suboptimal breastfeeding. This approach allows estimation of a single metric (e.g., benefit-cost ratio) demonstrating what economic returns are gained from every $1 spent in providing breastfeeding-support interventions.

Key Points

- Women are more likely to choose to breastfeed if they feel there are more incentives (benefits) than disincentives (costs)
- There is evidence of a negative economic impact of suboptimal breastfeeding indicating national health services could save millions of dollars every year if current rates of breastfeeding were to increase
- Investment in breastfeeding programmes needs to be targeted and evidence is available to suggest an integrated package of several interventions delivered concurrently is more cost effective than each activity delivered on its own
- A return on investment approach to evaluate a package of breastfeeding-support interventions may be helpful for decision makers until more good quality cost-effectiveness studies evolve

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12 Commercial Aspects of Breastfeeding: Products and Services

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Expected Key Learning Outcomes
- The importance of access to safe pumping facilities
- Guidelines to ensure safe supplementation
- Importance of donor milk
- Importance of access to skilled breastfeeding support and who should provide it

12.1 Introduction

Any discussion of a public health topic has a commercial aspect to it and breastfeeding is no exception. Similar to childbirth and parenting, the natural, biologically normal process of breastfeeding has been over-commercialised. Healthcare providers who focus specifically on providing lactation care recognise that for most breastfeeding couplets, all that is needed is a baby and lactating breast(s). Yet, any visit to a retail store or Internet search for maternity/baby products will reveal an astonishing array of items that the breastfeeding mother “needs”. The audience for these markets usually is the middle-to-upper socio-economic segments of a society with excess income to spare for non-essentials. Lower socio-economic families are less likely to spend scarce resources on breastfeeding products and this lack of ability to purchase “needed” items may influence the mother’s perception of how successful she will be at breastfeeding [1], [2].

A proportion of breastfeeding couplets encounter difficulties requiring professional lactation care and specialty products to help overcome those issues. In these situations, it is more likely that the higher-income mother can access services and products to help her sustain breastfeeding, while the lower-income mother cannot, leading to premature weaning. Global statistics on breastfeeding initiation and duration highlight the disparity in breastfeeding rates in many countries [3]. In some countries, this disparity is even reflected in the hospital of delivery. Hospitals that deliver a higher percentage of upper-income families are more likely to implement best practices to establish successful breastfeeding, while hospitals that deliver a higher percentage of lower-income families are more likely to maintain outdated practices that decrease breastfeeding initiation and duration rates [4].

This chapter describes commonly used products (breastfeeding and human milk products) and commonly available breastfeeding services (lactation service providers). Mothers may purchase accessories or items they perceive helpful for breastfeeding or they may be provided a breastfeeding tool needed as part of a plan of care to resolve a problem. Breastfeeding infants may need some type of human milk product, in addition to or in lieu of their own mothers’ milk. Virtually every breastfeeding mother and child benefits from the services of a healthcare provider specifically trained to provide some level of lactation care, ranging from the preventive/educational level of care to the more complex/clinical level of care. Policymakers and healthcare authorities can benefit from a clear understanding of essential products and services, and barriers to their access.

12.2 Breastfeeding Products

12.2.1 Milk Expression

One of the most frequently purchased breastfeeding products is some type of mechanical breast pump used for milk expression [5]. Breast pumps can be very useful for mothers who need to express milk on a regular basis, while manual/hand expression is a more effective and efficient method for many women worldwide. Globally, 54% of mothers are in the workforce while in the United States (USA) 64% of mothers of infants return to work, thus necessitating daily, regular milk expression to maintain milk production and provide milk for their infants [6], [7] (see Chapter 9). Mothers who give birth to a preterm or critically ill infant that cannot yet feed at the breast must initiate and maintain lactation through some form of milk expression (see Chapter 16). Preterm birth rates range from 5% to 18%, with a global average of 11% [8]. These vulnerable infants are more likely to survive and thrive if fed their own mothers' milk. Increasing frequency of milk expression is also recommended for mothers who have experienced a decrease in milk production for various reasons (e.g., difficulty latching the newborn, early formula supplementation).

Manual or hand expression is an option for most mothers that does not require special equipment, electricity or battery power, and is free. For a mother who is separated from her baby, use of a double electric multi-user breast pump is often considered an absolute necessity for initiating and maintaining milk production in the early weeks. However, newer evidence indicates that even the most expensive, quality pumps are less effective at milk removal than hand expression [9], [10], [11]. Combining hand expression with use of an electric breast pump is very effective and can reduce the time it takes a mother to express her milk [10]. Specifically, use of a breast pump may be more comfortable for a mother who has severely engorged breasts or some type of physical impairment, and may be psychologically more acceptable to a mother with a history of sexual abuse [12], [13].

Mechanical breast pumps range from low-cost manual pumps for occasional milk expression to various types of electric pumps. More expensive electric breast pumps will have more automated features, such as automatic cycling of vacuum and speed. Lower cost electric pumps require manual cycling of vacuum and speed and can cause nipple damage if the vacuum is not released appropriately. Any breast pump can cause pain and trauma if not used correctly. When mothers are not instructed in effective milk expression, they may inadvertently cause pain or damage by pumping for too long or with too high a vacuum, neither of which will help them remove more milk [14]. The section of the pump kit that fits over the nipple area (the pump flange) must be fit to the individual mother. A flange that is too tight can cause nipple pain and damage, and obstruct the flow of milk, reducing the volume removed and eventually reducing overall milk production [15].

Access to quality, safe breast pumps is a public health and economic issue. Some countries define breast pumps as consumer goods rather than medical devices [16]. Most countries do not regulate the quality of breast pumps though some may monitor and report safety concerns [17]. Upper socio-economic families are more likely to afford the higher quality breast pumps, while lower socioeconomic families may purchase a lower cost pump only to find that it does not function effectively, or worse, causes breast/nipple trauma. Resource-poor countries may not have quality breast pumps or access to replacement parts, different size pump flanges, batteries, or consistent electricity. Ultimately, if pumping is painful, too time consuming at work, or leads to a drop in maternal milk production, it is easier for many mothers to discontinue breastfeeding and turn to the ever present, highly marketed formula products.

Mothers who deliver in a Baby-Friendly designated hospital are more likely to receive timely breastfeeding support from trained hospital staff, including instruction in hand expression. They must also be taught early effective milk expression if separated from their newborn for medical reasons [3]. A mother who gives birth in a hospital that is not Baby-Friendly designated is less likely to receive either skilled breastfeeding support or instruction in milk expression. If the hospital has breast pumps, staff is less likely to be trained in their use, and mothers are more likely to receive formula for routine supplementation of their newborns and leave the hospital with breastfeeding problems.

12.2.2 Alternative Methods of Feeding

When infants are not nursed directly at breast, they must be fed milk by some other means. Once breastfeeding and milk production are well established, the breastfed baby can typically be fed by bottle in the absence of the mother (e.g., when she is at work). In the early postpartum period, when lactation is critically dependent on effective infant latch and milk transfer, introduction of bottle-feeding or use of artificial nipples (bottle nipples or pacifiers) can cause many breastfeeding difficulties [18]. Mothers are encouraged to breastfeed exclusively and to avoid supplementation with formula or use of artificial nipples [19], [20]. Feeding of formula to the newborn decreases the frequency of breastfeeding and stimulation of milk production, in addition to increasing risk of acute and chronic diseases in the infant. Use of artificial nipples or pacifiers also decreases suckling time at breast and can lead to painful breastfeeding due to changes in how the infant attaches at breast.

The Baby-Friendly Hospital Initiative guidelines require informed decision-making by the mother before a breastfed baby is supplemented with any type of milk or fed by any other method. If there is a medical necessity to supplement, the baby should be fed by an alternative method, not bottle, and the mother should be instructed immediately in milk expression [3]. Research on alternative methods of oral feeding that support continued breastfeeding is limited. Commonly described methods include feeding by cup or paladai, with a tube supplementing device at breast or by finger, or by dropper or spoon (▶ **Fig. 12.1**, ▶ **Fig. 12.2**). Babies who are completely unable to feed by mouth are likely to be fed by intra-gastric tube, an invasive method which is not discussed here. The largest body of evidence supports cup feeding, which is simple, non-invasive, easy to learn, easy to clean, and low cost in that it requires only a small cup, such as the 30 ml plastic medicine cups that are widely available in many hospitals. In India, the paladai is a small cup with a spout that channels the milk so the baby can sip easily.

The Academy of Breastfeeding Medicine's Model Hospital Policy recommends supplementation by cup when there is a medical reason to supplement a breastfed newborn [21]. Their 2009 protocol #3 on Supplementary Feedings provides a concise summary of the risks and benefits of various methods, ultimately stating that 'an optimal supplemental feeding device has not yet been identified' [22]. A tube-supplementing device delivers the supplement at breast for the infant that can latch and suckle to some degree. These devices are expensive, not readily available, can be complex to use, and are difficult to clean. Certain highly motivated mothers may prefer using a tube supplementer at breast to enable them to directly breastfeed their babies, e.g., adoptive mothers or mothers who are physically unable to produce milk [23]. Finger feeding is use of a tube supplementer attached to the caregiver's finger that the infant sucks on. Research on feeding with any kind of tube supplementer is very limited [22].

▶ **Fig. 12.1** Cup feeding an infant.

▶ **Fig. 12.2** Feeding with a paladai.

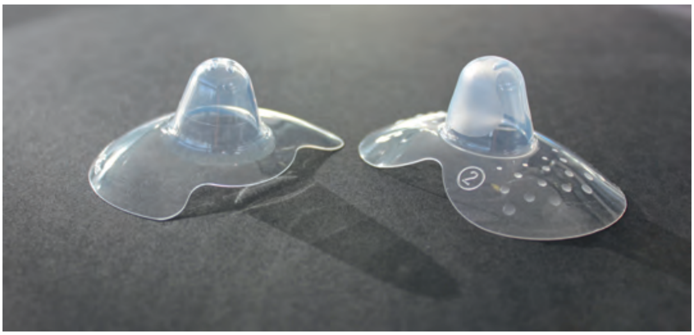
12.2.3 Breastfeeding Challenges

Nipple shields were initially developed for use by mothers with inverted or retracted nipples to help the infant grasp the breast and maintain their latch during feeding. Most current models are made of very thin silicone and designed to be placed directly over the mother's nipple (▶ **Fig. 12.3**). If the infant can attain a deep, areolar latch, the mother's nipple and breast tissue will be drawn well into the infant's mouth and rhythmically compressed during suckling. Nipple shields can be very helpful in certain circumstances and have been over-utilised in many cases [24], [25]. The strongest evidence for their use is with preterm babies in the neonatal intensive care unit (NICU) [26], yet they may often be given to mothers in the hospital who have no nipple anomaly but have a baby who is not consistently latching or is sleepy in the first few hours of life. Nipple shields have been helpful in cases where the infant has sucked on artificial bottle nipples or pacifiers and will no longer maintain a latch at breast. Nipple shields may also help sustain direct breastfeeding in cases of severe nipple trauma.

Early use of nipple shields should be accompanied by regular milk expression to protect maternal milk supply [27]. Nipple shields come in different sizes, and must be fit to the mother's nipple and baby's oral cavity. Early use of nipple shields can also lead to a baby who will not nurse without it, leaving the mother in a stressful situation if the nipple shield is lost. Nipple shields are easily purchased in many retail outlets, and may be obtained by mothers attempting to resolve a breastfeeding problem without professional help. Improper use of a nipple shield may compromise maternal milk production and lead to an ineffective infant latch. Use of a nipple shield requires follow up with an International Board Certified Lactation Consultant (IBCLC) to monitor infant intake, weight gain, and maternal milk production, and assess if the original problem has been resolved. Mothers need help in weaning their babies from the nipple shield and teaching them to latch without one [27].

Nipple everters are devices developed more recently to aid in correcting inverted nipples without having to utilise a nipple shield. They are designed to apply concentrated suction directly to the nipple immediately prior to latching the baby. Nipple everters are usually some type of syringe or bulb-syringe device, and there is no research on their efficacy. In lieu of evidence-based options, some lactation consultants recommend use of a mechanical breast pump to help draw the nipple out and protect the milk supply.

Gel dressings are glycerine or water-based gel pads that are placed over the nipple area to promote moist wound healing in cases of moderate-to-severe nipple trauma. Gel dressings are oxygen permeable, speed tissue healing, protect damaged skin from further trauma, and reduce nipple pain. While gel pads can be costly, one set (pair) can be reused for several days, which in many cases is the length of time they are needed. Gel pads should not be used when there is a known wound infection. They also have the potential to contribute to growth of yeast or bacteria if not used appropriately. Research on their efficacy is conflicting [28].



▶ **Fig. 12.3** Nipple shields. (Family Larsson-Rosenquist Foundation, Switzerland)

Pacifiers or dummies are a ubiquitous baby product worldwide. While designed for use by any infant caregiver, they are often considered a necessity for breastfeeding mothers due to the common misconception that babies who nurse frequently are "using her as a pacifier". Cultures that value early independence of children are more likely to perceive frequent nursing as a needy, demanding baby instead of normal physiological breastfeeding and mother-child bonding [29], [30]. Pacifiers can lead to breastfeeding problems if they are utilised because of an underlying breastfeeding problem [31], [32]. Early pacifier use before establishment of effective latch and maternal milk production can lead to missed feedings at breast, decreased milk production, decreased infant intake, difficulty latching, and increased nipple pain [33], [34]. Long-term use of pacifiers can increase risk of ear infections, change the shape of the oral cavity structure, and cause shorter breastfeeding duration [35].

Pacifiers can be useful for infants having painful procedures, who are not able to feed orally to help them associate sucking with milk intake, and who need calming when their mother is not immediately available. Pacifiers have also been recommended once breastfeeding is well-established, when infants are laid down to sleep to reduce risk of sudden unexpected infant death [36], [18]. The Baby-Friendly Hospital Initiative requires hospitals to educate mothers on risks of pacifier use and eliminate their routine use in newborns.

Nursing bras, nursing clothing, baby wraps/slings, and breastfeeding pillows are other commonly available products marketed heavily to breastfeeding mothers. These types of products can be nice to have for the mother that can afford them, but are not necessary for successful breastfeeding. Mothers do not need special clothing for breastfeeding, although a well-fitting bra that she can comfortably nurse in is helpful. Baby wraps for carrying the baby and allowing easy breastfeeding when out in public or managing other responsibilities are very useful. They keep the baby close, calm, and can be easily and inexpensively made with a large piece of cloth. In Bolivia and other Andean countries, the colourful aguayos are standard equipment for mothers with babies and young children (▶ **Fig. 12.4**). Specialty breastfeeding pillows that wrap around the mother and support the baby during feedings are popular and may facilitate easier breastfeeding for a first-time mother or a mother with twins. Some type of pillow support can be achieved with common household items, such as bed pillows or rolled up blankets.

▶ **Fig. 12.4** Bolivian aguayo.

12.3 Human Milk Products

12.3.1 Banked Donor Milk

The practice of giving a baby milk from another mother has existed throughout human history. The Code of Hammurabi from 2250 BC is the first known written information on breastfeeding and it described the qualities of a good wet nurse [37]. In past centuries, breastfeeding and human milk were commodities that could be sold by low-income women through the practice of wet nursing [38]. The concept of milk banking developed in more recent history when artificial formula milk products began to compete with breastfeeding and it became difficult to locate wet nurses when needed. The first milk bank opened in Vienna, Austria in 1909, while the first milk bank prototype in the US was opened by a physician in Boston, Massachusetts in 1910 [39]. The Boston Directory for Wet Nurses intended to address the sudden decline in breastfeeding rates by making it easier and more respectable to find a wet nurse. It gave 'destitute girls with babies an opportunity to earn an honest living' and sold expressed milk that had been purchased from the wet nurses [40]. The development of refrigeration allowed for safer storage of expressed milk in milk banks and hospitals, enabling more low-income mothers to have honourable employment by selling their milk to a milk bank while they cared for their own child at home.

In Australia, milk banking began on an informal volunteer basis in the 1970s, with some hospitals partnering with the Nursing Mothers Association of Australia to recruit members to donate expressed milk for certain sick infants [41]. The Human Milk Banking Association of North America (HMBANA) was formed in 1985 to establish standards for milk banks in Canada, Mexico, and the US, and it also promoted milk donation instead of payment for milk. As with most milk banks prior to the identification of the HIV virus, the milk was not pasteurised, although donor mothers were screened for infectious diseases. It is now common practice throughout the non-profit milk banking consortium to require milk donation in an effort to reduce the risk that a mother would be financially tempted to sell her milk instead of providing for her own baby or to adulterate the milk to increase the volume provided. Most banked donor milk is pasteurised by an evidence-based method specific for human milk known as Holder pasteurisation [42], [39]. Though active research is ongoing, current processes have a strong safety record. HMBANA reports no proven adverse outcome in infants receiving milk from a HMBANA milk bank in thirty years of operation.

A full description of milk banking is covered in Chapter 14. This section describes the increased demand for safe, pasteurised donor milk for use in hospitals and the current controversy between non-profit and for-profit milk banking. Milk banks have increased greatly in number as the evidence in support of donor milk feedings for preterm and critically ill infants has grown [43], [44]. There are milk banks in at least 37 countries worldwide with Brazil the leader in milk bank development at 215 banks [45]. Brazil cites its extensive milk bank network as instrumental in the dramatic decrease of infant mortality by 73% in less than 30 years [46]. The Brazilian model demonstrates the powerful impact of federal funding to build an adequate nationwide milk bank infrastructure rapidly (▶ **Fig. 12.5**). HMBANA, with no federal funding, reports an increase in distribution of pasteurised donor milk from 1.4 million ounces in 2008 to 3.7 million ounces in 2014. This volume is a significant increase yet still well below the 2011 estimate of 9 million ounces needed just to serve the preterm infants born weighing less than 1500 grams in the US [39], [44].

The vast majority of milk banks around the world are non-profits with similar standards for donor screening and the processing and distribution of donated milk. The International Milk Banking Initiative is an alliance of many of these milk banks formed to 'promote safe, ethical and accountable human milk banking around the globe' [45]. Non-profit milk banks in many countries belong to a national organisation that provides standards for best practice, such as the European Milk Banking Association, and promote international cooperation on research and milk bank processes, such as joint statements of EMBA and HMBANA [47].

While healthy breastfeeding mothers freely donate their milk, milk banks charge a service fee for

▶ **Fig. 12.5** Brazilian preterm Infant in kangaroo care and receiving breast milk.

any pasteurised milk dispensed to cover some of the costs of screening, testing, and processing. This practice is similar to the blood banking industry. Many milk banks also rely on government funding, grants, and financial donations to support their operations. Target populations served with pasteurised donor milk primarily include preterm or critically ill hospitalised infants. Some milk banks may provide milk on an outpatient basis to babies in the community with a medical need, while the lowest priority for most banks, due to current supply, are healthy term infants whose own mother cannot produce enough milk. Ideally all babies that do not have access to their own mothers' milk would be provided donor milk as the next best option. Worldwide current milk banking capacity needs to be greatly expanded and the Brazilian model is worth exploring, especially for resource-poor countries.

In recognition of the need for human milk products, lack of regulation in some countries, and the potential for financial profit has led to development of various for-profit models of milk banking. Prolacta Bioscience is a for-profit company based in the US which primarily produces human milk-based fortifier, designed to be added to own mother's milk or donor milk for very low birth weight babies in NICUs. Producing human milk-based fortifier requires about ten times the volume of donated milk to be concentrated into fortifier. Prolacta partners with other organisations to recruit donor mothers and offers US$1 per ounce of donated milk up to 300 ounces per donor mother [48]. All milk is sent to Prolacta's main facility in California for processing and dispensing. Partner organisations receive priority in the use of Prolacta products. Prolacta has sponsored and published its own research as well as some clinical trials that have been published in peer-reviewed medical journals [49].

Two other companies are Medolac and the International Milk Bank [50], [51]. Medolac lists itself as a "public benefit corporation", which in the US is defined as a for-profit corporation that can include some type of public benefit in its charter in addition to maximising profit. Medolac produces a donor-milk product that it advertises as 'commercially sterile' and stable at room temperature for three years but has not been independently tested for composition or health outcomes. The International Milk Bank (IMB) is in development and describes itself as a privately held company that will also produce 'commercially sterile' milk. It is partnered with an online-only organisation, Only The Breast, that provides an Internet platform for mothers to sell their breast milk to anyone in the country, for adult or child use (See Chapter 12.3.4).

The commercialisation of human milk raises concerns over allocation of a uniquely scarce and vulnerable resource. Human milk donation, as opposed to blood or organ donation, is unique in that the giving or selling of a mother's milk potentially impacts not just a single donor but the mother and her infant. The non-profit milk banks have a long history of checking the health status of both the donor mother and her baby as part of their donor screening [39]. Most non-profit milk banks worldwide belong to a national or regional network of banks that support each other and ensure the supply of pasteurised donor milk is available to the most critically ill infants, regardless of family income. Many HMBANA milk banks also provide charity care in their communities.

In the US, the Food and Drug Administration (FDA) does not currently regulate human milk banks, although they have begun reviewing HMBANA milk banks through onsite inspections. Medolac and IMB both state they follow the FDA's pasteurised milk ordinance, which applies to the dairy industry. Prolacta states that it is registered with the FDA as a food manufacturer and that its products are regulated as infant formulas.

12.3.2 Other Milk Products

The most common additional milk product is human milk fortifier. This product is typically used to provide additional nutrients to expressed human milk for the very low birth weight infant, weighing less than 1,500 g. With modern neonatal care increasing the survival rate of these tiny infants, research on optimal nutrition for a baby born months too early is ongoing. Human milk feedings, particularly the baby's own mother's milk, are the current standard of care in NICUs worldwide [52]. Fortification for very low birth weight infants is also commonly recommended to address the gap in protein, calcium, and phosphorus. While optimum growth rates may still be debatable (weight versus length), fortification is strongly recommended [43]. Until the recent development of the first human milk-based fortifier by Prolacta, the only fortifiers available were made by the formula industry from bovine-based products. These products are suspected of contributing to the development of necrotising enterocolitis even when the infant was otherwise exclusively fed human milk. For more detailed information on fortifiers in the NICU, see Chapter 13.

Due to the very high cost of human milk-based fortifier, both in monetary terms and usage of human milk resources, some neonatologists have proposed individualised fortification of human milk. Some research has looked at separate fortification with calcium and phosphorus instead of a packaged 'one size fits all' approach. Other research has looked at protein supplementation using hydrolysed bovine-based proteins. Individualising an infant's feedings would also benefit from pre-supplementation analysis of the mother's milk to increase accuracy of nutritional fortification. Most NICUs are not currently able to analyse human milk, although some have partnered with local milk banks to explore this option [53].

12.3.3 Other Human Milk Uses

Colostrum capsules and powders made from bovine products have been available for over 20 years and are advertised as potent immune system boosters. Social media and the Internet have now allowed the promotion of human colostrum and breast milk sold by individuals. Cancer patients have tried regular doses of donated human milk as a cancer treatment and to relieve the side effects of chemotherapy. While there is laboratory research indicating certain proteins in human milk can destroy cancer cells [54], [55], there is no published research that adult consumption can treat or prevent cancer. Human milk has also been touted as a nutritional therapy for transplant patients, and as a topical treatment for burn patients and acute infections of various types. Human milk is advertised by some sellers as 100% organic, dairy free, nicotine free, gluten free, etc. A newer trend is the purchase of human milk at even higher prices by athletes to increase stamina and boost energy [56]. There is no evidence to date to support any benefit of human milk for an adult diet or as a therapeutic topical treatment. Women selling their milk for unproven benefit raise concerns that some may sell their milk to generate income rather than feed it to their own baby, or that this action will discourage them from donating to a milk bank to help preterm infants.

12.3.4 Milk From Other Mothers

A more common historical practice has been the informal provision of human milk to family members or close friends or neighbours in one's community. This practice is now known as informal milk sharing to distinguish it from donating milk to a milk bank. Sharing or giving milk to someone that is known personally reduces the risk of receiving milk that is contaminated or adulterated in some way, or that the mother uses tobacco or other substances that could be transmitted through her milk. Giving milk or wet nursing historically was most often due to maternal illness or death, leaving the family with no safe alternatives for feeding the newborn.

In more modern times, the strong public health messaging about the importance of breast milk and breastfeeding has led to an increase in percentage of women wanting to breastfeed but not succeeding due to the multiple societal barriers that now exist (e.g., hospital practices, workplace obstacles, lack of maternity leave). In many countries, the vast majority of women initiate breastfeeding but less than half are doing any breastfeeding by six months and certainly not the recommended exclusive breastfeeding for the first six months [57], [58]. Mothers who want their babies to have the best nutrition and are unable to provide it themselves now turn to friends and family members for help in providing milk. EMBA and HMBANA have issued a joint statement concerning the topic of informal milk sharing (available online at www.europeanmilkbanking.com). When mothers and their babies are known to each other, the concept of beneficence is more likely to apply and the gift of milk is unlikely to carry any serious risk for the recipient baby, unless the mothers live in a region where breastfeeding with HIV is not contraindicated [39], [59].

12.3.5 Internet Purchasing of Milk

The new development in milk "sharing" is the donating or selling of human milk via social media and the Internet. Several websites and Facebook sites now help connect mothers with surplus milk to mothers or others seeking milk to feed an infant or for other uses as mentioned previously. This practice is currently not regulated and, similar to the sale of prescription medications online, would be difficult to do so. Some recent studies examining the content of human milk purchased over the Internet indicate possible bacterial contamination, lack of appropriate storage of the milk during transport, and adulteration with bovine products. Keim et al. found that 10% of 102 samples of milk purchased over the Internet contained at least 10% cow's milk, indicating a cow-milk product was purposefully added [60]. The same authors analysed the milk for bacterial contamination and found the majority of samples had significant bacterial growth when compared to unpasteurised milk donated by screened donors to a non-profit milk bank [61]. They concluded that mothers want to breastfeed due to the tremendous health advantages and have limited options when they encounter breastfeeding difficulties or struggle with milk supply issues. More access to lactation support is needed to help women successfully feed their own babies.

12.4 Lactation Service Providers

12.4.1 International Board Certified Lactation Consultants

The International Board of Lactation Consultant Examiners (IBLCE) is an independent, non-profit organisation whose mission is to establish the 'highest standards in lactation and breastfeeding care worldwide', and to certify 'individuals who meet these standards' (www.iblce.org [62]). IBLCE is accredited through the National Commission for Certifying Agencies of the Institute for Credentialing Excellence and has maintained that designation as a high quality certification program for over 30 years. IBLCE administers the global certification program for International Board Certified Lactation Consultants (IBCLCs), which currently includes over 28,000 IBCLCs in 102 countries.

IBCLCs are skilled healthcare professionals trained in all aspects of breastfeeding and lactation care. Candidates must meet the eligibility requirements of college-level health science courses, 90 hours of lactation-specific education, clinical practice hours, and pass IBLCE's rigorous, independent exam (http://iblce.org/certify/eligibility-criteria/). The psychometrically evaluated exam is administered worldwide and translated into 15–17 languages from year to year. IBCLCs must maintain certification through a recertification process every five years including re-examination every ten years. Recertification every five years through continuing education encourages continued professional development and lifelong learning. Recertification by exam every ten years assesses current knowledge and cognitive skills and is based on a global practice analysis that captures new developments in the profession.

IBCLCs practice within the Scope of Practice for IBCLCs, must comply with the Code of Professional Conduct for IBCLCs and are subject to IBLCE's disciplinary process. The Clinical Competencies for the Practice of IBCLCs provides a detailed description of the knowledge and expertise expected of currently certified IBCLCs, while the Standards of Practice published by the International Lactation Consultant Association provide guidance on a minimum expectation for clinical practice and professional behaviour (www.ilca.org). Current certification status of any IBCLC can be verified at IBLCE's online registry at https://iblce.org/public-registry/. While the IBCLC credential is recognised worldwide, IBCLCs must comply with any legal requirements in the country or jurisdiction in which they practice.

As the only healthcare team members independently certified as specialists in breastfeeding and lactation care, IBCLCs can provide preventive and diagnostic care, advocate for policy changes to support breastfeeding families, and educate healthcare professionals, policy makers, and families about the importance and management of breastfeeding. IBCLCs work in many healthcare settings, such as hospitals, birth centres, physicians' offices, and public health clinics, and as home-visiting providers. IBCLCs are key members of not only the clinical healthcare team but the public health team. Access to IBCLC care is a public health issue and can increase breastfeeding initiation and duration rates. A 2013 study in Pediatrics showed that 60% of breastfeeding mothers in the US stopped breastfeeding before they intended to, many due to breastfeeding problems [1]. A 2006 study demonstrated a four-fold increase in breastfeeding at hospital discharge for low income women enrolled in the US Medicaid program when the hospitals employed IBCLCs [63]. Bonuck et al. found that mothers who spent an average of three hours total with an IBCLC were almost three times more likely to initiate breastfeeding and continue breastfeeding to three months [64]. An earlier study by these authors published in Pediatrics found that IBCLC contact also increased breastfeeding intensity and duration in low-income minority women [65].

12.4.2 Other Lactation Training and Certification

While IBCLCs are important healthcare team members, valuable breastfeeding support can and should be provided by others. Lactation and breastfeeding are impacted by many factors, including physiological, psychological, sociological, and cultural factors. At a minimum, any professional working in maternal-child health should have a basic knowledge of the importance of breastfeeding and how to access skilled support for families. Depending on their level of contact with families of breastfeeding infants or young children, health professionals need further training in basic breastfeeding management, particularly preventive care. The World Health Organization and UNICEF developed a 40-hour course in breastfeeding appropriate for any health professional [66]. The US Breastfeeding Committee identified core competencies in breastfeeding for all health professionals [67]. The Baby-Friendly Hospital Initiative requires a minimum of 20 hours of training, including skills verification for nurses working in maternal/newborn units [3].

There are numerous lactation courses worldwide, many readily available online. Courses that are at least 45 hours in length and meet quality standards established by the Lactation Education Approval and Accreditation Review Committee can be found at www.leaarc.org. Some courses may provide a title after attending or completing the course. These education courses are often proprietary and only confer a title if their specific course is completed such as Lactation Educator (LE), Certified Breastfeeding Educator (CBE), Certified Lactation Educator (CLE), or Certified Lactation Specialist (CLS). Some courses may offer attendees a test at the end, such as the CBE or the Certified Lactation Counselor (CLC). The CLC course was initially based on the WHO 40-hour course though it has been increased to 45 hours. Typically, there are no prerequisites for these types of courses and they are targeted to professionals and para-professionals.

In many countries, para-professionals or community health workers increase access to care and may provide basic breastfeeding support in the community or in the home setting. These health workers also need breastfeeding training. In India, every village selects a local woman who is trained as an Accredited Social Health Activist (ASHA) [68]. ASHAs provide education and information on a number of public health issues such as hygiene, nutrition, healthy living, and sanitation. ASHAs receive training in reproductive issues including safe delivery and breastfeeding, and may be the first contact for women and children with limited access to healthcare services. Latino communities in the US and many Latin American countries may employ a similar type worker known as a promotora [69]. The advantage of these types of community health workers in breastfeeding support is that they are more likely to represent the culture and background of the families in the community. Disparities in breastfeeding rates that are often seen in minority populations can be reduced when culturally and ethnically supportive breastfeeding care is available in the community [70].

12.4.3 Mother-to-Mother/Peer Support

Historically, before the advent of artificial milk substitutes that were and continue to be heavily marketed to replace breastfeeding, mothers received support from other breastfeeding mothers. Often defined as mother-to-mother support (MTM) or peer support, perhaps the best known organised version of this type of support is La Leche League International (LLLI). LLLI was launched in 1956 by a small group of mothers in the Chicago, Illinois area when breastfeeding initiation rates in the US were hitting their nadir of 20% (http://www.llli.org/lllihistory.html). LLLI is now 60 years old with chapters in close to 70 countries. LLLI leaders are volunteers trained in breastfeeding counselling and must have breastfed at least one child. The Australian Breastfeeding Association (ABA) also trains breastfeeding mothers to provide MTM support (https://www.breastfeeding.asn.au/).

In 1985, the ABA (then known as Nursing Mothers Association of Australia) and LLLI recognised the need for a healthcare professional specifically trained in lactation care and, with initial funding from LLLI, advocated for the launch of the IBCLC profession. In the US, the Women, Infants and Children Supplemental Nutrition Service (WIC), adapted the MTM or peer support model to the WIC population by training WIC Breastfeeding Peer Counselors (BFPC). These paid counsellors are required to have been a WIC client and also successfully breastfed a child. WIC BFPCs have been shown to have a significant positive impact on breastfeeding initiation, exclusivity, and duration [71]. In Oklahoma, US, counties with WIC BFPCs have breastfeeding initiation rates higher than the state and national averages when WIC populations typically have some of the lowest breastfeeding rates [70], [72], [73].

12.4.4 Levels of Lactation Care

All breastfeeding families need access to timely, adequate lactation and breastfeeding care. The level of care needed can vary significantly and can be influenced by the level of knowledge and training of the available lactation-support provider. Some countries may define breastfeeding care as a preventive-type service, with education of the family about breastfeeding as an option for infant feeding. The expectation is that breastfeeding is ‘natural’ and therefore the family can manage without further healthcare support. If the infant requires a higher level of care, for example if the level of bilirubin is elevated and requires re-admittance to the hospital, then diagnostic care is implemented. This situation can lead to a “diagnosis” of breastfeeding failure and recommendation to change to formula feeding. This type of suboptimal breastfeeding care can occur in systems where healthcare professionals have not had any breastfeeding training and IBCLCs are not available. A more optimal application of a preventive/diagnostic model of care would involve the following:

- Trained healthcare staff that provide effective prenatal breastfeeding education
- Delivery in a Baby-Friendly hospital that provides optimal breastfeeding care
- Access to trained community support after discharge for low risk breastfeeding families
- Access to IBCLC care in hospital and in the community for high risk or complicated breastfeeding situations

Another model defines breastfeeding care based on acuity [74]. Defining different breastfeeding situations as low acuity versus high acuity helps to allocate appropriate resources in a timely fashion. Patient acuity is a concept that is used widely in healthcare and is applicable to lactation and breastfeeding care. In Mannel's 2011 article [74], Defining Lactation Acuity to Improve Patient Safety and Outcomes, lactation acuity levels were defined based on the potential risk of poor maternal/infant health outcomes, including premature cessation of breastfeeding. Couplets with low acuity or level I acuity have minimal risk factors and effective breastfeeding occurring at the time of assessment. Low-acuity couplets can be managed by trained healthcare professionals or para-professionals, such as bedside nurses, CLCs, or community health workers. Higher-acuity couplets have multiple risk factors or complications and require referral to IBCLC care. When inadequately trained staff or volunteers try to manage high-acuity breastfeeding problems, care is less efficient and less effective, and risk of poor outcomes increases, which ultimately leads to higher costs to the healthcare system [75]. Matching lactation acuity to appropriate resources, including appropriate lactation-support providers, makes better use of staff, provides timely, effective care to breastfeeding families, and improves breastfeeding and maternal-infant outcomes [76].

12.4.5 Insurance Coverage

Any discussion of insurance coverage or payment for lactation support services is challenging due to the wide variety of healthcare systems around the world. In countries that have some level of national healthcare available, perinatal services are usually covered, including childbirth and postpartum/newborn care. Skilled breastfeeding care may not necessarily be available depending on the knowledge of policymakers in defining what care and services should be provided [77]. A common assumption of policymakers is that perinatal care providers are adequately trained in breastfeeding management when that may not be the case. Even in countries where midwifery care is common for low-risk births, midwives are unlikely to be trained to manage high-acuity lactation cases that require IBCLC care [78]. In a system with universal healthcare, the return on investment for providing timely, effective lactation care is clear, with increased breastfeeding duration rates and long-term improvement in maternal and child health.

In the complicated US healthcare system, there is great discrepancy in access to adequate lactation care [79], [80]. Middle-to-upper income families are more likely to be able to afford lactation care if it is not covered by their health insurance. Low-income families must rely on Medicaid benefits that may not include IBCLC services or any type of skilled breastfeeding support. The Affordable Care Act requires coverage of breastfeeding equipment, such as breast pumps and lactation consults, although it did not define who should provide the lactation care [81]. Thus, many insurance payers consider lactation consults a service already provided by clinicians in their network, such as physicians and advanced practice nurses who may not be trained to provide basic breastfeeding care, much less care for high-acuity lactation situations.

12.4.6 Licensure/Regulation

Licensure or government recognition of IBCLCs as healthcare team members could help to increase access to lactation care. In some countries, the majority of IBCLCs hold another healthcare credential such as physician, midwife or nurse, although this is not required by IBLCE. Requiring the IBCLC to be a secondary credential limits access to the profession, especially by younger generations and minority populations, increases cost of acquiring IBCLC certification, and does not guarantee payment for IBCLC services separate from the care provided by the initial credential. Ideally, IBCLCs should be recognised as healthcare providers independent of any other credential. Licensure efforts are ongoing in the US, with Rhode Island and Georgia the first states to officially license IBCLCs. Licensure currently is achieved on a state-by-state basis with another thirty states actively engaged in some level of effort.

12.5 Conclusion

Ultimately providing access to timely, effective breastfeeding care and products has a cost as does any other aspect of healthcare. The cost of not providing this care is even greater, with the increased occurrence of poor health outcomes for both mothers and children [82], [83]. A provocative 2013 article reporting the potential loss of economic value from not protecting women's lactation and milk, estimated the value of human milk production at $3 billion per year in Australia and $110 billion per year in the US [84]. The author concluded that 'failure to account for mothers' milk production in GDP and other economic data has important consequences for public policy'. This devaluing or ignoring the cost of human milk allows for the continued lack of prioritisation and funding of programmes and regulations to protect, promote, and support breastfeeding.

Key Points

- Breast pumps can be very useful for mothers who need to express milk on a regular basis. Access to quality, safe breast pumps is a public health and economic issue
- The Baby Friendly Hospital Initiative guidelines require informed decision making by the mother before a breastfed baby is supplemented with any type of milk or fed by any other method. More research is needed to identify optimal methods of supplementing breastfed babies when medically-indicated supplementation is needed
- Mothers need access to skilled lactation support providers when any kind of commercial breastfeeding device is used to address a breastfeeding problem
- Safe, pasteurised donor milk should be available any time a baby does not have access to his/her own mother's milk
- Non-profit milk banks follow well established evidence-based guidelines and network with each other to meet the demand for donor milk to their maximum capacity. Milk banking could be expanded rapidly with more governmental support
- IBCLCs are skilled healthcare professionals trained in all aspects of breastfeeding and lactation care. Access to IBCLC care is a public health issue and can increase breastfeeding initiation and duration rates
- Licensure or government recognition of IBCLCs as healthcare team members could help to increase access to lactation care
- The cost of not providing access to timely, effective breastfeeding care and products is even greater with the increased occurrence of poor health outcomes for both mothers and children

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13 The Promotion of Breastfeeding

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Expected Key Learning Outcomes

- Definition of the World Health Organization (WHO) Code or Milk Code
- Reasons breastfeeding rates remain so low despite the WHO Code
- Reason for the market success of formula milk
- Strategies to promote breastfeeding

13.1 Breastfeeding Promotion

13.1.1 The Milk Code

In the mid-20th century, the promotion of breastfeeding rose rapidly as a response by public health professionals to the increasing number of women who were opting to use formula milk. These efforts were supported by the introduction of the International Code of Marketing of Breast-milk Substitutes, otherwise known as the Milk Code, which was adopted in 1981 by the Health Assembly of World Health Organization (WHO) and UNICEF. The aim of the code was to 'contribute to the provision of safe and adequate nutrition for infants, by the protection and promotion of breast-feeding, and by ensuring the proper use of breast-milk substitutes, when these are necessary, on the basis of adequate information and through appropriate marketing and distribution' [1].

The introduction of the Milk Code has been a significant achievement despite often being met with strong opposition from the formula milk companies. Within the first three years, 130 countries had passed legislation or formulated policies to restrict advertising [2]. In Iran, for example, formula milk is obtained only via prescription and the packaging must be a generic label with no brand names or promotional messages. In Brazil, no advertising or promotion of breast milk substitutes is allowed for children younger than two years and, in Papua New Guinea, there is a ban on the advertisement of feeding bottles, cups, teats, and dummies, with sales very tightly controlled [3].

Large corporations such as Nestlé have also committed to the Milk Code in the developing world and higher risk countries, by implementing many different methods in order to obey the Code. These include not 'advertising of infant and follow-on formula for babies under 12 months of age' [4], and not labelling, promoting or selling complementary foods or drinks for infants under six months of age unless otherwise mandatorily required by local code or measures [5]. Many may postulate that companies such as Nestlé only made such a commitment following the negative media they received previously due to their aggressive marketing in the developing world [6], and are using it to ease the criticism. However, it can also be argued that babies in vulnerable countries still benefit from the move.

There are, however, a number of loopholes within the Code that have been exploited by formula milk companies. At the time the Milk Code was written, all formula milk was known as "infant formula". The manufacturers of breast milk substitutes thus created the concept of "follow-on formula" as a reaction to the Code. They claimed that formula milk for children over six months was not a breast milk substitute and therefore did not have to comply with the marketing regulations of infant formula [7].

There have been numerous reports of countries breaking the Code [6], [8]. This situation has also perhaps been exacerbated by a suggested lack of awareness of the Code. For example, in 2008, 70% of 427 health professionals in Pakistan were unaware of their own breastfeeding laws and 80% were unaware of the Code; 12% had received sponsorship from pharmaceutical companies for training sessions or attendance at conferences, giving them a vested interest to promote formula milk [9]. This example from Pakistan is by no means unique and is the situation in many other countries that have the Code in place [10].

13.1.2 Breastfeeding Promotion

In addition to the introduction of the Code, many national and local health departments have developed materials and advertising campaigns to try and encourage breastfeeding. Many of these campaigns have focused on the health benefits of breastfeeding (for both child and mother), and some the emotional bond that breastfeeding can create.

In the USA, an advert sourced as being from the US Surgeon General and the National Institutes of Health, stressed the health benefits of breastfeeding for both mothers and children, including reduced risk of obesity for the baby, and reduced stress and postpartum depression rates for the mother [11]. In the UK, as with the US, adverts have communicated health benefits through the brand Start4Life, such as 'Breastfeeding lowers your risk of breast cancer and ovarian cancer' and 'Breast milk boosts your baby's ability to fight illness and infection' (National Health Service [NHS], [12]). In Mexico City, the government launched an advertising campaign with a slogan that translates as 'give your breast to your child, don't turn your back on them' [13].

These health messages are not always well received by mothers and the evidence base behind them is questioned. This was illustrated by the response to the Mexican City advert, where mothers and women's groups stated that the government was 'guilt-tripping women instead of addressing real-life barriers to breast feeding' [14]. Claims around the link between obesity and breastfeeding have also been queried [15].

Despite the apparent backlash, promotional activities counteracting the effectiveness of the advertising of formula milk companies are critical, particularly in the non-developed world. In less developed countries, there are severe dangers of using formula milk, as the inability to access clean water and insufficient sterilisation of bottles can lead to grave consequences such as infection or even mortality [16], [17]. Consequently, effective support structures have been put in place. In Africa, for example, UNICEF have intervened at the community level, creating community structures such as mother-to-mother groups, health system support to breast feeding, and health workers [18]. UNICEF have also initiated breastfeeding campaigns, such as one showing a women breastfeeding on a farm, with the advert reading 'Breastfeeding and work, let's make it work', and another with a woman breastfeeding in a factory, with the advert stating 'Breastfeeding is universal, protecting children everywhere and giving them the best start in life' [19].

13.1.3 Promotional Work and the Code

Despite the progress that has been made by the Code, as well as the promotional work, there is much work still to be done. Breastfeeding rates (exclusive for the recommended six-months) remain low in many of the developing and developed world countries that have both introduced and enforced the Code, and invested heavily in health promotional campaigns.

Recent figures from Germany show that at three months around 40% of babies are exclusively breastfeeding and at six months around 22% are exclusively breastfeeding [20]. In Haiti, in 2008–2012, early initiation of breastfeeding occurred in just 46.7% of cases, with the proportion falling to 39.7% for exclusive breastfeeding at six months [21]. In the UK, the Infant Feeding Survey in 2010 showed that 81% of mothers initially breastfed their infants. However, the prevalence of breastfeeding fell to 69% at one week and to 34% at six months, making infant formula an important source of nutrition for many infants [22].

With the focus of health promotional materials on health benefits, it might be assumed that the main barrier to uptake and continuation of breastfeeding is a lack of women's knowledge of its benefits. However, this is not always the case; a recent survey showed that 83% of women in the UK knew of the health benefits of breastfeeding regardless of the feeding method they chose [22]. This shows that awareness and knowledge is not always the main barrier, and that mothers will not always chose to breastfeed.

It might also be easy to blame the low breastfeeding rates on the remaining aggressive advertising still underway. The UK Infant Feeding Survey also highlighted that 46% of mothers said that they had seen an advert for first-stage formula milk, despite such adverts being banned, and when asked for reasons as to why they used formula milk, 18% of mothers said that it was better for the baby or had more nutrients [23]. However, is it maybe time to appraise the existing promotional work done by government health departments critically and take some of the formula milk industry's successful tactics and use them for social benefit as opposed to increasing profitability? As Professor Gerard Hastings, who has used similar tactics with the tobacco industry, stated: 'Why should the devil have all the best tunes?' [24].

13.2 Social Marketing and Breastfeeding Rates

13.2.1 Defining Critical Social Marketing

Critical marketing 'seeks not to just determine what is "wrong and bad" about commercial marketing, but to reflect on its nature, learn from its successes, and analyse its weaknesses' [25]. The use of critical marketing in anti-tobacco work is well established and clearly needed as in the late noughties, when the European ban on tobacco advertising was being debated, it was estimated that the tobacco industry had more than 200 lobbyists in Brussels [26].

Critical analysis of commercial marketing has resulted in the development of an extensive and convincing evidence base showing that marketing can influence behaviour. This is demonstrated by research conducted by the National Consumer Council in the UK, which showed that the average British child today is familiar with up to 400 brand names by the time they reach the age of ten. The study also found that 69% of all 3-year-old children could identify the McDonald's golden arches, while half of all 4-year-olds did not know their own surname [25].

13.2.2 Learning from the Competition

Competition is a fact of commercial life in that business is driven by the law governing the survival of the fittest and that any potential threats are turned into an opportunity by studying the activities of competitors. Thus McDonald's will carefully analyse Burger King's offerings to help work out their own efforts, and Cow & Gate will carefully monitor SMA and all the other competing brands' marketing strategies.

In the same way, those working to promote breastfeeding can gain the same insights about their customers by studying the commercial formula milk companys' successes and failures. By answering questions such as 'What messages do the competition promote? How do they make mothers feel?', and 'What communication channels do they use?' These questions are explored in further detail in the remainder of this chapter. Health promoters can gain insights into how the formula milk industry's marketing is used to encourage formula milk use, and hence do the opposite.

13.2.3 The Mother's Perspective

Formula milk and other commercial companies develop their marketing strategies on comprehensive customer understanding. The industry takes great care to know its customers using a combination of ethnographic research and detailed segmentation studies. To do this they often allocate a substantial amount of budget to gain an in-depth picture of their target audiences' lives. It is unclear what formula milk companies spend on gaining this customer understanding and usually budget depends on industry type, product type, market conditions, product life cycle, and many other factors. However, a 2013 survey of commercial companies conducted by the consulting firm, Frost and Sullivan, found the average market research spend as a percentage of revenue was 1%; that being, a company with revenues of $100 m spends about $1 m on marketing research [27].

It is unlikely that those working to promote breastfeeding will ever have access to budgets that commercial companies enjoy. Therefore, to develop effective campaigns and tailored services that result in the desired behaviour (i.e., increasing the number of women who choose to breastfeed exclusively to six-months), issues from the perspective of mothers need to be fully understood. Health promoters need to understand,

- What benefits do mothers gain from bottle feeding (perceived and actual)?
- What are the barriers to breastfeeding from the mother's perspective (perceived and actual)?
- Who do mothers listen to and trust (who are the main influencers in their lives)?
- How does breast/bottle feeding make the mother feel (positive and negative emotions)?
- What pressures are mothers facing in their day-to-day lives (not just in relation to breastfeeding, but looking at the person overall)?

By answering these types of questions, health departments can develop more effective campaigns and services, which do not simply promote the health benefits but overcome some of the barriers faced by mothers.

13.2.4 What We Know

The good news is that health promoters do not need to start from scratch as the existing literature provides an understanding of the main reasons why mothers "give up" on breastfeeding early (despite them often stating that they had wanted to carry on and/or regretted their decision to stop), and the perceived benefits mothers receive from bottle feeding.

In summary, reasons for "giving up" vary but include the need for mothers to return to work, fear the baby is not drinking sufficient milk [28], [29], and more commonly, the "*inconvenience or fatigue associated with breastfeeding*" [30]. Additionally, an inability for the baby to "latch on" [31] and being able to share the feeding task [32] are often cited.

Added to this, it appears that there are a number of unrealistic expectations with regard to breastfeeding, partly because the antenatal breastfeeding preparation often 'makes it sound so easy' [33] and promotional materials present a romantic view of breastfeeding. Many mothers and fathers feel that the preparation they were given 'did not prepare them well for reality'. Early discharge from hospital was also a primary concern for new mothers who did not particularly want to extend their stay. This concern was prioritised over learning how to breastfeed correctly. As such, mothers felt if they gave their baby formula milk it would expedite discharge [34].

13.3 Learning from the Formula Milk Industry

13.3.1 Advertising Strategies

Formula milk companies currently position their brands alongside the responsible and hard-working mother who wants to do their best for their child and, in some developing countries, formula milk is positioned as the sophisticated choice [34]. The companies use aspirational images, and sympathise with the mother about how hard raising a child can be, stressing that they are doing a good job – words all tired mothers want to hear. This is demonstrated in the SMA follow-on milk advert on UK television, which highlights the struggle that having a baby can be,

> *'At SMA our follow-up milk is supported by 90 years of advancing baby nutrition and over the years we've really got to know mums, so take it from us you're doing great' [35].*

Other examples of advertising messages include:

- A HiPP organic campaign played on the lack of sleep new mothers may experience, with their advert stating 'Now everyone can get a good night's sleep'. In reality, mothers of formula-fed babies do not sleep more than breastfeeding mothers [36]. However, adverts suggesting that babies will sleep at night are likely to appeal to mothers who are usually suffering from sleep deprivation, while building on the widespread belief that formula milk-fed babies sleep for longer between feeds [37], [38].
- The Aptamil Follow-on Milk Today for Tomorrow TV advert cleverly uses breastfeeding to promote the product by claiming that 'Breastfeeding provides them with the best start in life, inspired by 30 years research in breast milk, our researchers created Aptamil follow on milk' [39]. This reassures mothers that they are giving their child something "just as good" as breast milk and, therefore, there is no need to worry about the dangers of not breastfeeding. This again is exactly what mothers want to hear, especially as many feel guilty about not breastfeeding or discontinuing before the recommended time [40].

- In Russia, Enfamil promotes how their milk can help support the intellectual development of the baby: 'A mother's love and the right nutrition can do miracles. Enfamil premium – for a complete development of the brain' (Enfamil, [41]). This tactic is also used by other companies that suggest that the added ingredients in formula milk improve intelligence (Alpha Parent Blog, [42]). This appeals to many mothers who desire for their children to achieve academically and have successful careers [43].
- Another highly effective formula milk advert was the Cow & Gate Laughing Baby advert. A laughing baby can do nothing but make you smile and, more importantly, mothers want that for their child [44]. They also released an advert with the soundtrack 'If you are happy and you know it...' [45]. Both adverts highlight Cow & Gate's 100 years of experience, capitalising on the trust a mother would place in them and the added "essential" nutrients their formulas contain.

In essence, it appears that formula milk companies attempt to reassure mothers that bottle feeding is not bad for their baby and that they should not feel guilty about giving up breastfeeding (something we know many mothers do feel, and one of the reason why they cite health reasons for stopping breastfeeding early) [33]. The benefits for the baby are stressed rather than the negative consequences of not breastfeeding.

13.3.2 Promotion by Healthcare Professionals

In some countries, promotional messages about formula are coupled with the development of a "trusted" sales force of healthcare professionals who provide free samples of formula milk to mothers and distribute branded promotional gifts. Internet marketing through company websites and social media forums also provide mothers with access to information and advice from healthcare professionals.

In the UK, through Cow & Gate's website, mothers can chat online with healthcare professionals and gain instant responses, which is important for mothers who are anxious and stressed. The company also offers a first-infant milk starter pack, containing six 70 ml bottles, six teats, and a cuddly toy. The Aptamil start-up pack also contains these items but additionally is pre-sterilised and ready-to-use. For a struggling, tired, and stressed mother, a simple, ready-to-go, easy-to-use, and understandable pack is all that is needed. In contrast, for breastfeeding, a new mother will at most receive a simple booklet.

In Hong Kong, one mother claimed she received 'a set of toys that would cost HK$599 at Toys 'R' Us for free when I ordered HK$1,200 of milk formula'. It was also noted that the first 200 customers who brought six cans of milk formula received a free set of Fisher-Price toys [46]. In the US, many mothers are given discharge bags when leaving hospital, containing promotional materials about formula milk; a national survey reported that 91% of US maternity hospitals distributed company-sponsored discharge packs [47].

In other countries, particularly low- and middle-income countries, formula milk company representatives have offered financial incentives to healthcare professionals for promoting their products in countries as diverse as Ukraine, India, China, Indonesia, the Philippines, Togo, Burkina Faso, and other parts of Central and West Africa [49]. In China, it is reported that formula milk companies have been provided contact information on new births for the purpose of product promotion by healthcare professionals [48].

This aggressive marketing has led to bottle feeding becoming a social norm in many communities, with generations of women being bottle fed by their mothers. In turn, when these women have become mothers themselves, they too have often opted to bottle feed due to unsupportive social norms [22]. The effects of this marketing is further bolstered by the formula milk adverts where parents are encouraged to buy formula milk and are able to justify their actions despite the best efforts of breast feeding initiatives.

13.4 Conclusions

Despite the introduction of the Code and the restrictions it imposes on promotional work, formula milk is marketed directly to mothers through mass media, printed advertisements, and indirectly via incentives, free samples, and through health workers. Internet marketing by company web sites and social media is also on the rise [49].

The marketing efforts of formula milk companies have successfully positioned formula milk as a sophisticated and modern choice, which mothers should not feel guilty about using as it is comparable to (or better than) breast milk. Given the massive advertising budgets available for infant formula companies [50], it would be almost impossible for health promoters to directly influence the purchasing behaviour of their customers. However, healthcare professionals can learn from the way these companies position their products and engage with healthcare professionals.

Such product positioning could be used to the benefit of breastfeeding, to develop campaigns to generate the significant media and public awareness needed to put pressure on product "distributors", and to force regulators to introduce tougher controls on the marketing of infant formula. Moreover, such action could help public health teams develop integrated public relations and marketing strategies that resonate with mothers on an emotional level, rather than solely being a health information-giving exercise.

Key Points

- The WHO Code is a set of recommendations to regulate the marketing of breast-milk substitutes, feeding bottles and teats that requires incorporation into a countries legal system in order to become effective
- The WHO Code is not incorporated into law in many countries and even where it has, monitoring is difficult, leaving formula companies with many loopholes to exploit
- Formula companies have substantial budgets at their disposal to successfully position formula milk as a sophisticated and modern choice as well as to incentivise doctors and health workers to recommend it to mothers
- Formula companies are very successful with their sophisticated marketing campaigns focusing on the needs of the mother and maybe it is time for breastfeeding promotion and communication to learn from their strategies

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14 Infant Feeding in History: an Outline

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Expected Key Learning Outcomes
- The importance of lactation for infant survival
- Reasons many infants did not receive mothers own or donor breast milk
- An historical view of breastfeeding over the centuries
- Main reason today's focus is back onto breastfeeding
- Possible approaches to ensure mothers make informed choices

14.1 Overview and Introduction

Mammalian lactation assures a reliable supply of quality food for the young, and was critical to evolutionary success. From some 13 million years ago until recorded time, evolving humans, like their primate cousins, breastfed their babies for anything from 2–7 years. Lactation is a robust, resilient and reliable survival mechanism [1]. Milk is both highly species-specific and responsive to both the environment and the needs of the young. Thus their own mother's milk fed from her breasts, supplemented if necessary by surrogate breastfeeding, should have been, and generally was, the automatic universal birth right of children throughout history [1], [2]. Without it, in any context, infant mortality rates rise.

But thanks to pressures rooted in the social and cultural status of women, many babies throughout recorded history have never received that birth right. Commercially organised surrogate feeding and the use of foods other than women's milk have been recorded in many cultures. 19th century industrialisation and the growing authority of medical professionals early in the 20th century resulted in substantial shifts away from breastfeeding towards commercial products: thanks to well-targeted hospital-based marketing by the infant food industry, by 1960 fewer than 20% of infants in some countries received any breast milk. In some nations summarised as WEIRD (western, educated, industrialised, rich, and democratic), virtually all infants were exposed to bovine formula products perinatally. The use of these animal and vegetable "soups" and mixtures has become the dominant mode of feeding in such nations, resulting in new epidemics of disease, much of it also affecting succeeding generations. Impacts on the economy, the environment, and population growth remained largely unrecognised, although substantial [3].

Marketing by association with health professionals established an unjustified belief in the complete safety and efficacy of infant formula feeding [4]. The change to formula feeding as the norm was led by advantaged western women who trusted doctors and hospitals to know what was best for their babies. By the 1970s that same demographic would lead the drive back to mother-feeding, but in cultural contexts that increasingly required physical separation of mother and child for long periods in each day [5]. In such contexts, simply promoting breastfeeding as best is ineffective in raising breastfeeding rates and duration. The effective solutions to low breastfeeding rates have been structural changes to enable breastfeeding, such as adequate maternity leave, implemented in states such as Finland that bear the costs of increased illness due to artificial feeding and care outside the home [4]. The alternative, more commonly practised, has been the provision of equipment to enable women to express their milk for others to feed their baby. The increased work and cost of this latter strategy, an impossible task for many women, is only now being realised as an unfair burden on mothers and an overlooked societal responsibility (see Chapters 8 and 9). However, breast milk expression has legitimised the feeding bottle and teat as a way of providing breast milk, undermining awareness of the impacts of the feeding method itself.

So industrial innovation has provided solutions that separate the breast from feeding, mother from infant, creating new norms and expectations around breastfeeding that are a long way from what the World Health Organization recommends as ideal: exclusive breastfeeding until around 6 months, and continued breastfeeding into the second year and beyond. Yet in the 21st century, exclusive breastfeeding's critical role in the development of the microbiome and lifelong health, in the prevention of vertically-communicated inflammatory disease such as obesity and cardiovascular disease, is being revealed by research. Both the positive biological effects of breastfeeding and the negative effects of early infant formula exposure are creating pressure in this century to see all human infants receiving only women's milk, and new strategies are already emerging as advantaged parents seek to use the new media to ensure that their babies get the best possible start in life. Milk sharing by women is increasing, as are the numbers of milk banks (see Chapters 12 and 17). Here, breast pumps and feeding bottles play a valuable role in allowing children whose mothers cannot provide enough milk (or any) to receive species-specific women's milk, albeit not from a living breast.

This chapter can only be a generalised outline of a vast topic, which cannot do justice to many national and regional variations and their consequences. Readers wanting a more complete or in-depth discussion should read the works of Valerie Fildes [3], [6], Rima Apple [7], Jacqueline Wolf [1], [8], Christina Hardyment [9], Philippa Mein-Smith [10], Florence Williams [11], and Maureen Minchin [4] and their sources. Additionally, fascinating work by Sarah Blaffer-Hrdy [12] and Wenda Trevathan [13] puts recorded history into its evolutionary and biological context. Tables in the following roughly chronological sections list only a few of the notable people and events.

14.1.1 Infant feeding in Antiquity

- **3500 BC:** Egyptian papyri praised breast milk's healing powers and described ways of stimulating milk flow [13].
- **2000 BC:** Clay feeding vessels, oblong with a nipple-shaped spout, date from 2000 BC onwards in graves of newborn infants. Casein residues show that animal milk was used, possibly explaining the death of the child [14].
- **1550 BC:** The earliest medical encyclopaedia, The Papyrus Ebers from Egypt, mentions lactation failure [15]. Surrogate nursing was accepted as the natural alternative to starvation for such infants; it could become adoptive nursing.
- **950 BC–625 BC:** Greek women of higher social status frequently employed wet nurses. Greek Paulus Aegina recommended that a wet nurse should be between 25 and 35 years old, with well-developed breasts and chest and should have recently given birth to a male child. (Others contested this latter point.) She should avoid salty and spicy foods and sexual activity, and she should regularly exercise her arms and shoulders, by grinding or working at a loom [14].
- **400 BC–200 BC:**
  - Ayurvedic texts reported that children should be fully breastfeed for at least six months, until the eruption of teeth. Illustrations described the importance and value of breast milk and breastfeeding.
  - Byzantines fed newborns with honey during the first 4 days of life. Aetius (2nd century BC) and Oribasius (320–403 BC Greece), considered colostrum to be unsuitable for newborns, therefore breastfeeding was ideally started between the 3rd and 5th day of life. Aristotle (384–322 BC) shared this prejudice, though he considered maternal breastfeeding a duty, and was aware of its contraceptive value [16].
- **300 BC–400 AD:** At the height of the Roman Empire, written contracts obliged wet nurses to feed abandoned infants, as a cheap source of slaves [6].
- **approx. 100 AD–400 AD:**
  - Medical authors such as Soranus of Ephesus, Galen of Pergamon, and Oribasius (Greek physician for Emperor Julian) wrote about breastfeeding and wet nursing, including qualifications for a wet nurse [14].
  - Soranus recorded a milk quality test: When a drop of breast milk is placed on a nail and the finger moved, the milk should be thick enough to not run across the surface of the nail. When the finger was turned downwards,

the milk should be watery enough to not adhere to the nail [14].
   - Soranus also wrongly saw colostrum as indigestible, and so advised mothers not to breastfeed in the first two days after birth, a widespread prejudice that has done great harm. Colostrum was considered harmful, possibly because of its laxative qualities, and mothers gave babies cows' milk, water and honey [17], [18].
- **609–632 AD:** The Koran evolved over this period; it includes a great deal about breastfeeding and the right of the child to be breastfed for two years, and endorses some foster-nursing as establishing kinship.

14.2 The Middle Ages and Renaissance

As is still usual in many cultures, an infant's mother was ordinarily the primary caregiver and infants were cared for within families, with older children and female relatives assisting with care [2]. The Church encouraged mothers to breastfeed, valuing breast milk as the food that grew the infant Jesus, and breastfeeding was seen as an expression of charity. Images of Mary lactating (Maria lactans) were objects of devotion in western churches; a mother breastfeeding her own child was an act of virtue [19]. Society viewed childhood as a time of risk and vulnerability, and there were many concerns about the use of wet nurses. Breastmilk was thought to transmit both physical and psychological characteristics. This belief resulted in protests against the hiring of women for wet nursing, and concern about their moral character [17]. But as in any place with a high child mortality rate from infectious disease, the emphasis was on producing large families. Fertility was prized. It was not uncommon for women to bear 10–20 children, few of whom would survive to adulthood. The contraceptive effects of lactation were known; for many husbands, the role of wives was to produce children that others could suckle and raise past the danger period of early infancy.

Feeding devices were made from wood, ceramics, and animal horns. A perforated cow's horn may have been the most common type of feeding bottle during the Middle Ages [15]. All resulted in infant deaths from infection, as did many later types. Open boats and feeders were (and are) more readily cleaned than spouted pots and bottles.

14.2.1 Infant Feeding in the Renaissance

- **1472:** In Padua, Italy, Paolo Bagellardus published De infantium aegritudinibus et remediis, an early paediatric text describing the characteristics of a good wet nurse, and offering advice about gut disorders.
- **1545:** Thomas Phayer described in the first English textbook, The Boke of Chyldren, the criteria for choosing a wet nurse, the nail test and remedies for increasing milk supply. He also believed that the milk of a nurse influenced temperament and morals, in addition to diseases [14].
- **1565:** The first French paediatric text, Cinq Livres de la Manière de Nourrir et Gouverner les Enfants des Leur Naissance by Simon de Vallambert, recommended the use of cow's or goat's milk after the third month of life. He was also the first to mention the possibility of transmission of syphilis from the nurse to the infant [14].
- **1577:**
   - De Arte Medica Infantium, written by Omnibonus Ferrarius, stated that the mother is the best option for infant feeding, with the wet nurse second best if the mother could not breastfeed, and that babies might prefer the nurse over their mother. His book contains an image of an early suction breast pump: a receptacle with an opening for the nipple and a long spout reaching up to the mother's mouth [14].
   - Jacques Guillemeau (1550–1630) stated four objections to wet nursing: the child — often taken as an infant and returned as a toddler — could be exchanged for another child; the love between mother and child might be affected; the child might adopt an undesirable trait from the nurse; or they might pick up transmissible diseases [20].

- **1584:** Thomas Muffett's book, De jure et praestantia chemicorum medicamentorum, recommended the use of breast milk for the sick elderly, and saw donkey milk as the best nutritional substitute at any age.
- **16th century:** Tintoretto and Rubens both depicted the vigorous milk ejection reflex that in classical mythology produced the Milky Way galaxy.

14.3 17th to 18th Century

In Europe, most women breastfed, many not exclusively from birth. In some regions (generally in colder climates where animal milks were available), artificial feeding or hand-rearing, also referred to as dry nursing, was becoming normative, as deaths during infancy and childhood were accepted. Those who survived might well have been the initially breastfed with the strongest immune systems.

Wet nursing was still accepted. Wealthy families might employ more than one wet nurse. For unmarried or poor mothers, wet nursing in an upper-class home was sometimes one of the few possible ways of earning a relatively comfortable living, sometimes at the expense of their own child's health or life. The importance of wet-nurses to the survival of children gave them greater social status than other servants, and children could become very attached to the nurse, who might live with the family for some years. In England, royal physicians mandated dry nursing for infant Prince of Wales in 1688. Starved and dying after 7 weeks of hand-rearing, his life was saved by a wet nurse. That royal physicians preferred hand rearing to breastfeeding by some lower class woman might have influenced the recorded rise in infant mortality in the last decades of the 17th century [6]. From around 1500–1700 very few wealthy English women had breastfed, but this would change towards the end of the 18th century.

However, most families could not afford a resident nurse. Many more children were farmed out to wet nurses in their own homes, often in villages at some distance from the child's family. Infant mortality was high in such cases, as living conditions were poorer and children not always breastfed or well-cared for, and they were kept quiet with opiates and alcohol. Foundlings and unwanted children were almost never wet nursed but hand reared, and almost all died. High mortality rates eventually caused some governments to regulate wet nursing [3], [16], [21]. The promotion of maternal breastfeeding was associated with a decline in infant mortality during the second half of the 18th century.

By the end of the 18th century in Europe, four modes of feeding were in use: maternal breastfeeding, wet nursing, hand feeding with animal milks, and with pap and/or panada (soft mushy mixtures of bread or flour with milk or water or egg, some cooked in broth) [16]. The use of soft starchy foods based on local staples has been common in many parts of the world, and contributes to higher mortality wherever it is practised. Nicolas Brouzet, physician to Louis XV, in An Essay on the Medicinal Education of Children, posed three questions: Should infants be nourished with milk? Should that milk be human? Should that milk be the mother's milk? In some regions infants were rarely breastfed; raw fish and cream were fed by advantaged Icelandic families. Other foods given included animal milks, raw meat juice, and eggs. That some children survived is a tribute to human omnivore adaptability, not proof of dietary suitability — just as survival and growth on infant formula is not proof of its perfection, least of all where antibiotics are available to treat infection. Artificial feeding had become an accepted alternative to breastfeeding, reducing the duration of breastfeeding from approximately 18 months in the early 16th century to around 7 months in the late 18th century [6].

14.3.1 Infant Feeding in the 17th and 18th Century

- **1662:** The influential Dowager Countess of Lincoln wrote on the duty of nursing, by mothers to their children, after birthing 18 children, 17 of whom died, and then seeing her son's child mother-fed and healthy.
- **1668:** Francois Mauriceau in The Accomplisht Midwife advised giving only breast milk for at least 2–3 months and warned against early in-

troduction of paps; he noted that the first day's milk had a laxative effect and suggested – after the first day – expressing milk into the baby's mouth if need be, and then feeding little and often day and night, whenever the baby wanted to.

- **1676:** Nicholas Culpepper's A Directory for Midwives contained advice undersupply and oversupply as well as a recipe for pap: barley bread steeped in water and boiled in milk, basically the same as the first infant formulas of the 19th century.
- **1712–1778:** Jean Jacques Rousseau's writings highlighted the significant decline of infant mortality associated with maternal breastfeeding; the influence of his philosophy led to growing popularity of natural feeding [6].
- **1748:** William Cadogan published An Essay upon Nursing and the Management of Children, from their Birth to Three Years of Age [22] based on his experience as a father and as physician at the London Foundling Hospital. His advice promoted breastfeeding – he urged early feeding of colostrum – but also undermined it by limiting the number of feeds to four per day.
- **1760:** In his Treatise of Physical Upbringing of Children, Jean Charles Des-Essartz compared the composition of human milk to that of the cow, sheep, ass, mare, and goat, justifying human milk as the best infant food [23].
- **18th century:** The disastrous experience of hand feeding in anglophone foundling hospitals testified to the importance of women's milk. The worst record was Dublin (founded 1702) where 99.6% of all children under one died, none were wet nursed. The hospital closed in 1829.

14.4 The 19th Century

The 19th century was an era of rapid technological change, urbanisation and population growth and mobility. Lost agricultural jobs were replaced by factory work as people moved to urban areas. Mothers, some sole breadwinners, had to work away from home for long hours, making frequent breastfeeding impossible and artificial substitutes unavoidable [16]. Poverty and poor maternal nutrition were associated with high infant mortality, notably less in communities where breastfeeding was normal. Women often ate last and least in poor families, as many still do in patriarchal societies. Despite the ongoing development of sanitation and urban water supplies, the high infant mortality rate remained static for the major part of the 19th century, or even increased in the second half in England along with artificial feeding. It is generally accepted that this rise was due to the high incidence of gastroenteritis [24]. Foods other than liquids and paps were not generally introduced early to infants in poor households: where food was scarce, breastfeeding was seen as a way to economise and the continuation of breastfeeding into the second year of life could be a sign of poverty.

14.4.1 Infant Feeding in the 19th Century

- **1835:** William Newton invented and patented evaporated milk [15].
- **1838 onwards:** Chemists such as Justus Von Liebig and Arthur V Meigs pioneered chemical analysis of milks, and this unreliable information would be used to create "Milchsuppe" or "Kindersuppe" claimed to be perfect or virtually identical to mother's milk [15].
- **1845:**
  - Teats for feeding developed as technology improved. In 1845, the first Indian rubber nipple was introduced [19] replacing leather and cloth and cork devices. With different chemical composition and treatment, latex teats would remain the norm until the development of silicone teats a century later. Latex allergy was not immediately recognised as a problem.
  - In some foundling hospitals in Europe, infants were fed directly from the udder of goats and donkeys [6]. Survival and growth were sometimes charted; long-term consequences were not, despite beliefs that milk would influence character.
- **1851:** The glass feeding bottle began to evolve. French feeding bottles created in 1851 contained a cork teat and ivory pins at air inlets to regulate the flow [15]. A simpler, open-ended,

boat-shaped bottle was developed in England in 1896, became popular, and was sold well into the 1950s [25]. Other bottles contained a glass tube connected to a long rubber tube with a teat on the end, to enable the baby to self-feed. These “murder bottles” were outlawed in France [4] in 1912, but variants are still sold today.

- **1853:** Texan Gale Borden added sugar (a preservative) to milk, and sold cans of Eagle Brand Condensed Milk, soon a popular infant food [15]. Epidemics of scurvy, rickets, convulsions, malnutrition and anaemia would result from its deficiencies, although the causes would not be identified or remedied for decades, and so did not affect the growing popularity of artificial feeding.
- **1860s onwards:** Louis Pasteur (1822–1895) and Robert Koch (1843–1910) drew attention to the danger of microorganisms in milk, so that sterilized undiluted cow’s milk was seen by some as best when breast milk was not available.
- **from 1865:** Von Liebig patented and marketed artificial infant food in granule form to be dissolved in hot water, then (often unhygienic) milk added. Liebig’s recipe for milk soup — consisting of cow’s milk, wheat and malt flour, and potassium bicarbonate — quickly became the then state-of-the-art infant food [23] thanks to advertising in contemporary media, along with medical and popular credulity and ignorance about breast milk. Modern epidemics of hypersensitivity to milk and wheat would develop over generations.
- **1866:**
  - William Newton advanced the production of dehydrated milk using vacuum extraction processes. The unsterile outcome was packaged and sold in “tin boxes” [16]. In parallel with the evolution of dried milk, numerous infant foods were developed and sold as modern and safe.
  - By 1883, there were at least 27 patented brands of commercial infant food [26]. All were cereal and/or milk bases with added carbohydrates such as sugars, starches, and dextrins; some contained egg. Brands included Nestlé’s Food, Horlick’s Malted Milk, Hill’s Malted Biscuit Powder, Mellin’s Food, Eskay’s Food, Imperial Granum, and Robinson’s Patent Barley.
  - In an era when fat babies were prized, the foods were fattening, but seriously deficient. Then as now, weight gain was the main criterion for assessing dietary adequacy, and suspicion – and so dectection – of other or more subtle negative effects was (and in places is) almost non-existent.
- **1868:** Henri Nestlé started selling his infant food – baked rusks crumbled into sweetened condensed milk then dried into brown granules – in Switzerland, Germany, France, and England and from 1873 in the USA [8]. This food did not require milk to be added after dissolving the granules in hot water, and so rapidly gained market share.
- **1885:** John B. Meyenberg developed an unsweetened evaporated milk. Highly recommended by paediatricians, this was a popular choice for home formula-making in the USA until the 1940s or later [8].
- **1894:** First edition of L Emmett Holt’s The Care and Feeding of Children: A Catechism for the Use of Mothers and Children's Nurses. Watson’s Psychological Care of Infant and Child (1928) and then Spock’s Baby and Child Care (1946 onwards) succeeded this manual as American norms [9]. In different ways, all undermined breastfeeding in practice while supporting it in theory.
- **1892:** Pierre Budin (physician at the famous Charité and later Maternité hospital in Paris, which had extensive wet-nurse experience) founded the first infant feeding and welfare clinic, the Consultation des Nourissons, where breastfeeding was encouraged — and sterilized bovine milk was provided in sealed bottles, for single use [16]. His book, Le Nourrison, would be a classic, and was translated into English in 1907. It contains detailed infant growth charts of breastfed, wet nursed and hand-fed infants.

14.5 The 20th Century

Development of the feeding bottle and the availability of cleaner animal milks reduced the market for wet nurses, and increased both the workload of mothers and infant morbidity and mortality. By 1900, wet nursing was becoming less common, although it would persist into the mid-20th century in some hospitals which recognised its value for preterm infants. Milk banking would develop where human milk was recognised as life-saving. Wherever human milk was not used, an epidemic of necrotising enterocolitis (NEC) affected up to 7% of all preterm infants by the 1970s–80s, and some term infants. (By comparison, in some European hospitals using only human milk, the NEC rate was .05%, with NEC arising only from causes such as asphyxia or transfusions [27].) The accepted mortality rate for NEC is 20–25%; in 1990 Lucas estimated NEC caused 500 extra cases and 100 unnecessary deaths per year in the UK alone.

Early 20th century concern about high infant mortality rates in western countries brought structural action for change. The child welfare movement arose from many concerns, not least the appalling health of male army recruits for the many wars of the late 19th and early 20th century [29]. Emphasis was placed on cleanliness and the improvement in the quality of milk supplies, such as providing better care for dairy cattle and forming infant milk clinics to disburse clean milk to the public [15]. A steady reduction in infant mortality from record levels began during this period, as sanitation brought cleaner water supplies. Welfare clinics were set up to educate mothers about the great value of breastfeeding and the safer use of dried milks. Ignorance about normal lactation meant that the advice given often caused lactation failure [4], [30].

The control of infant feeding was instrumental in the creation and success of the profession of paediatrics [8]. Doctors knew little about breastfeeding problems, although they still urged women to breastfeed and were considered experts – though their advice undermined breastfeeding. Artificial feeding could require frequent return visits, impractical for all but advantaged women. Many new infant formulas were developed by, or with the help of, noted US paediatricians [31] [32]. This close relationship, together with the status of doctors at the time, helped convince many that modern scientific formulas were preferable to, or at least more reliable than, women's milk.

Hospital birthing allowed ignorant management of normal processes to become the norm, sabotaging the initiation of lactation and modelling the use and normality of commercial products. Data from the National Fertility Study (USA) show that the percentage of initially breastfed infants declined steadily from the 1930s estimate of 40–70%, to just 20–50% in 1946–1950 [16]. By 1960 more than 80% of those being bottle-fed were drinking evaporated milk mixtures; by 1970 this would decline to just 5% as brand name formulas were used by hospitals and so mass marketed to birthing women. One industry source stated that loyalty to the hospital brand was 93% [4]. By the 1970s exposure to infant formula was almost universal in major hospitals, and the duration of breastfeeding shortened as mothers weaned on to formula as safe and equivalent to breast milk.

Such mothers were known to continue to use formula for longer than mothers who began to formula feed from birth, who typically moved on to cows milk and other foods from three months onwards. The use of infant formula for the first full year of life, not merely the first three or six months, began to be normalised in the 1980s, and so-called Stage 2 or Follow-on milks (post 3 or 6 months) were developed. These were condemned by the World Health Assembly in 1986 as unnecessary, and by some paediatric authorities as less suitable than a first infant formula for the first 12 months. In the 1990s, formula feeding was extended again, into the second year of life, with the development of so-called Toddler milks or Stage 3 milks. This was probably inevitable, but has been interpreted as an attempt to evade the controls on infant formula marketing required by the International Code of Marketing of Breast-milk Substitutes endorsed by the World Health Assembly (WHA) in 1981. The World Health Organization's (WHO) concern about appropriate complementary feeding increased as problems emerged [33].

Early in the 20th century no such "weaning foods" were generally introduced to fully breastfed children under 6 months, even 9 months. The development of the canned food industry and its mass marketing [34] led to rapid changes in some countries and to unexpected epidemics of disease.

14.5.1 Infant Feeding in the 20th Century

- **Early 20th century:**
  - Roller drying made larger scale production of cheaper powdered milk possible. Better transport, ice boxes and later refrigerators began to reduce microbial growth rates in milk. (No powdered milk could (or can) be sterile.)
  - Local government agencies in western countries began to purchase and supply dried milk products labelled as suitable for infant feeding to poor families, sometimes as much to subsidise agriculture as to support child health.
  - Early infant formulas caused children to develop deficiency diseases. Orange juice was prescribed to prevent scurvy from around the 1920s, and cod liver oil drops to prevent rickets from the 1930s; vitamin C was added to increase iron bioavailability and by the late 1950s a form of iron was found for use in formula to prevent anaemias. A wide range of iron was added to formulas, from 1–12 mg/L. Deficiency is damaging, while iron overload promotes gut dysbiosis, and has been associated with IQ loss of up to 12 points (discussed in Milk Matters [82]).
- **1909–1910:** In 1909 the first milk bank — and also the first blood bank — was established in Vienna, Austria. In 1910, two more milk banks were established: one in Boston, Massachusetts, and one in Germany. Breast milk bank centres were set up where breast milk from several women was pooled and pasteurized before distribution. The first ones to open were in Boston in 1910 and in London at Queen Charlotte's Hospital and after that, several more were established all over Europe [16]. Interest in milk banking grew as premature infants of earlier gestational age and infants with more complex illnesses survived owing to advances in health care and human milk feeding [35].
- **1919:** The International Labour Organization (ILO) proclaimed, in its "Maternity Protection Convention" [36], the right of mothers to take breastfeeding breaks during working hours. Few countries would implement this right for decades to come. Italy was the first country to do so, through the Regio Decreto [37].
- **1920–1950:**
  - Physicians and consumers in America came to regard the use of formula as a well-known, popular, and safe substitute for breast milk [26].
  - The US government published Infant Care as a free guide to parents; it 'emphasized cod liver oil, orange juice and artificial feeding' [38].
  - In British countries, the institutionalised work of Sir Frederick Truby King (1858–1938) would continue to promote, but undermine, breastfeeding well into the 1960s and beyond by its unscientific emphasis on scheduled feeds and regularity [9], [10].
- **1929:** The American Medical Association (AMA) formed the Committee on Foods to approve the safety and quality of formula, forcing infant food manufacturers to seek their "Seal of Acceptance" [15]. To be given that Seal, companies were required to remove all preparation instructions from the can. This was to ensure that bottle feeding parents regularly consulted doctors, on the grounds that their children were at greater risk of illness. Those who could not afford to see doctors were put at greater risk. In other countries, governments were passive onlookers as formula companies regularly provided free "educational" literature to parents and advertised their consumer help services, bypassing doctors to educate and recruit parents.
- **1932:** US manufacturers wanting AMA approval were to advertise directly only to physicians [15]. Cost-effective mass marketing to professionals and via hospital contracts expanded, along with paid advertising in journals and sponsorship of conferences and associations. Hospital exclusivity contracts could be worth millions of dollars, and determined what brand mothers were exposed to [1], [7].
- **1939:** Cicely Williams's Milk and Murder speech in Singapore testified that artificial feeding was killing children. During the war that followed, in her prison camp all eleven birthing mothers breastfed, and all babies survived until liberation. Lactation is protective for mothers as well as infants [1], [41].

- **1941:** The Food and Drug Act required infant food labels to declare only moisture, energy, protein, fat, carbohydrates, fibre, calcium, phosphorus, iron and vitamins A, B1, C and D. This unpoliced declaration added to the population's perception that formula feeding was as safe and beneficial as breastfeeding [16]. There was little awareness of the many deficiencies of these formulas.
- **1950–1960:**
  - In America by 1950, artificial feeding was the cultural norm. Lip service was still paid to the idea that breastfeeding was best for baby, but it was seen as incompatible with modernity, and embarrassing, since breasts were sexual objects [41], [42].
  - Other countries affected by the Second World War lagged behind in acceptance, but soon followed America's lead. Marketing and availability of artificial food increased globally in the post-war period, and played a significant role in the dramatic decrease of breastfeeding rates in developing countries, as well as increases in infant and maternal mortality and morbidity.
  - Industry literature blamed negative outcomes on poverty and lack of clean water, or maternal carelessness in preparation. Regrettably, many breastfeeding advocates have accepted this rationale uncritically, although milk powders cannot be sterile.
- **1950s–1970s:**
  - Dr Mavis Gunther made original observations on human lactation and interested animal physiologists in studying lactation. Her work and eventual book, Infant Feeding (1970) was extremely influential and helped reduce the excessive sodium levels involved in annual summer epidemics of hypernatremia.
  - New high-dose hormonal contraceptives led both to advice not to breastfeed, and to difficulties sustaining lactation.
  - Research demonstrated that responsive feeding on request and rooming in facilitated the establishment of lactation, requiring hospitals to rethink controlling policies such as four-hourly feeds [4]. Most did not.
- **1952–1954:** Discovery of formula problems continued: Processing temperature destroyed B vitamins leading to permanent neurological damage. In 1981 one victim appeared on TV and a confidential settlement followed [4].
- **1956:**
  - La Leche League was founded to give information and encouragement to all mothers wanting to breastfeed their babies [43]. Similar groups followed, such as the Nursing Mothers' Association of Australia in 1964 [44]. Increasing awareness of environmental issues would lead many to a "Back to Nature" mentality that favoured breastfeeding, as concern about nuclear testing arose and radioactive compounds were found in cows milk and breast milk, tested as measures of human exposure to radioactivity.
  - Pioneering work on negative pressure breastpumps by Einer Egnell [35]. Rapid development and uptake would follow.
- **1959:** More bioavailable forms of iron were introduced into formulas, reducing cases of anaemia in formula-fed children. Megaloblastic anaemia caused by the lack of Vitamin C in formula had earlier been identified after Ross Laboratories, makers of Similac, convened a conference on the subject in 1950. At the same time, formulas with too little iron continued in use, as the permitted range of formula iron was and remains very wide.
- **1970s:**
  - Awareness of the excessive sodium content of infant formula led to product re-formulations, to reduce potential kidney damage and the constant epidemics of hypernatremia in hot weather.
  - Concern about lead solder in cans contaminating infant formula (up to 50 mcg/100 mL) was heightened by the realisation of the (still ongoing) high levels of lead in some municipal water supplies in the USA. Industry was given 10 years to phase out lead solder, possible because of new canning technology. FDA set tolerable limits of 30 ppb in municipal water supplies. Lead is an ongoing problem [45].
  - Whey-dominant formulas containing tropical oils such as palm and coconut began to challenge older casein-dominant formulas containing both oils and bovine fats (milk fat and

oleo/destearinated lard). US companies led this change; milk fat was still used in other dairying nations for some time. Marketing falsely claimed that all-vegetable oils would decrease cardiovascular disease. Some older original formulas were later re-purposed as follow-on formulas.
  - The supplemental use of fish liver oil drops declined after cases of harm from the overload of fat-soluble vitamin drops, so that for the first time in human history healthy infants would lack important long chain fats needed for optimal brain and immune development. These would later be added to expensive "gold" formulas (USA 2003, other countries in the 1990s).
  - Lack of iodine in early soy formulas caused cases of goitre. Concerns about thyroid issues persist in relation to soy, especially given the wide range of iodine found in water supplies used to make formula. (In Denmark in the 1990s, the variance was a hundredfold.) Arsenic and other minerals in water supplies used in infant feeding are ongoing concerns. Concerns were first raised about levels of manganese in soy infant formulas in the 1970s.
- **1974:** UK Oppe Report, Present Day Practice in Infant Feeding, was the first of an invaluable series of five-yearly reports between 1975 and 2010, regrettably the victim of ill-advised conservative government cost-cutting in 2014. No similar series exists anywhere else.
- **1978:** Derrick and Patrice Jelliffe's encyclopaedic Human Milk in the Modern World [46] was published by Oxford University Press, summarising what was then known. This was a true milestone in awareness of the value of human milk, but not widely read.
- **1970s:**
  - In the 1970s, religious, medical, and development groups campaigned vigorously to end "commerciogenic malnutrition" as Professor Derrick Jelliffe labelled the problem in 1968. The US Kennedy hearings (1978) called on WHO to convene a meeting, with all stakeholders present. This took place in Geneva in October 1979. NGO representatives at the meeting formed the International Baby Food Action Network (IBFAN), which then campaigned for a strong and effective marketing code for all foods that act as ersatz substitutes for breast milk.
  - Reproductive biologists such as Roger Short researched lactation; the Lactational Amenorrhea Method was developed as global contraception. Promotion of breastfeeding is seen as critical by major groups such as Family Health International, and UN bodies.
- **1978–1979:** The first institution to offer courses in clinical lactation, The Lactation Institute, was created by Chele Marmet and Ellen Shell in Encino, California.
- **1980:**
  - Global infant formula sales were US $2billion. A quarter was US sales, as the US Department of Agriculture's Women Infants and Children (WIC) programme paid full retail price for formula to be given free to poor families, discouraging breastfeeding.
  - Unlike the rest of the world, most 1980s US formula sales were of sterile liquid ready to feed or concentrates, reducing formula's negative health impacts [47].
  - After yet another recall of defective infant formula, publicised by parents of damaged children, the American Academy of Pediatrics (AAP) recommended 4–6 months for the introduction of solid foods to all infants, despite clear awareness of the Committee Chair that this was early, and possibly disadvantageous, for breastfeeding infants [33]. Four months was stated as being a compromise to protect formula fed infants from possible nutrient deficiencies after their *in utero* body stores were exhausted [4].
  - US Congress passed the Infant Formula Act, which attempted to regulate the required content of formulas for sale in the US, mandating the USFDA to develop new standards and enforce them. It was years before any regulations were finalised [33].
  - The United Nations International Children's Fund (UNICEF) Director James P Grant calls for a Child survival Revolution and subsequently states that a million children die every year because they are not breastfed. UNICEF makes breastfeeding a key interven-

tion in its global GOBI-FFF programme. (G for growth monitoring, O for oral rehydration therapy, B for breastfeeding and I for immunisation against the six basic childhood diseases: tuberculosis, polio, diphtheria, tetanus, whooping cough, and measles. The FFF were food supplement, family planning and female education.)

- **1980s onwards:** Allergy had become commonplace in the United States by the 1960s, and by the 1980s parent support groups in Australia, NZ, the UK and Canada were advocating action about the rising incidence of food allergy and intolerance. Breastfeeding mothers made connections between the hospital use of infant formula and the emergence after 10–21 days of infant gut distress. Their concerns were often dismissed, but prompted growing research into food hypersensitivity, an emerging epidemic. Professor John Gerrard [48] wrote an influential small book on food allergy among Canadian children, and Minchin published Food for Thought: a parent's guide to food intolerance [49], summarising Australian breastfeeding mothers' experiences, recognising the intergenerational impacts for which epigenetics and genomics would later provide explanatory mechanisms [49].
- **1981:**
  - In 1981, the WHA adopted The International Code of Marketing of Breastmilk Substitutes as a recommendation to governments. WHA has since adopted further relevant Resolutions. The IBFAN reports regularly on the implementation of the Code [50]. Most countries and companies have taken little or no effective action to implement the Code, so it has made little difference to industry market expansion.
  - The Codex Alimentarius Commission specified basic minimum standards of infant formula globally. This would be revised and updated periodically; some countries created more rigorous standards.
- **1985:**
  - Addressing the need to improve health worker knowledge of infant feeding, La Leche League International (LLLI) funded the creation of the International Board of Lactation Consultant Examiners® (IBLCE®) [51]. A professional NGO, the International Lactation Consultant Association (ILCA), was soon launched. Lawrence's Breastfeeding: a guide for the medical profession [38], and Minchin's Breastfeeding Matters: What we Need to Know about Infant Feeding [4] argue strongly for better clinical practice by health professionals. Both see breastfeeding failure as the almost inevitable result of poor health professional care and socio-cultural pressures.
  - The Human Milk Banking Association of North America (HMBANA) was founded with the goal of standardizing US donor milk banking operations [35]. Similar organisations exist in the UK (UKAMB) and Europe (EMBA) and expand worldwide. By 2016 Brazil leads the world in structural support for, and the number of, milk banks, while Norway continues its since-1920s unbroken tradition of using fresh donor milk.
- **1988:** Formal creation of the multidisciplinary scientific International Society for Research on Human Milk and Lactation (ISRHML)
- **1980s onwards:**
  - Just as global agencies begin to advocate breastfeeding as a key intervention, Ziegler et al. in Australia reported a single case of postnatally-acquired HIV [52]. This was assumed to be due to breastfeeding, publicised widely (including via free videos from the infant formula industry), and led to blanket bans on breastfeeding by HIV+women living in the USA and Europe, and the closure of many milk banks. No research was done on likely outcomes prior to this ban, although the replacement of breast milk in NICUs increased rates of NEC and sepsis [28]. The ban created enormous prejudice about breast milk, and reinforced myths about infant formula safety; it persisted even after studies in the 1990s began to show higher death rates of children given "replacement" feeding by charities and NGOs. But no change in global policy occurred until after the Botswana government called in the CDC in December 2005 to investigate the very high mortality rate in HIV-exposed formula-fed babies following flooding in Mozambique and Botswana (see Chapter 16). Re-

search in Scotland [53] and Brazil [54] proved formula feeding per se causes gastroenteritis, regardless of socio-economic status.
  - Joint WHO/UNICEF Statement, Protecting Promoting and Supporting Breastfeeding: the special role of the maternity services. This contained the Ten Steps to Successful Breastfeeding that form the basis of the global Baby-Friendly Hospital Initiative (see below).
- **1989:** The UN General Assembly adopted The Convention on the Rights of the Child.
- **1990:**
  - WHO and UNICEF and representatives of 32 national governments and organisations drafted and signed the Innocenti Declaration, calling for structural changes to improve declining breastfeeding uptake and duration.
  - WHO stated that the optimal way to feed an infant is exclusive breastfeeding up to 4–6 months, with continued breastfeeding along with appropriate complementary foods for up to 2 years and beyond [55].
- **1991–1992:** WHO and UNICEF develop and launch the Baby-Friendly Hospital Initiative (BFHI) [56]. The first pilot assessments take place in February 1992 in 12 countries.
- **1991:**
  - Formation of the World Alliance for Breastfeeding Action (WABA). WABA envisioned a global breastfeeding strategy.
  - WHO created the Global Databank on Infant and Young Child Feeding. Few studies past or present ever control for hospital exposure of breastfed infants to infant formula (assumed to be of no significance despite 1970s studies showing long-term effects on gut flora); few define exclusive breastfeeding accurately.
  - WHO published Infant Feeding: the Physiological Basis. Translated into 13 languages, this slight book (now in need of updating) was a ground-breaking forerunner of later WHO infant feeding resources still online.
- **1992:** WABA established World Breastfeeding Week, endorsed by UNICEF, WHO, FAO and the International Pediatric Association (IPA).
- **1995:**
  - Creation of the Academy of Breastfeeding Medicine (ABM), a global physician-only organisation attempting to remedy medical ignorance about infant feeding.
  - Pope John Paul II spoke publicly in support of breastfeeding, hosting an important Vatican conference on the topic of Breastfeeding, science and society [57].
- **1990s:**
  - UK studies demonstrated conclusively that infant formula increased the rates of NEC [58], and decreased average IQ scores [59]. Prior maternal choice of infant feeding made no difference to cognitive outcomes; actual breastfeeding duration did [28], [59]. Preterm infant formulas develop which, by comparison with the sole use of older formulas, result in better IQ scores. However, little notice was taken of the fact that giving even a little breast milk to the infants fed term formulas had obliterated the outcome difference, while breastfeeding at hospital discharge was associated with higher IQ. Preterm formula rapidly replaced both breast milk and term formula use in neonatal units, and NEC continued at 6–7% in some units.
  - Unsterile formula powders become the dominant US product, after competitive tendering reduced what WIC pays for formula, and so increased formula costs at retail. From around 1960 end-sterilised liquid concentrates and ready to feed products had dominated the US market after evaporated milk products were abandoned. For cost reasons this had never been the case in other Anglophone countries.
  - Some formula companies add 5 nucleotides to infant formula. Marketing suggests this aligns formula more closely with breast milk and supports better immune function. Nucleotides are later judged unnecessary [4] but justify price increases.
  - Companies other than in the USA add microencapsulated DHA and ARA produced in the US on an industrial scale using genetically modified marine algae and soil fungi. The encapsulating proteins in formula for milk-allergic infants trigger reactions; traces of neurotoxic hexane used to extract oils from biomass cause concern.
  - Debate continued from the 1970s about levels of selenium fortification needed for infant formula. The UK specified a minimum of 1mcg/L and maximum of 9mcg/L in its 2007 Infant

Formula and Follow On Formula Regulations. The FDA considered the issue in 2013, accepting industry's levels of added selenium [4].

14.6 The 21st Century

Evolutionary medicine and medical anthropology has established the normalcy of human infant feeding patterns, and the physical and psychological harms done by deviations from highly evolved norms [12]. New research in microbiology, genomics and epigenetics make it clear that mother's milk remains the best food for any baby for the first 6 months of life, and advantages the breastfeeding mother as well. Increasing evidence emerges that breastfeeding needs to be exclusive from birth to create the normal microbiome that is the basis for good health through life.

Further changes in infant formula composition attempt to mimic breast milk effects on the infant gut microbiome, by adding new ingredients such as probiotics (bacteria) and prebiotics (largely indigestible carbohydrate food for those bacteria). Press releases and marketing succeed in persuading many people that infant formula has now "closed the gap" with breast milk. An articulate minority of advantaged western women make such claims via electronic media, and start protesting against any truth-telling about infant formula risks or harms by public health advocates [33].

Research has by now established that lack of breast milk and the presence of infant formula increases the risk of many serious diseases in the infant, such as acute otitis media, non-specific gastroenteritis, severe lower respiratory tract infections, atopic dermatitis, asthma, obesity, type 1 and 2 diabetes, childhood leukaemia, sudden infant death syndrome (SIDS) and NEC [60], [61], [62]. Early biological differences between children who are breastfed and those who are not are documented, such as differences in organ size and structure (enlarged kidneys, smaller thymus, different heart structure in preterms), brain white matter development, DNA damage and chromosomal breaks, differences in reproductive tissue growth evident by ultrasound at 4 months of age, different trajectories of body growth and patterns of adipose tissue deposition (all referenced and discussed in Milk Matters [33]). The accepted concept of programming makes it clear that such children are likely to grow on different developmental trajectories. And the rapid growth of allergy and other inflammatory disease epidemics since the 1970s means that parental reports of infant food intolerances are now being taken seriously. Allergy practices are expanding, but struggling to cope with the need for their services, where parents can afford to consult doctors under national health schemes.

Economic research proves that artificial feeding results in greater short- and long-term national health expenditures, and loss of productivity [63]. Not breastfeeding also adversely affects women's health. The loss of lactational amenorrhea and normal postpartum hormonal levels exposes women to greater risk of postpartum infection and anaemia, as well as higher rates of stress and reproductive cancers, diabetes and osteoporosis.

World health authorities and national economists [64] have started to recognise the enormous impact of breastfeeding on individual and population health. Despite the strong efforts by different non-governmental organisations to raise breastfeeding to international and national health agendas, the pace is slow, and hampered by vociferous opposition and "pushback" from advantaged western women with media access, who believe that infant formula is harmful only when misused, and is a safe breast milk equivalent, so that breastfeeding advocates are not genuine public health advocates, but are shaming women who choose not to breastfeed. How much of this "pushback" is due to culpable ignorance, and how much is astroturfing by vested interests remains unresearched. Formula industry presence online is substantial, with special offers and mother's clubs and many forms of marketing and recruitment [65].

Meanwhile, human milk and breastfeeding research remain under-explored, but growing, fields with high potential for impact on long-term health. However, much of this research is funded by the infant formula industry with a view to identifying even more possible new additives that can be industrially produced and then marketed as acting in formula as they do in breast milk. To date, this has proved impossible, as breast milk is a complex living tissue in which multiple ingredients interact to produce positive effects, and no industrially-produced heat-treated and/or dehydrated product can replicate the action of its complex biological structure and microbiome.

14.6.1 Infant Feeding in the 21st Century

- **2000:**
  - the International Labour Organisation (ILO) adopts Maternity Protection Convention 183 and Recommendation 191 [66].
  - UK government funds publication of a structured review of factors promoting or inhibiting breastfeeding, entitled Enabling women to breastfeed [67].
  - Despite the evidence base for responsive infant care, self-styled experts and "baby whisperers" promote regimented care akin to that of Truby King and earlier authors.
- **2001:** WHA adopts Resolution 54.2 calling for strengthened BF promotion: recommends exclusive breastfeeding for 6 months, to be continued with appropriate foods, for two or more years.
- **2002:**
  - WHA adopts the Global Strategy on Infant and Young Child Feeding WHA 5525 [68]
  - The United Nations Millennium Campaign started to support the eight Millennium Development Goals (MDGs) — which range from halving extreme poverty to halting the spread of HIV/AIDS and providing universal primary education started. It mentions interventions to improve maternal nutrition, especially before, during and immediately after pregnancy; early and exclusive breastfeeding; and timely introduction of safe, appropriate and high-quality complementary food for infants, accompanied by appropriate micronutrient interventions [69].
- **2002–2003:** US Office of Women's Health and the US Breastfeeding Coalition (formed in 2000) created a professional risk-based advertising campaign with the National Advertising Council: Babies Are Born to be Breastfed [70]. The Campaign was undermined and reduced in effectiveness by industry lobbying of government, with TV spots withdrawn at the insistence of the DHHS [38].
- **2000 onwards:** Industry increased its online presence, stating support of breastfeeding but in fact defending the normalcy and safety of artificial feeding and perhaps inadvertently encouraging increasing "pushback" against the public promotion of breastfeeding. Creation of "the Mommy wars" encouraged bullying of breastfeeding advocates. The Internet emerged as a major promotional vehicle for infant formula as global sales increase dramatically [41].
- **2003:**
  - DHA and ARA finally added to US infant formulas. These "Gold" brands then rapidly became the de facto standard for US infant formulas after a Bush administration decision in 2004 not to allow WIC programmes to specify the infant formulas on which companies would base their WIC tenders [47]. Repeated Cochrane Collaboration reviews show no benefit to these supplements [71].
  - Following infant deaths over previous decades in Israel, France and the United States from Cronobacter infections (formerly E. Sakazakii), the WHO website stated that powdered infant formula was not a sterile product and recommended mixing with water at no less than 70 °C. Other pathogens documented in formula include Salmonellas, Klebsiella, Bacillus cereus, and Citrobacter, along with moulds. Controversy continued about how to make up infant formula, as heat will kill newly-added bacteria (probiotics) and possibly affect nutrients. Given that infant formula products vary, the effects may be different for each brand or even batch.
- **2005:** Publication of a major ground-breaking scientific paper on ultrasound investigation of lactating breast anatomy by Hartmann Group researchers at The University of Western Australia [72]. Other evidence-based studies followed in this centre, which had previously developed accurate ways of measuring breast volume and infant intake.
- **2006:** WHO Child Growth Standards published: the first normative growth tables based on breastfed rather than formula or mixed-fed children.

- **2007:** Codex Committee finalised revised standard for infant formula; the European Commission set the requirements for the composition and labelling of infant and follow-on formula milks in Europe.
- **2007/2012:** Researchers from the Hartmann Group discovered the presence of stem cells in human milk [71] and revealed their embryonic stem cell (ECS)-like properties [74], [75].
- **2007:** A Witness Seminar on the Resurgence of Breastfeeding was held by the Wellcome Trust Centre for the History of Medicine at UCL, London, on 24 April 2007. The transcript is available online [76].
- **2008:**
  - WHO published Indicators for Monitoring Infant and Young Child Feeding practices.
  - Publication of a ground-breaking systematic review of the cleaning and sterilising of infant feeding equipment [70].
- **2009:** Major campaign funded by the Gates Foundation is said to have tripled the rate of exclusive breastfeeding in Vietnam.
- **1997–2009:** Except where artificial feeding was acceptable, feasible, affordable, sustainable and safe (AFASS), WHO advised exclusive breastfeeding for 6 months and abrupt weaning (called "early cessation") for HIV + women [78]. This policy, promoting replacement feeding by HIV + mothers, was reversed in November 2009 after researchers attending a consultation in Geneva threaten to publicise the excess deaths from formula feeding.
- **2010:**
  - WHO advised anti-retroviral therapy (ART) on diagnosis and continued for life for HIV + women, with exclusive breastfeeding for 6 months and continued breastfeeding for up to 24 months, as studies showed greater harm when breastfeeding ends at 6 months, and infection via breastfeeding is extremely rare [79].
  - Eats on Feets Facebook page created to organise responsible community breast milk sharing, as advantaged women realised that this was the way forward for those mothers unable to fully breastfeed.
- **2011:** Creation of global network for milk sharing: Human Milk 4 Human Babies (HM4HB).
- **2010 onwards:**
  - Some allergists and nutritionists overlooked the harm to infants (more infections) and mothers (e.g., more cases of reproductive cancers, CVD, increased cost and workload) and challenged the WHO advice for 6 months exclusive breastfeeding. This seemed to arise from research indicating that tolerance was more likely to develop if foods were introduced before 11 months and while mothers are still breastfeeding, together with an assumption that breastfeeding ended at 6 months – which in WEIRD (western educated industrialised rich and democratic) nations it often did. This could change given the importance of normal breastfeeding duration.
  - Creation of First Steps Nutrition Trust, the first independent website to provide evidence-based detailed and accurate information about current infant formulas. Many valuable resources are free online at http://www.firststepsnutrition.org/index.html
- **2013:** Family Larsson-Rosenquist Foundation (FLRF) was set up under Swiss law, the only foundation created to promote and support scientific research of human milk and breastfeeding [80].
- **2014:** Professor Allan Walker and others concerned with immune development and the microbiome wrote of 'the necessity of breastfeeding as the first food for infants' [81]. Walker and other scientists participating in Nestle Nutrition Institute Workshop 88 (September 2016) agreed on the importance of exclusive breastfeeding (EBF) in the first days of life; one comments that an intergenerational databank of First Nations families had unexpectedly revealed that among the offspring of women with gestational diabetes, no child who was EBF for just 2 days (the extent of data collection) developed diabetes in adolescence, as is common.
- **2015:**
  - The extensive and updated review, Breastfeeding and Maternal Health Outcomes: a systematic review and meta-analysis, outlined the risks of not breastfeeding for women [63].
  - Pope Francis invited mothers to breastfeed in the Sistine Chapel, spoke in support of breastfeeding [82].

- United Nations Sustainable Development Goals [83] to end poverty, protect the planet, and ensure prosperity for all were adopted. Breastfeeding is a necessary factor in most if not all the goals, though not highlighted.
- Milk Matters: Infant Feeding and Immune Disorder proposed the Milk hypothesis: that the interlinked inflammatory epidemics of immune disorder, obesity, diabetes and cardiovascular disease all have their origins in formula-related distortions of normal postpartum processes. Epigenetics indicate that these effects are heritable and may compound through succeeding generations. The book brings together current evidence for infant formula's separate detrimental effects on biological development as well as the effects of the absence of breastfeeding and women's milk, chronicling the evolution of infant feeding as a series of ongoing uncontrolled, and almost entirely unexamined, experiments [82].

- **2016:**
  - Joint statement by the UN Special Rapporteurs on the Right to Food, Right to Health, the Working Group on Discrimination against Women in law and in practice, and the Committee on the Rights of the Child affirmed breastfeeding as a human rights issue for mother and child alike and called for government action to enable breastfeeding [84].
  - Consensus statement from the CFAR Summit on Food Allergy held in May 2016 at the Royal Children's Hospital in Melbourne, Australia offered hope of resolving disagreement between allergists and WHO on the age for introduction of other foods to breastfed children [85].
  - Major American collaborative review, Suboptimal Breastfeeding in the United States: Maternal and paediatric health outcomes and costs, estimated excess 3,340 needless premature maternal deaths and 721 excess paediatric deaths, along with billions in healthcare costs [64].
  - Ongoing efforts to improve infant formula included adding back some bovine milk fat products and complex sugars, because many (different and interactive) types exist naturally in breast milk!
  - Increasing awareness of the multiple structural issues inhibiting successful breastfeeding in high-income countries [42].
  - Infant formula sales ($2 billion in 1980) exceeded $45 billion and were projected to reach $70 billion by 2019. China became the world's largest market for infant formula; demand estimated to reach $30 billion by 2017 [41].
  - Type 1 diabetes increased dramatically in China, especially in children, the fastest increase in the under 5s.

14.7 Current Overview and Conclusion

Rates of exclusive breastfeeding in hospitals worldwide are still not being well monitored, and infant formula use for newborns is still prevalent. Definitions of "exclusive breastfeeding" still ignore in-hospital exposures. Health authorities are clearly not being effective in countering industry presence and marketing strategies. Many are co-opted partners in promoting artificial feeding, because they refuse to provide the information about infant formula risks and harms that parents need to make any truly informed choice. In a rationale unique to this one major public health message, refusal to publicise known harms is publicly justified by the desire not to create anxiety or guilt among parents already feeding artificially.

In WEIRD nations (western, educated, industrialised, rich and democratic) in the 21st century, it is now largely advantaged women who breastfeed and/or are able to pump their milk to feed their babies, together with – in some areas – women too poor to have any choice but to breastfeed. Proportionally, it is less advantaged women with some disposable income who are now feeding artificial substitutes for breast milk to their children. Breastfeeding support is increasingly seen by researchers as an important strategy to reduce social inequality. So too is generous maternity leave [42], [49].

In emerging economies, advantaged women are now repeating the mistakes their advantaged sisters made a century ago in the 1920s, wasting money on buying dehydrated substitutes for a priceless living liquid that provides daily free stem cell transplants. And the elite's example will lead disadvantaged women in those communities to buy the unaffordable status symbols of imported infant formula [39], wanting "the best" for their babies. In fact, such families are risking their child's life and pushing the whole family further into poverty, closing off avenues of escape from poverty via the education of gifted children. Artificial feeding is closing the poverty trap on the bodies of some children, tightening it for many of those exposed too early to an expensive industrial product valuable as a supplement or replacement only when breast milk is unavailable.

In desperately poor communities exposed to global media, breastfeeding women are watching. With billions of dollars being spent on marketing, and with western governments supporting the expanded production and global export of infant formula, it will not be long before the cycle of artificial feeding's dysnutrition and dysbiois and immune disorder grows even in the poorest communities. Naïve parents believe that there are regulations that would not let companies sell products that harm their children: 'they wouldn't let them say those things if they weren't true'; 'they wouldn't let them sell formula if it would harm my child'. A recent book by Professor George Kent illustrates the extent to which governments have themselves become formula-pushers, and are failing to regulate infant formula, or to protect and enable breastfeeding adequately. Few parents understand that industry self-regulation is the reality, and that routine independent assays of infant formula products do not occur in most countries.

Infant formula became the dominant norm in WEIRD countries because of many decades of sustained taxpayer-funded structural support for the industry, and for parents wanting or needing to formula feed. One senior scientist stated in 1984 that the FDA 'needs to reassure parents that American formula is safe because American society depends on bottle feeding' [4]. Promoting breastfeeding as the mother's responsibility while buying or exporting or subsidising millions of cans of infant formula is divisive and hypocritical. Not informing the community of the risks and harms of infant formula feeding is negligence at best. It may well be judged as criminal liability once class action lawyers investigate the possibilities that Professor Peter Hartmann foresaw when he said that 'Infant formula is the tobacco of the 21st century'.

A formula slogan, once found on every can of Cow and Gate infant formula, was this:

What we feed them now matters forever.

It does. So what we feed babies needs to be women's milk.

Enabling breastfeeding and providing women's milk for those who cannot breastfeed, are both possible, once they are seen as necessary for normal human health and development.

Science makes clear that they are.

Societies need to invest significant funds (on the scale of industry subsidies for formula ingredients and products) in enabling, as well as promoting and protecting, breastfeeding. Establishing breastfeeding as the community norm worldwide will save much more than it costs.

Key Points

- Lactation is a robust, resilient, and reliable survival mechanism, and was critical to mammalian evolutionary success. With the development of bovine derived products many infants are missing out on this valuable resource
- Industrialisation and pressures from modern society has resulted in shifts away from breastfeeding towards readily available commercial products
- With the increased understanding of the health benefits to both baby and mother, the focus is shifting back to breastfeeding
- Providing unbiased information – not only about breastfeeding, but also about the risks of formula feeding – is essential in ensuring a refocus on breastfeeding and the use of human milk

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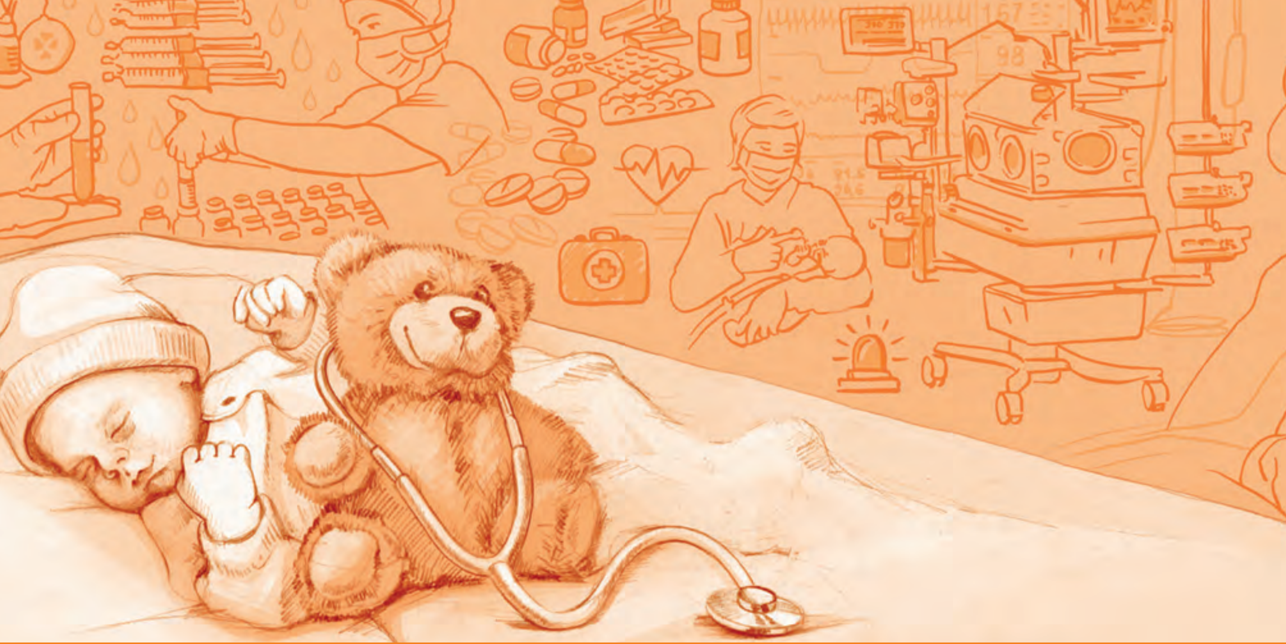


Part 3
Human Milk in Special Circumstances

15 Introduction

Paula P. Meier, Prof, PhD, RN, FAAN

Whereas human milk is important to every infant's health, there are specific circumstances, like premature birth, where the absence of a mother's milk is particularly detrimental to the health of the infant. The chapters in Part III (see Chapters 16 to 20) summarise the evidence, best practices and research priorities for three such circumstances, as well as the use of pasteurised donor human milk as a supplement or alternative. These chapters reiterate a common theme – the importance of basing the decision to feed an infant with mother's milk on available evidence, instead of adopting a default stance of "being on the safe side with pasteurised donor human milk or formula."

The section provides evidence about how the unique nutritional and bioactive components of a mother's milk cannot be replaced by donor human milk for multiple reasons, including those linked to pasteurisation and storage processes. Furthermore, it outlines evidence that formula – especially for premature infants during the early postbirth period – is in fact detrimental. Research shows formula in these circumstances may result in short- and long-term health complications due to its inflammation-inducing properties and its negative impact on early nutritional programming. Thus, it supports the concept that the decision to advise a mother on how to feed a premature infant (in the case of a neonatal intensive care unit, or Neonatal Intensive Care Unit [NICU], infant) should be individualized and situation-specific, with the indisputable knowledge that the benefits for the neonate of receiving own mother's milk greatly outweigh the risks.

Part III (see Chapter 16) begins with a chapter written by myself and members of my team, Dr Beverly Rossman, Dr Aloka L. Patel, Dr Tricia J. Johnson, Dr Janet L. Engstrom, Dr Rebecca A. Hoban, Dr Kousiki Patra, and Dr Harold R. Bigger, all experts in the use of human milk in NICU. Each offers real-life examples and recommendations of how to ensure these high-risk infants benefit from the life-giving properties of human milk. This is complemented by chapter 17, providing summary interviews with well-respected human milk banking experts. It provides on-the-ground insight into approaches that ensure infants receive as much of their own mothers' milk as possible, rather than compromised outcomes following rushed decisions for donor human milk use. Each strategy highlights the need for specialists with combined expertise in lactation processes, human milk science and pediatric care (including neonatology for NICU).

This is followed by Dr Lukas Christen (see chapter 18), a former PhD student in the Hartmann Human Lactation Research Group, who then addresses the promising alternatives to current methods of pasteurisation that eradicate pathogenic bacteria and improve storage options for donor human milk now being studied.

Next is a chapter on a subject that has received considerable attention in the last decade: breastfeeding when mothers are human immunodeficiency virus (HIV) positive (see chapter 19). Professor Anna Coutsodis, a Professor of Paediatrics and Child Health at the University of KwaZulu-Natal, discusses the risks, options and latest recommendations from professionals in the field.

Part III concludes with a chapter (see Chapter 20) from Professor Tom Hale, a Professor of Paediatrics and Associate Dean of Research, and Dr Teresa Ellen Baker, MD, FACOG, both at the Texas Tech University Health Sciences Center School of Medicine, that takes a closer look at the various aspects of breastfeeding in situations where the mother requires medication. While all medications transfer to human milk to some degree, risks vary according to the class of drug. Most drugs have little to no effect on infants. Others, however, do present risks clinicians and mothers should be aware of. This chapter looks at these classes and the risk/benefit analyses that must be conducted to ensure optimal health for both infants and mothers. It provides information about measuring infant exposure to certain medications, and covers considerations and recommendations for those clinicians prescribing medication to lactating women. Finally, the authors present details about where to find further help and advice.

16 Human Milk in the Neonatal Intensive Care Unit

Paula P. Meier, Prof, PhD, RN, FAAN; Beverly Rossman, PhD, RN; Aloka L. Patel, MD; Tricia J. Johnson, PhD; Janet L. Engstrom, PhD, APN, CNM, WHNP-BC, CNE; Rebecca A. Hoban, MD, MPH; Kousiki Patra, MD; Harold R. Bigger, MD

Expected Key Learning Outcomes

- **Successful feeding option for premature infants in a neonatal intensive care unit**
- **Why human milk is so vital to preterm and vulnerable infants**
- **How human milk provides protection from multiple short- and long-term morbidities**
- **Approaches to enable preterm mothers to provide enough milk for their infants**

16.1 Introduction

Human milk (HM, milk from the infant's own mother) feeding of premature infants during hospitalisation in a neonatal intensive care unit (NICU) reduces the risk of multiple short and long-term complications, including necrotising enterocolitis (NEC), late onset sepsis (sepsis), chronic lung disease (CLD), retinopathy of prematurity (ROP), rehospitalisation after NICU discharge, and neurodevelopmental problems in infancy and childhood [1]–[16]. The benefit is dose related, with larger amounts (doses) of HM translating into greater risk reductions for these morbidities during specific critical development periods that occur while hospitalised [1]–[5], [8]–[10], [12]–[20]. Furthermore, by reducing the risk of these morbidities, HM feedings represent a safe and effective mechanism to lower health care costs that are associated with them and their sequelae [4], [8], [15], [21], [22]. Donor HM does not provide this same protection [6], [23] and commercially-available formulas increase the risk of these morbidities in premature infants [8], [24]–[26]. Thus, interventions that target the initiation and maintenance of maternal lactation and the exclusive use of HM are priorities worldwide for this vulnerable population [18], [19], [27].

This chapter reviews the health outcomes and costs of HM feedings for premature infants. It describes the mechanisms by which HM functions to protect immature organs and physiological pathways from NICU stressors of inflammation, oxidative stress and suboptimal nutrition. Strategies to prioritise HM volume in breast pump-dependent mothers of premature infants and evidence-based techniques to ensure that premature infants receive the highest possible quantity of HM during the NICU hospitalisation (NICU dose) are detailed. Evidence-based and best practices that facilitate the transition from gavage to at-breast feeding are also reviewed.

16.2 Human Milk Feedings for Premature Infants: Health Outcomes, Costs, and Mechanisms of Protection

16.2.1 Health Outcomes of HM Feedings

Several studies support the effectiveness of HM in reducing the risk, incidence, and/or severity of NEC, sepsis, ROP, and CLD, four primary acquired NICU morbidities that are serious, potentially handicapping, and costly in premature infants [1]–[17], [22]. However, until recently this impact was not fully appreciated due to several limitations in the available literature [19], [20], [28], including:

- Lack of distinction between receipt of HM and donor HM feedings (e.g., HM feedings included both donor and own mother's HM)

- Inconsistent study samples that included mixtures of premature infants with low birth weight (< 2,500 g birth weight), very low birth weight (VLBW; < 1,500 g), and/or extremely low birth weight (< 1,000 g birth weight)
- Retrospective methodologies and secondary analyses of studies that were not designed to measure outcomes of HM feedings
- Use of inexact measures of the amount (dose) and timing (exposure periods) during which infants received HM feedings

Recently, a team of investigators has addressed these limitations in the large prospective Longitudinal Outcomes of Very Low Birthweight Infants Exposed to Mothers' Own Milk (LOVE MOM) cohort study, which was designed specifically to measure health outcomes and cost of HM feedings for very low birth weight (VLBW) infants. (National Institutes of Health [NIH] grant NR010009) [29]. The LOVE MOM cohort enrolled 430 VLBW infants between 2008 and 2012 (95% of eligible infants), the majority of whom were born to minority (52% Black, 27% Hispanic), low-income (70% Supplemental Security Income, Women, Infant Child [WIC]-eligible, 185% of the poverty level) mothers [19], [27], [30]. A unique feature of the LOVE MOM cohort is that the dose and exposure period of HM feeding was measured prospectively by calculating the total amount of HM and the total amount of commercial formula (in mL) received by each infant daily during NICU hospitalisation [20]. Of the 430 infants, 98% received some HM (range 3–28, 229 mL during NICU hospitalisation), 76.8% and 59.7% of the cohort receiving exclusive HM during the Days of Life (DOL) 1–14 and 1–28 exposure periods, respectively. Over the NICU hospitalisation, 48.6% of all enteral feedings consisted of HM [19], [20], [27]. Donor HM was not used during this study, so all non-HM consisted of commercial formula, and HM was fortified with a commercial bovine powder [4], [8].

In the LOVE MOM cohort, high-dose HM feedings during three critical exposure periods during NICU hospitalisation significantly reduced the risk of NEC, sepsis, and CLD and their associated costs [4], [8], [20], [31]. During exposure period DOL 1–14 any amount of formula (e.g., < 100% of HM feeding) increased the risk of NEC three-fold. After controlling for costs due to NEC risk, each additional mL of HM received during DOL 1–14 decreased the total NICU costs by US $534 [8]. During exposure period DOL 1–28 each additional 10 mL/kg/day of HM feeding reduced the risk of sepsis by 19% [4]. The difference in sepsis-related NICU costs between the highest (≥ 50 mL/kg/day) and the lowest (< 25 ml/kg/day) HM doses for exposure period DOL 1–28 was US $31,514 (in 2010). For CLD, every 10% increase in HM enteral feedings during NICU hospitalisation up to 36 weeks post menstrual age (PMA) reduced the risk of CLD by 9.5%; CLD was associated with an additional US $41,929 in NICU costs [15]. In addition to increasing NICU cost of care, NEC, sepsis, and CLD predispose VLBW infants to neurodevelopmental delay and other lifelong health care problems and their associated costs [22], [32]–[40]. Thus, feeding HM during NICU hospitalisation represents a safe and effective strategy to reduce lifelong health problems and their associated costs in VLBW premature infants.

At the time of this writing, 251 LOVE MOM infants who had reached 20 months of age, corrected for prematurity (corrected age, CA) were evaluated to determine the impact of NICU HM dose on subsequent neurodevelopmental outcome. After controlling for known confounders, each additional 10 mL/kg/day of HM during NICU hospitalisation translated into increases of 1.37, 1.48, and 1.44 for scores on cognitive, language, and motor evaluations, respectively [16]. Overall, differences between the lowest and highest NICU HM-dose groups (HM 2 ± 2% and HM 98 ± 5% of total enteral feed volume, respectively) were clinically significant, with 5–10-point differences (1/3–2/3 of standard deviation) across cognitive, language, and motor outcome measures. These outcomes were noted despite the fact that infants in the highest HM quintile grew more slowly during NICU hospitalisation and were significantly more likely to be classified as extra-uterine growth retardation (EUGR; weight at 36 weeks < 10th percentile for weight) as compared to subjects in the lowest HM quintile [16].

The LOVE MOM cohort provide meticulously measured, prospective evidence for the positive impact of high NICU HM dose on neurodevelopmental outcome in NICU-hospitalised VLBW infants [4], [20], [22], [41]–[46]. It is likely that high-dose HM feedings received during critical periods during NICU hospitalisation impact on neurodevelopmental outcome through both direct mechanisms (such as nutritional and bioactive substrates) that facilitate brain growth and development, and indirect mechanisms (including reducing the risk of NEC, sepsis, and CLD) that contribute to neurodevelopmental and chronic health problems [16], [47], [48].

16.2.2 Cost of Human Milk Feedings

A primary barrier to the achievement of higher NICU HM doses in premature infants is lack of investment in clinical resources that target HM provision and feeding during NICU hospitalisation [18], [19], [21], [27], [43], [44]. These resources include maternal access to hospital-grade electric breast pumps for use in the NICU and at home, and adequate HM storage containers and space (e.g., food-grade storage containers, refrigerators, and freezers). They are required to store all pumped HM in the hospital under temperature-controlled and tamper-proof conditions. Most importantly, breast pump-dependent mothers of NICU infants need access to NICU lactation specialists who have expert skills in lactation physiology following premature birth; breast pump use and other lactation technologies (e.g., measurements of HM calories and HM intake during breastfeeding); safety of maternal medications and associated health conditions; and HM expression manipulation and measurement technologies. Such care facilitates adequate infant growth without unnecessary addition of and/or replacement with commercial formula [18], [19], [27]. These necessities are relatively inexpensive when compared with the cost of acquired NICU morbidities for which HM is protective [21].

However, removal of barriers to providing and using HM also requires upfront investments in products and personnel. These are often seen as superfluous by administrators unless they are linked cogently to the reduction in overall NICU and societal costs. Economic data from the LOVE MOM cohort indicate that the institutional costs of providing HM are lower than providing either donor HM or commercial formulas [21], [22], [43], [44].

16.2.3 Protective Mechanisms of HM for Premature Infants

Multiple nutritional components and bioactive mechanisms in HM act synergistically to provide protection for premature infants whose organs are in immature stages of development and susceptible to damage. Such damage may be caused by inflammatory stimuli, oxidative stress, and suboptimal nutrition, which are common in the NICU [15], [19], [39], [48]–[63]. The impact of these noxious stimuli continues to contribute to and/or program abnormal organ growth and development long after the initial insult [48], [51], [52], [59], [62]–[68]. A key mechanism afforded by HM feeding is provided by the gut and its microbiome and metabolome, which contribute early protective programming, and reparative processes to multiple body organs and physiological pathways [39], [48], [49], [51], [52], [60], [61], [69]–[78]. Gut dysbiosis up regulates inflammatory cytokines and facilitates translocation of pathogenic bacteria and their pro-inflammatory toxins from the gut lumen to the underlying gut mucosa. Thence, these pro-inflammatory cytokines migrate, potentially altering the structure and/or function of organs (e.g., brain, lung, and eye) and pathways (e.g., immunomodulatory pathways) during critical developmental stages [39], [48], [50]–[52], [60], [70], [72]–[75], [77]–[82].

16.2.4 Protection via HM Feedings

HM feedings provide unique nutritional substrates and bioactive components that stimulate and/or program optimal growth and development of immature organs and physiological pathways while preventing/moderating biological insults from inflammation, oxidative stress, and suboptimal nutrition [18], [19]. Early HM (DOL 1–28) from mothers who deliver prematurely has high concentrations of bioactive components [51], [72]–[75], [83]–[98] that:

- Stimulate growth, differentiation, and reparative functions in the gut epithelial border
- Decrease intestinal permeability and thus translocation of bacteria to the underlying mucosa
- Down regulate inflammatory and oxidative stress processes

Large HM doses thereafter likely have an even greater impact on post-NICU health and neurodevelopmental outcomes because they provide:

- Probiotic (eg., live bacteria via the HM microbiome) [51], [99]–[106] and prebiotic (food for commensal bacteria via HM oligosaccharides) activity [101], [107]–[109], [110], [111]
- Pattern recognition receptors (Soluble CD14) that facilitate bacterial-enterocyte crosstalk in the immature gut [112]–[114]
- Potent anti-inflammatory (interleukin 10, lactoferrin, glutamine) [88], [115]–[117] and antioxidant [87], [89], [118], [119] functions
- Specific substrates for brain growth and myelination, including lactose and triglycerides for energy, fats that optimise myelination (cholesterol, long chain polyunsaturated fatty acids), and insulin-like growth factor-1) [58], [120]–[124]

Some of the more than 200 HM oligosaccharides as well as HM stem cells are thought to have neuroprotective and neurodevelopmental activity [105], [125]. Recent magnetic resonance imaging studies of term [126] and preterm infants (born 1982–1985; Lucas cohort) studied during adolescence [124] revealed a dose-response relationship between the lifetime HM dose and brain white matter development, especially for males. Thus, HM appears to play a strong biologic role in the shaping of childhood health and neurodevelopmental outcomes in former premature infants.

16.2.5 Donor HM as a Supplement/ Substitute for HM

Both the American Academy of Pediatrics (AAP) and the European Society for Paediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN) have recommended the use of donor HM when HM is not available [127], [128]. However, compared to HM for VLBW infants, the nutritional and bioactive deficiencies in donor HM are sizeable, and are demonstrated most dramatically in slower growth rates and greater proportion of NICU morbidities [6], [23], [129]–[136]. The strongest empirical evidence for the efficacy of donor HM is its associated reduction in the risk, incidence, and severity of NEC in premature infants [23], [129]–[131], [136]–[138]. However, it is unclear whether this is due to donor HM efficacy or the avoidance of bovine-based products (for which donor HM is a substitute), especially during the early weeks post birth [1], [8], [19], [24], [25], [129], [138], [139]. There is inconclusive published evidence for the impact of donor HM on sepsis, CLD, and later neurodevelopmental outcome [6], [23], [129], [135], [136], [138]. However, a limitation in nearly all donor HM studies is that most infants have received either donor HM or formula as a supplement to HM, and the dose and exposure period of HM has not been measured or standardised [6], [19], [23], [129], [138]. Thus, the infant's initial and/or partial exposure to HM may minimise the additional impact of donor HM versus formula.

A nearly universal concern of donor HM feeding is the slower growth rate in cohorts of donor HM-fed premature infants versus HM-fed and formula-fed premature infants [6], [23], [131], [134]. Whereas the most common clinical solution for slower growth is more aggressive fortification, particularly earlier introduction and longer use of high exogenous bovine protein concentrations, no long-term outcome data exist to indicate that this is the best practice [19], [23], [140]. Additionally, several differences between donor HM and HM potentially affect growth rate but have been given little clinical consideration, including:

- Stage of lactation, especially with respect to adipokine concentrations and protein type [73], [114], [141]–[150]
- HM following preterm versus term birth [91], [92], [97], [141], [151]
- HM collection, storage, and handling procedures except pasteurisation [19], [105], [125], [152]–[155]
- Specific mother-infant mismatch between specific HM components[156]
- The different effect from HM of donor HM on infant digestion processes such as fat absorption that influence growth [157]–[159]

Overall, the evidence suggests a positive impact of donor HM as a supplement or replacement for HM during early NICU hospitalisation when premature infants are at the greatest risk of NEC. However, additional short- and long-term outcomes of donor HM feedings remain inconclusive.

This evidence underscores the importance of prioritising mothers' own HM in the NICU, including articulating the differences between donor HM and HM to infants' families as they make feeding decisions. Second, the evidence indicates that donor HM and HM should not be included in the same outcome metric (e.g., HM feeding that includes both milks) for research and quality improvement initiatives. The outcomes for these two feeding regimens are not the same and the combined metric likely underestimates the impact of HM alone on short- and long-term outcomes for premature infants.

16.2.6 Summary – Human Milk Feedings for Premature Infants

HM provides the premature infant with protection from the common NICU stressors of inflammation, oxidative stress, and suboptimal nutrition; reduces the risks of NEC, sepsis, CLD, and ROP; and predicts 20-month CA neurodevelopmental outcome in a dose-response manner. This impact is likely due to the interaction and synergy of multiple HM components, many of which are concentrated more highly and/or function more selectively in HM of mothers who deliver prematurely. Donor HM does not provide these same outcomes for reasons that extend beyond pasteurisation. Priorities in the NICU should focus on the channelling of resources into programmes that promote initiation and maintenance of established lactation in mothers of premature infants. As a first step, messaging for families in the form of talking points about the importance of HM should be evidence based and standardised so that consistent, factual information is shared by health care providers [18], [19], [27], [160]–[162]. A sample of such talking points is shown in ▶ **Table 16.1**.

▶ **Tab. 16.1** Sample messaging and talking points to share evidence about the importance of human milk feedings with families of premature infants in the NICU.

Topic	Talking Points	Evidence
Making the Decision to Provide Own Mothers' Milk	• Your baby will need your milk as a part of his or her overall treatment plan • Receiving your milk reduces the chances that he or she will develop common complications of prematurity, such as infections and bowel disease	• Several studies indicate that mothers of premature infants do not feel guilty, pressured or coerced by a proactive message from physicians and nurses about the importance of HM [27], [160], [162], [228] • Clarifying "reducing the chances" versus "benefits of human milk" nomenclature most accurately reflects the research findings about outcomes of HM for premature infants [18], [27]
Why is my milk so important for my baby?	• The milk mothers make in the first few days after birth, called colostrum, provides many special substances that your baby's intestines need to grow and develop, and that help their immune systems to develop to fight infection • We are also concerned about feeding formula during the early weeks after birth. Several studies suggest that formula increases the chances that premature babies will develop complications • Premature babies have not developed the same defenses against infection and other diseases as full-term babies	• Premature infants immature body organs and immunomodulatory and metabolic pathways are vulnerable to inflammation, oxidative stress, and nutritional deficiencies [18], [48], [50], [51], [53], [341] • Mothers who deliver prematurely produce HM with higher concentrations of many of the protective components (e.g., lactoferrin, and secretory immunoglobulin A, interleukin-10) that down regulate inflammatory processes. This is especially true of maternal colostrum and transitional HM [18], [19], [91]–[93], [95], [96], [99], [148] • Bovine formula exerts a separate detrimental impact via several mechanisms, including: greater and prolonged post-birth intestinal permeability, direct cytotoxicity, and gut dysbiosis [24]–[26], [139], [154], [342], [343]

HM = human milk, NICU = neonatal intensive care unit.

16.3 Prioritising Initiation and Maintenance of Established Lactation in Mothers of Premature Infants in the NICU

Mothers of premature infants confront multiple challenges when initiating and maintaining lactation during their infants' NICU hospitalisation [27], [163]–[166]. Whereas many of these challenges such as maternal health status and birth-related complications are unmodifiable, the lack of evidence-based practices also places these vulnerable mothers at risk for establishing an inadequate HM supply [27], [163]–[167]. Lactation care in the NICU is a specialty practice area. It should be provided by health care providers with expertise in the management of breast pump dependency and use of other lactation aids (e.g., breast-shield sizing, HM analysis technologies, test weighing, and nipple shields), which facilitate pumping and HM feeding [19], [27], [168]–[172]. Additionally, mothers of NICU infants need specific information and guidelines about their own health conditions and medications that impact on HM provision and feeding [18], [27]. Although various models for providing NICU lactation care have been proposed, three have been implemented, evaluated, and disseminated in the research literature:

- The Rush Mothers' Milk Club, which incorporates breastfeeding peer counsellors (former NICU parents themselves) as primary lactation care providers [27], [173]–[176]
- The Nurse Resource Model, which expands the role of the bedside NICU nurse to expert lactation care provider [168], [172], [177]
- The NICU Baby Friendly 10-step model that is based on the original World Health Organization criteria [178]

16.3.1 Breast Pump Dependency

Mothers of NICU infants are completely breast pump-dependent. This means that the breast pump rather than the infant regulates the lactation processes of HM removal and mammary gland stimulation, which are critical to continued HM production [179]. Even after at-breast feeding is initiated in the NICU and continued post-discharge, these mothers remain partially breast pump-dependent (i.e., the breast pump remains the primary regulator of lactation) until the infant consistently takes all daily feedings at the breast effectively and efficiently; this is usually at 40–44 weeks postmenstrual age [179], [180]. These mothers therefore need access to a hospital-grade electric breast pump that is effective, efficient, comfortable, and convenient, and which offers simultaneous versus serial pumping, variable sucking rates, rhythms and pressures, and custom-fitted and warmed breast shields [18], [166], [181]–[192]. These criteria, the underlying evidence, and specific recommendations about individualising breast pump technology to both the degree of breast pump dependency and lactation stage are reviewed elsewhere [179].

A major barrier for many mothers is that public and private insurance plans and public nutrition programmes do not consistently provide or reimburse hospital-grade breast pump rental costs, despite a physician order of HM feedings for a NICU infant [18]. Instead, less costly manual or double-electric personal pumps that do not meet the abovementioned criteria for effectiveness, efficiency, comfort, and convenience are substituted; as such, mothers experience problems with establishing and maintaining an adequate HM volume [179]. A series of studies has examined maternal and institutional costs of providing HM for VLBW infants, and reviews have compared the upstart costs of providing HM with the costs incurred for morbidities that are potentially preventable with HM feedings [21], [22], [43], [44], [193], [194]. These studies have consistently shown cost savings when providing mothers with hospital-grade electric pumps for use in the home versus purchasing donor HM or commercial formula [21], [43], [44]. Thus, substantial evidence exists to support the institutional or other third-party payment for hospital-grade electric breast pumps for breast pump-dependent NICU mothers [179].

16.3.2 Strategies to Prioritise Established Lactation for Breast Pump-Dependent Mothers

Breast pump-dependent mothers of NICU infants have specific, predictable barriers to the initiation and maintenance of lactation, which infrequently occur for mothers with healthy term infants [27], [164], [165], [171], [179], [195]–[199]. These barriers, which have been detailed in individual studies [45], [164], [165], [173], [176], [196]–[201] and delineated in a recent review paper [179], can be divided into three stages of lactation: initiation, coming to volume, and maintenance of established lactation. A brief overview of these stages and common barriers is provided below.

Early lactation: initiation and coming to volume

The initiation of lactation coincides with the closure of tight junctions in the mammary epithelium [202]–[204], a process that is disrupted and/or delayed by preterm and/or complicated birth [27], [197], [198], [205], [206], lack of exposure to human infant-specific sucking patterns [166], delayed breast pump use [165], [196], early hormonal contraception [207], [208], and prolonged hand expression in the absence of breast pump use [167].

Coming to volume refers to the lactation stage between the onset of lactogenesis II and the establishment of a threshold HM volume, typically ≥ 500 mL/day [27], [179]. This transition heralds the autocrine control of lactation [166], [202], [209]–[213] via the suckling-induced prolactin surge [214]–[217] and feedback inhibition of lactation [210], [218]–[220]. It is fraught with problems for even healthy mothers and infants [18], [166], [202], [221], [222]. Coming to volume in a breast pump-dependent mother with a NICU infant is further complicated by maternal stress, fatigue, pain, lack of clarity about HM volume targets, incorrect type/use of the breast pump (e.g., suction pressures, frequency, and pumping duration), and improperly-fitted breast shields [27], [179].

Furthermore, the early post-birth stages of initiation and coming to volume represent critical periods for the programming of lactation structures and functions, making it difficult or impossible for mothers with low HM volume to “catch up” after these critical periods have passed [27], [165], [167], [179], [196]. All available evidence indicates that the first 14 days post-birth should be prioritised by NICU staff with proactive interventions to prevent or detect these common problems.

During these early lactation stages, a major barrier to adequate HM feeding is that mothers do not receive information about the importance of establishing a threshold HM volume of ≥ 500 mL/day during the first 14 days post-birth when programming of lactation structures occurs. Nearly all NICU infants, born either prematurely or with medical/surgical complications, require only small HM feedings during this time; mothers are therefore able to provide exclusive HM feedings despite pumping small HM volumes. However, as infants' conditions improve and they receive the customary 150–180 mL/kg/day of HM, the mothers' HM volumes are no longer sufficient; these insufficiencies often manifest at 4–6 weeks post birth [27]. It is likely that these HM insufficiencies originate in the initiation and coming to volume stages because mothers do not have the necessary information about HM volume targets to help them achieve their HM feeding goals [27]. Whereas mothers with healthy term infants who feed on cue do not need to worry about HM volume targets because their infants create the HM demand, mothers with NICU infants must create HM demand with the breast pump. Mothers of NICU infants therefore need to understand that there are two HM volume targets: one that is sufficient for exclusive HM feedings when infants receive small HM volumes (e.g., as little as 100 mL/day), and the other that is sufficient to protect and program long-term lactation (i.e., ≥ 500 mL/day by the end of DOL 14) [27]. Published monitoring tools and parent education sheets about this important concept are summarised in ▸ **Table 16.2**.

Maintenance of established lactation

Several recent reports highlight the fact that increasing numbers of mothers of VLBW infants begin providing HM for their infants, but that significantly fewer are still providing exclusive or partial HM at the time of NICU discharge [20], [163],

▶ **Tab. 16.2** Tools to monitor human milk volume for breast pump-dependent mothers of NICU infants.

Tool	Purpose
Maternal goals for providing HM in the NICU	• Clarifies and communicates maternal goals for type of milk feedings (exclusive, partial, no HM) for NICU infants on a week-by-week basis and the method (exclusively at breast, exclusively pumped HM in a bottle, mixture of HM from breast and bottle) by which the want to provide HM at the time of NICU discharge • Denotes changes in HM feeding goals over the course of the NICU and alerts NICU staff to mothers at risk for not achieving their goals
Coming to Volume assessment tool for breast pump-dependent mothers in the NICU	• Succinct checklist that monitors physiologic changes that coincide with the initiation and coming to volume stages of lactation for mothers who are at risk for delayed lactogenesis and who are breast pump-dependent • Identifies irregularities so that they can be quickly triaged and managed to avoid long-term HM volume problems
"My Mom Pumps for Me!" HM Volume Record and Diary	• Convenient and engaging HM volume diary that helps NICU mothers and staff track pumping volumes for the right and left breasts separately, and time spent per pumping • Checkbook type insert pages permit journaling as well as the posting of decals that chronicle special events in the breastfeeding trajectory for NICU mothers, including 1st Kangaroo Care and 1st Tasting at the breast • Used to identify and manage HM volume problems with specific data (e.g., mLs pumped and time spent pumping) versus non-specific outcomes (e.g., "my milk is going down")

HM = human milk, NICU = neonatal intensive care unit

[199], [223]–[226]. It is well known that mothers of preterm and other NICU infants often change their decision from using formula to HM after conversations with healthcare providers [160]–[163], [227], [228]. They also do not plan to breastfeed long-term [160]–[163]. Regardless, the majority of mothers do not meet their self-stated goal to provide partial or exclusive HM at the time of NICU discharge. Few evidence-based findings inform this worldwide outcome [20], [163], [199], [223]–[226], even in NICUs that prioritise support for HM and breastfeeding [20], [27], [163], [199], [223]–[226]. It is likely that long-term breast pump dependency, maternal stress and fatigue, lack of access to hospital-grade electric breast pumps, having an infant who is no longer critically ill, insufficient support from family and friends, and inconsistent advice in the NICU all play a role in these mothers' discontinuation of HM provision.

Profound dislike of the pumping process and lifestyle inconveniences required to maintain an adequate HM volume during NICU hospitalisation are common in breast pump-dependent mothers [45], [164], [176]. These personal factors interact with events over the NICU trajectory, leading mothers to perceive that their HM given at a later time post birth is not as critical to their infants' outcome as it is during the early post-birth period. These NICU events do not necessarily follow a logical progression, making it difficult to identify whether the maternal HM volume declined because of the clinical event. The following series of NICU events illustrates this phenomenon. When the infant is no longer critically ill and requires larger volumes of HM, the mother's HM volume is no longer adequate for exclusive HM feedings. The infant is therefore supplemented with donor HM or preterm infant formula and tolerates it well. Once the mother observes that her convalescing infant grows, gains weight, and reaches milestones on donor HM and/or formula, she questions whether her dislike and inconvenience of pumping are worth the effort. When the mother's HM volume further decreases, it is likely due to a reduction in pumping patterns and acceptance of a less ambitious goal for HM provision [45], [163], [176], [229].

It has been suggested that maternal (e.g., prenatal intention, motivation) rather than infant factors (e.g., weight, critical health status) are the primary drivers in the decline in HM provision at NICU discharge [225]. It is clear that messaging by NICU care providers impacts on the mothers' decisions to initiate lactation. However, researchers have theorised that mothers revert back to their original prenatal intention to formula feed their infants when faced with the challenges of maintaining an adequate HM volume for weeks at a time, while observing their infant thrive on donor HM or formula [163], [230], [231]. Further research is needed to develop and test strategies that extend early messaging to include self-efficacy and longer-term health outcomes of HM provision for NICU infants and their mothers. An additional priority is the design of breast pumps that optimise efficiency (e.g., the total number of minutes per day spent pumping) in breast pump-dependent mothers without compromising the pump's effectiveness, comfort, and convenience.

16.3.3 Summary – Prioritising Initiation and Maintenance of Established Lactation

Breast pump-dependent mothers with NICU infants face numerous barriers to the initiation and maintenance of established lactation that are not experienced by mothers with healthy infants. Such barriers require management by specialists in NICU lactation care. Of particular concern is the early post-birth period, which includes the initiation and coming to volume phases of lactation, when mothers frequently receive inappropriate advice and equipment that compromises long-term HM production. Significant evidence exists to mitigate many of these problems but is not routinely implemented due to resource and ideological concerns. The maintenance of established lactation through to NICU discharge is a research priority, as is the design of more efficient hospital-grade electric breasts so that pumping is not so arduous for mothers of NICU infants who are breast pump-dependent for long periods.

16.4 Managing Human Milk Feeding in the NICU

Several studies provide evidence about best practices for collecting, storing, handling, and feeding HM in the NICU setting [19], [27], [169], [170], [232], [233]. However, the majority of these findings have not been integrated into comprehensive HM feeding programmes specific to NICU infants. This slow translation from research to practice has been influenced by a lack of scientific knowledge about HM by NICU care providers and institutional investment in products to support best HM feeding practices. This section reviews evidence and strategies for managing the variability in pumped HM, and principles for the safe handling of HM in the NICU setting.

16.4.1 Variability in Pumped HM in the NICU

The marked within and between-mother variability in the composition of pumped HM for NICU feedings has been studied extensively [18], [234]–[238], and a recent review paper has detailed clinical techniques to identify and manage this variability [19]. Three primary causes of clinically significant variability in the composition of pumped HM in the NICU are stage of lactation, degree of breast fullness immediately before HM removal, and the completeness of breast emptying during pumping [19]. A basic understanding of these principles can help resolve most growth and feed tolerance problems related to HM feedings in the NICU.

Stage of lactation

Major within-mother HM compositional changes occur between lactation stages [19]. Colostrum, secreted prior to the closure of paracellular pathways in the mammary epithelium, is almost exclusively high molecular weight developmental and protective proteins. It includes a myriad of growth factors, immunoglobulins, cytokines, lactoferrin, lysozyme, anti-inflammatory agents, and anti-infective components (e.g., live cells, probiotic HM-borne bacteria, and oligosaccharides) [84], [97], [99], [105], [107], [144], [239], [240]. As such, colostrum is more like amniotic fluid than mature HM [83], [239], [241]. In contrast to mature HM, colostrum contains only traces of casein and lactose, and a relatively high sodium concentration [239]. A study of HM transcriptome showed that immune proteins are upregulated during colostrum and transitional HM secretion, whereas nutritive proteins are upregulated later in lactation [148]. As the tight junctions in the mammary epithelium close, coinciding with the onset of lactogenesis II (secretory activation), HM composition changes dramatically, with higher lactose and lower sodium concentrations [239]. Total HM protein remains elevated in all mothers during the first month of lactation, but especially in those with premature infants, primarily due to concentrated developmental and protective proteins [88], [91]–[93], [97], [142].

Colostrum is extremely important for NICU infants who have immature or compromised gastrointestinal tract development, are immunosuppressed, and/or are at risk of NEC [18], [19], [47]. The many growth factors in colostrum work synergistically to stimulate rapid growth and differentiation of the intestinal epithelial border, catalyse the closure of tight junctions in the gut, and may selectively effect the growth of other body organs [72]–[75], [91], [92], [242]–[246]. Secretory IgA, lactoferrin, and other bioactive components provide barrier protection and down regulate inflammation and oxidative stress responses [87], [119], [242], [244]–[246]. Specific colostral cytokines appear and disappear in a temporal manner, suggesting that the order of colostrum feeding is of physiologic significance for the infant [18], [247]. Thus, priority should be given to collecting, labelling, and storing colostrum so that it can be fed in the order that it is pumped by NICU mothers (procedures are detailed elsewhere) [18], [19], [27].

Several non-randomised and one randomised study have demonstrated the safety, feasibility, and preliminary efficacy of colostrum administered via the oropharyngeal route [42], [248]–[250]. Colostrum should be given first as a feed, with increases in feed volume per NICU protocol. Colostrum should not be fortified using bovine products due to their effect on bioavailability of the protective components in HM [47]. Of particular concern is lactoferrin, a potent anti-infective and anti-inflammatory cytokine that is most highly concentrated in preterm colostrum and transitional HM, and that is inhibited in the presence of exogenous iron supplementation [88], [244], [251]–[255]. HM fortification, while standard of care for most VLBW infants, should be delayed for as long as feasible during feeding with colostrum to enable maximum growth, colonisation, and protection to the fragile premature infant intestinal tract [19].

Breast fullness immediately before HM removal

Healthy term infants who breastfeed exclusively demonstrate remarkable variability in the total daily amount of HM consumed, daily breastfeeding frequency, and amount of HM consumed from each of the two breasts (including over and underproductive breasts) [256]–[258]. Whereas this variability is normal, it can be problematic in the NICU where infants are typically fluid-restricted, have high caloric needs, and are prone to immaturity-related feed intolerance [19]. A principle factor driving the total caloric content in pumped HM is the degree of maternal breast fullness immediately before HM removal [256]. Basically, when a mother pumps a very full breast, a larger volume of HM is removed but it contains less lipid and fewer calories, and has a relatively greater proportion of calories to lactose, compared to a less full breast [19], [256]. Unlike the mother with a healthy infant who breastfeeds according to infant demand, the NICU mother schedules pumping sessions around her other daily activities. Long stretches between pumping to enable sleep or return to employment outside the home can result in pumped HM that is of high volume, low calorie, and has low-lipid and relatively high lactose concentrations [19].

In the term infant, the HM removed after a long inter-pumping interval is balanced by higher lipid HM over the course of the day when the breast is not filled to capacity [256]–[258]. However, for the NICU infant, a single pumping of low-calorie, low-lipid, high-lactose HM from a full breast may provide sufficient volume for several sequential feedings over the course of a day [19]. The clinical consequence of this common NICU scenario is slow weight gain and occasional symptoms of feed intolerance, which often lead to formula supplementation or use of more highly concentrated exogenous HM supplements [19]. This problem is easily preventable or correctable with appropriate parent education, HM diaries, and creamatocrit measures [19], [27], [236], [237].

Completeness of breast emptying during pumping

The lipid and calorie contents of HM increase dramatically over the course of feeding or pumping; with low-lipid HM flowing early in the pumping (fore-milk) and high-lipid HM flowing near the end of pumping (hind-milk) [19], [236], [237], [259]. However, the pattern of lipid release into HM is not strictly divided into two phases but is a continuum of increasing lipid content during HM removal [259]. Breast pump-dependent mothers can visualise HM flow from the breast, with the rate of flow decreasing over the course of HM removal (as lipid content increases) [19]. Mothers tend to stop pumping before removing high-lipid HM because they observe that the HM flow rate is slower than it was after initial milk ejection. Key to avoiding this scenario is to instruct mothers to pump until they no longer see HM droplets for 1–2 consecutive minutes; a standardised pumping time (e.g., 10–15 minutes) does not reflect research about individual mothers' HM flow rates and lipid release. In another scenario, a mother whose HM volume per pumping exceeds the receptacle into which she is pumping may store the pumped HM in serial receptacles as pumping progresses. This results in individual receptacles containing HM with markedly different lipid and calorie contents. Unfortunately, in the NICU, all receptacles of HM are typically fed to infants as if equivalent. Additionally, clinical case studies indicate that infant growth and feed tolerance may be affected by variable lipid and calorie contents of pumped HM following incomplete breast emptying [19].

16.4.2 Safe Handling of Human Milk in the NICU

Few NICU infants are able to consume exclusive HM feedings at the breast, so HM must be collected, stored, and fed via gavage infusion until the infant is able to breastfeed effectively and efficiently. Each of these handling processes compromises the nutritional and bioactive components in HM, and introduces the potential for microbial and environmental contamination [260]. Thus, the overarching priority for HM feeding in the NICU is to implement best practices that optimise preservation and delivery of nutritional and bioactive components in HM, while minimising the risk of contamination [19]. This section reviews the evidence for fresh versus frozen or pasteurised HM feedings, guidelines for care of breast pump and HM storage supplies, and best practices for HM administration via gavage infusion.

Fresh versus frozen HM

The nutritional and bioactive components in HM are optimally preserved, and microbial contaminants are minimised when freshly pumped HM (i.e., never refrigerated or frozen) is fed in the NICU [19], [47]. Freshly pumped HM is exceptionally robust with regard to bioactivity of live cells that phagocytise bacteria in the HM, and can easily be kept at room temperature for up to 4 hours post expression [261]. Most HM components are preserved with refrigeration (4 °C), and unfortified HM can be refrigerated for at least 96 hours post collection without significant changes in composition or microbial growth [262]. Whereas many bioactive components in HM are partially preserved with freezing (–20 °C), live cells (including stem cells, and macrophages that phagocytise potential pathogens) are completely destroyed [261]. Freezing also disrupts the structure of the HM lipid globule membrane, making thorough mixing of thawed HM more difficult [262]. Furthermore, freezing HM does not inactivate the HM lipases, so free fatty acid concentrations are frequently higher and pH may be lower in frozen-then-thawed HM than in fresh HM [259], [264]. Once frozen, HM must be thawed and warmed prior to feeding. Studies have addressed the potential for bacterial growth in previously-colonised HM during these processes, especially when water rather than dry heat is used for warming [264]–[266]. While eradicating most bacteria and viruses, pasteurisation of HM also destroys or markedly reduces the concentration and/or bioactivity of multiple clinically significant HM components including the HM microflora; it should therefore not be used routinely for own mother's HM in the NICU [23], [135], [267]–

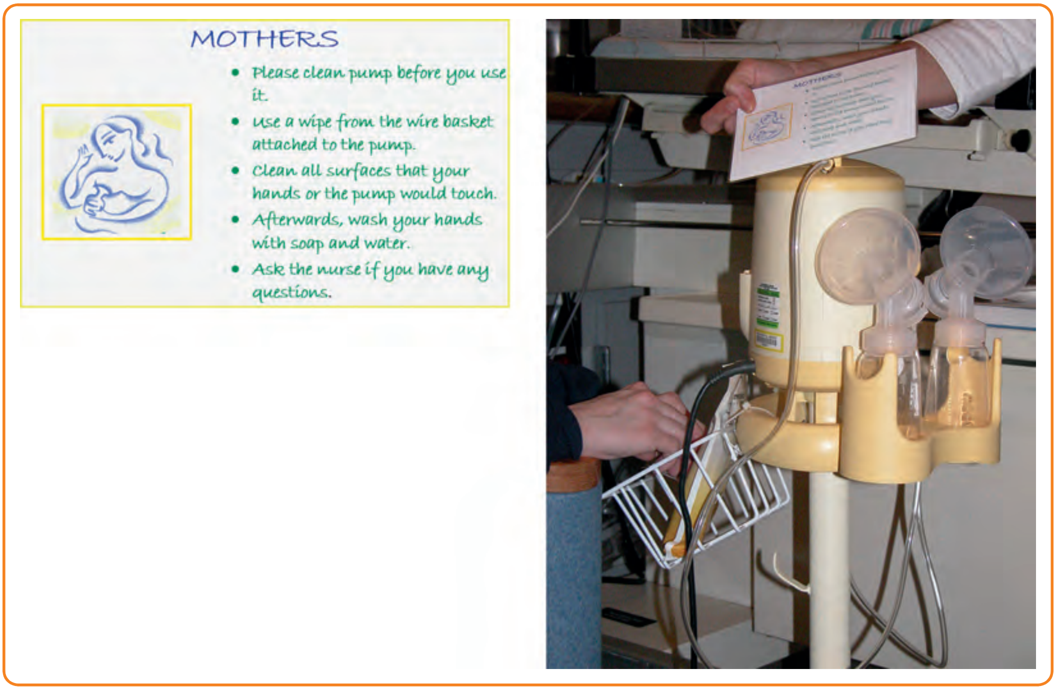
[269]. Thus, several lines of evidence support the prioritisation of feeding fresh, unfrozen HM in the NICU, with frozen (then thawed and warmed) HM as a second-best practice [18], [19], [47], [270].

Storage of HM

In the NICU setting, all refrigerated and frozen HM should be stored in industrial-quality refrigerators and freezers that are continuously monitored, temperature controlled, and connected to a central monitor that alarms when HM safety is compromised. However, it is not uncommon for families of NICU infants to be told to keep HM at home due to lack of appropriate storage facilities (as a consequence of lack of NICU investment). This practice places both infant and institution at risk because there is no quality control of in-home storage conditions. Families have been known to store pumped HM in the trunk of the family car during winter months, and at family or friends after journeying on public transport for several hours in summer months. The basic safety issue of uncontrolled HM storage conditions is easily preventable by avoidance of HM storage at home.

Care of breast pump supplies and HM storage containers

Nearly all NICU mothers use a breast pump to remove HM; these pumps and their accompanying collection kits must be cared for hygienically to reduce the risk of HM-borne bacteria [271]. In contrast to older model electric breast pumps that were sources of NICU infection outbreaks [272], [273], all newer hospital-grade electric breasts are designed for multiple users and have internal safeguards that prevent bacterial transfer between mothers. However, when shared among NICU mothers, the exterior pump surface and other areas that come in direct contact with the pump kit should be thoroughly disinfected between users. NICU mothers can disinfect the breast pump just before use provided they are properly educated in this practice and have a visual reminder attached to the breast pump (▶ **Fig. 16.1**). Non-hospital-grade pumps for personal use should not



▶ **Fig. 16.1** (a) Sample laminated instruction card for mothers to use in the NICU (neonatal intensive care unit) to disinfect the exterior of the breast pump prior to use. (b) The nurse shows the card, attached to the breast pump, to the mother as she demonstrates the disinfection procedure. (® Rush Mothers' Milk Club, 2016. All rights reserved)

Rush Mothers' Milk Club

Caring for Your Breast Pump Equipment

Most mothers who provide milk for their Neonatal Intensive Care Nursery (NICU) babies need to use a breast pump. Germs that are all around us — at home and in the NICU — can grow in breast pump equipment, and must be removed with careful clean-ing. **So, it is very important that all of the pump pieces that touch your milk are cleaned com-pletely after each breast pump use so that germs don't get into your baby's milk.** Follow these steps each time you clean your breast pump equipment. You should also sterilize your breast pump equipment once each day to remove germs that may escape hand-cleaning. **Always wash your hands carefully with warm water and soap before touch-ing your clean equipment, and take care not to cough or sneeze on it once it is cleaned.**

What cleaning supplies do I need to wash my breast pump equipment?

You will need a dishwashing (not dishwasher) detergent, hot water, and a baby bottle brush (figure 1). You also need a tiny brush that will reach into the narrow openings of the breast shield section of the pump. Most bottle brushes have a smaller brush built into the brush handle (figure 2).


Figure 1


Figure 2

Which parts of the breast pump equipment should I clean?

You should clean everything that touches the milk. These pieces are shown in figure 3. You do not need to clean the tubing pieces or the part that attaches the tubings to the breast pump.


Figure 3

What steps should I use to clean my breast pump equipment?

Always wash your breast pump equipment separately from the family dishes and food preparation items. Use hot, soapy water that has not been used to wash other dishes. Follow these steps each time you clean your equipment:

- Rinse your equipment in cold water to remove the milk residue.
- Using hot water and detergent, scrub the equipment with the large and small bottle brushes.
- Take extra care to clean the hard-to-reach areas, including:
  1. the main collecting jar where the sides meet the bottom (figure 4).
  2. the tunnel part of the breast shield (scrub inside with the bottle brush) (figure 5).


Figure 4


Figure 5

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Neonatal Intensive Care Unit, Rush University Medical Center

▶ **Fig. 16.2** Sample parent education sheet that reinforces staff teaching about proper care of breast pump collection equipment. (® Rush Mothers' Milk Club, 2016. All rights reserved)

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3. the little grooves in the part that holds the breast shield (figure 6).
4. the part of the breastshield attachment that holds the tiny white plastic diaphragm (figure 7).

- Rinse all of the parts with warm water, making sure that you remove all of the soap.
- Place the parts on a clean paper towel, and cover them with another paper towel. Let them dry in the air.

Figure 6

Figure 7

How do I sterilize my breast pump equipment once a day?

Your breast pump equipment can be sterilized by putting it into a dishwasher that has a special hot-water sanitizing cycle, or by boiling the pieces in a large pot for about 15 minutes. If you have a microwave at home, you can use the special sanitizing bags by Medela, Inc, shown below. Each bag can be used for 20 separate microwavings. Just ask your baby's nurse to provide you with a bag for your at-home use. You can also use the bags in the NICU microwave. Follow these steps when using the sanitizing bags.

- Wash your equipment, as described above.
- Then, place all of the pump parts that you have washed into the bag (figure 8).
- Add 4 ounces of water to the bag and close it securely.
- Place it into the microwave and set the timer according to the instructions on the bag (timing varies with type of microwave) (figure 9).
- **When the microwave finishes, remove the bag using insulated mitts or potholders, because the contents in the bag are hot. Be careful not to spill the hot water on your skin.**
- Remove the pump parts and place them between two paper towels to air-dry. **Use tongs and potholders to handle the bag and pump parts, as shown below** (figure 10).

Figure 8

Figure 9

Figure 10

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Neonatal Intensive Care Unit, Rush University Medical Center

This parent information sheet was funded by a grant from the Illinois Children's Healthcare Foundation, Hinsdale, IL.

Fig. 16.2 continued

be shared among mothers; this is especially important when pumping HM for immunocompromised NICU infants [271].

HM collection containers and tubes (e.g., the pumping kit) should not be shared among mothers unless thoroughly sterilised between users in a designated hospital area. In most of today's NICUs, mothers receive and are expected to care hygienically for a single-user breast pump kit. To ensure quality cleansing, the NICU should provide the mother with necessary equipment (e.g., standardised dishwashing detergent), a demonstration of kit-cleaning procedures, and a back-up visual guide such as an education sheet (▶ **Fig. 16.2**). To reduce the risk of contamination, pumping HM into a combination collection kit storage container is an excellent alternative to the transfer of HM from one container to another. However, care must be taken if the mother's HM yield from an individual breast exceeds the capacity of the storage container. If not instructed otherwise, the mother would pump sequential containers of HM, each with a successively higher lipid and calorie content [19]. A recent paper reports evidence-based guidelines for decontamination of breast pump collection kits in the hospital and home, and is an excellent resource for NICU policies and procedures [271].

The NICU should provide mothers with an adequate quantity of sterile, food-grade containers for HM storage. These containers should be easy to use by NICU staff, particularly if HM feedings are prepared at the bedside by NICU nurses. Specifically, the containers should have a lid that is easily removed and replaced without contaminating either lid or HM, be durable to prevent puncture or damage during storage, and have an external surface that allows firm adhesion of identification labels during handling. Furthermore, the nurse should be able to mix the HM thoroughly and to withdraw the prescribed feed volume with a sterile syringe. In the Rush Mothers' Milk Club programme [19], four separate sizes of containers (11 mL for colostrum, 60 mL, 120 mL, and 240 mL) are used to minimise storage space and to accommodate different volumes of pumped HM. Larger storage containers are available to pool pumped HM over the course of a 24-hour period, and the safety of this practice has been demonstrated [238]. HM for NICU infants should never be collected or stored in commercially-purchased plastic bags that are unsterile and/or non-food grade [274]. Even food-grade HM storage bags present limitations in the NICU because of the difficulty in mixing HM lipids (that adhere to bag crevices) in and maintaining sterility during HM removal [274].

Routine culturing of HM samples

In the 1970s and 1980s, several original research reports documented the potential for HM as a source of bacterial contamination and/or bacterial growth in the NICU [272], [273], [275]–[279]. Bacteria potentially spread via mothers' hands, contaminated breast pumps, kits and storage containers, nurses' technique during feed preparation, and water-bath warming. Continuous gavage infusion, during which the already colonised HM was warmed and maintained at room and/or isolette temperatures for several hours, was found to be a particular risk [280]. While widely known that healthy term infants ingested an array of bacteria during breastfeeding [281], concern for immunocompromised NICU infants led to routine microbiologic surveillance of pumped HM in many NICUs [275], [276], [282]–[284]. However, this practice is not as effective in preventing HM contamination as is parent and nurse education about hygienic practices of caring for HM that is collected, stored, and fed artificially [284], [285].

Schanler, et al. [285] found that exposure to bacteria cultured from mothers' pumped HM did not increase the infection risk in extremely premature recipients, leading to the conclusion that there is no clinical utility in routine microbiologic surveillance. These data are consistent with previous reports demonstrating that mother and infant can be exposed to a common microbe simultaneously. Thus, isolates in HM and infants do not guarantee that the mother was the source of the organism. Consequently, there is no scientific rationale for routine HM cultures in the NICU. Instead, data indicate that NICU resources should be invested in HM equipment such as waterless HM warmers and commercial freezers, and maternal education about hygienic practices for the care of pumped HM should be prioritised.

Options for handling and feeding pumped HM

Although maternal techniques for pumping and transporting HM are frequently assumed to be the primary source of HM contamination, multiple sources and handling procedures within the NICU introduce new contaminants or facilitate growth of existing ones. For example, once HM is received in the NICU, it is stored, thawed (if frozen), warmed, fortified with an exogenous commercial product, and administered artificially by intermittent gavage, continuous gavage, or bottle until the infant can consume feedings directly from the breast. Although substantial evidence exists for optimal procedures for each of these steps, they are more often informed by cost and tradition, and vary widely among individual NICUs [19], [286].

Currently, there are two overall approaches to HM handling in the NICU: Feedings are prepared (including fortification) either offsite by HM technicians and delivered to bedside nurses every 24 hours [170], [287], or at the bedside by the NICU nurse [18], [19]. Advantages of the former include: fewer health care providers handling HM and thus less variation in standardised practices; purported less misadministration errors (e.g., infant receiving HM from the wrong mother); and resource consolidation for cost-effectiveness. In contrast, the nurse's mixing of HM at the bedside enables: customisation of specific HM collections to feed (e.g., colostrum, high-calorie hind-milk, and fresh versus frozen HM), which may benefit the individual infant; less inadvertent HM wastage; and the ability to add exogenous fortifiers to warmed HM immediately before feeding instead of up to 24 hours in advance of feeding. There are no data to indicate which method is superior; this can easily vary with the NICU size, bedside nurses' education, and the basic NICU approach of standardisation versus individualisation of feedings.

Warming and thawing stored HM

Stored HM must be thawed and/or warmed before administration, and several studies indicate that use of a water bath presents an additional infection risk to HM handling in the NICU [265], [266]. Studies suggest that water bath heating of HM also results in variation of administration temperatures, some of which may be considerably below or above infant body temperature [264], [288], [289]. From a safety perspective, HM should therefore be heated without water and the administration temperature should be around body temperature for extremely premature infants (note that in such infants unwarmed oxygen and blood are considered inappropriate). For the smallest infants, HM feeds can be prepared an hour in advance and placed in the infant's incubator (▶ **Fig. 16.3**). This technique ensures waterless warming to a physiologic temperature. A randomised clinical trial of HM heating by a commercial waterless HM warmer versus the makeshift water bath demonstrated that the waterless warmer is safe and effective for warming and thawing HM in the NICU [264]. To reduce the impact on HM bioactive components and prevent marked increases in HM osmolality, exogenous bovine fortifiers should be added after HM warming and just before administration.

▶ **Fig. 16.3** The nurse has prepared the infant's 2-hourly bolus feeding and is placing it in the incubator approximately 1 hour prior to feeding so that it can warm (without water) to approximately body temperature. (® Rush Mothers' Milk Club, 2016. All rights reserved)

Fortification of pumped human milk

Most HM feedings for extremely premature infants will be fortified with an exogenous product of concentrated macro and micro-nutrients in powder or liquid form, added before feeding [290]. While there are many references to the inadequacies of HM fortification for this infant population

[291], the indication for fortification largely depends on the infant managing to consume only a fraction of the average daily HM volume produced by the mother [19]. The distinction between inadequacy of HM versus limited volume of intake is important for NICU mothers; while encouraged to provide HM, mothers may also be told that their HM is inadequate for their infants. It is almost universally recognised that extremely premature infants need additional protein, calcium, phosphorus, and other nutrients, although there is no agreement as to when to initiate/terminate these supplements [290]. Central to this issue is the fact that commercially available bovine-based fortifiers interfere with the nutritional integrity and bioactivity of HM components [47], [119], [251], [292], [293]–[297], and that many of these HM components provide protection from NEC [19], [47].

From a clinical perspective it would make sense to delay the introduction of bovine-based supplements until full enteral HM feedings are well established, and the baseline lipid concentration is individualised to 55–60% of total calories [19]. An alternative perspective is based on the fact that extremely premature infants experience a period of marked nutrient deficiency immediately post birth (especially protein), and that protein deficiency may be linked to long-term neurodevelopmental delay [291], [298]. Although the latter perspective arises from observational studies [298] with one randomised trial reporting no beneficial effect of high-protein supplements during NICU hospitalisation [140], early and longer duration of fortification, especially with bovine protein, has become a widely accepted practice worldwide [127], [291], [299], [300].

One promising approach in this area is the use of supplements derived by concentrating HM protein and other components into a true HM-based fortifier. HM-based fortifier has demonstrated the potential to preserve HM components and bioactivity while providing additional macro- and micro-nutrients required by extremely preterm infants [129], [297]. The primary disadvantage to HM-based fortifiers is that they displace the mother's own HM, which may be > 50% of the feed volume during early enteral feeds in extremely premature infants. From a pragmatic viewpoint, the HM-based fortifier displaces mother's own HM with a pasteurised donor HM product. This product does not negatively affect the infant but reduces the early dose of mother's own HM, which is linked with protection from NEC [1], [2], [8]. Randomised clinical studies that measure short- and long-term outcomes of the various feeding approaches are needed to clarify the best way to fortify early HM feedings for extremely premature infants [290].

Gavage Infusion rate of pumped HM

Considerable data indicate that HM feedings should be administered by intermittent rather than continuous gavage infusion. However, these data are frequently disregarded by clinicians who purport that continuous feedings are associated with fewer episodes of apnoea and bradycardia than intermittent feedings. Slow infusion and/or continuous gavage feedings trap HM lipids in the syringe and administration tubes, potentially resulting in the delivery of HM containing significantly fewer calories and lipids compared with baseline [155], [301], [304]. This may be even more pronounced when thawed frozen HM versus fresh HM is administered [303]. Over 24 hours, lipid losses can be sizeable and affect infant feed tolerance and weight gain. Every attempt should be made to shorten the duration of gavage HM infusion to the maximum safety point, particularly in extremely premature infants whose growth and feed tolerance are especially susceptible to this deficiency. This practice is in direct contrast to the non-evidence-based opinion of it being safer to administer feeding slowly. Feeding smaller volumes of HM every 2 hours via intermittent gavage for the smallest premature infants (e.g., < 1,250 g) may have physiologic benefits, and would solve the problem of lipid loss in slow infusion continuous HM feedings [305]. However, the main reason cited for not feeding frequent small volumes is nursing efficiency, e.g., the cost savings associated with less frequent gavage feedings may outweigh the benefits of physiologic stability and feed tolerance in extremely preterm infants [305].

An additional concern about feeding very slow-flow continuous gavage HM infusion is that bacteria in already-colonised HM continue to increase over the course of infusion [280]. Depending upon the duration of continuous gavage feeding, bacterial load can be of concern, especially if the HM has been previously frozen thereby diminishing HM phagocytic properties [19]. If very slow gavage HM infusions are absolutely necessary, it is important to prioritise the feeding of fresh (never frozen) HM to optimise its bacteriostatic and bactericidal functions in already colonised HM.

16.4.3 Summary – Managing Human Milk Feeding

Best practices for the management of HM feedings in the NICU have been delineated in multiple research studies as well as summarised in state-of-the-science reviews. These practices include the understanding and managing the variability in pumped HM that is fed in the NICU. HM should be fed to infants fresh, never frozen or pasteurised, as much as possible. Specifically, HM from the infant's own mother should not be routinely pasteurised. All pumped HM should be stored in the NICU in commercial refrigerators and freezers that are temperature controlled and tamper proof, and practices that ensure breast pumps, collection containers, and storage containers meet hygiene standards must be implemented. HM should not be warmed in a water-bath prior to NICU feedings, and any fortification should be added immediately prior to feedings. Furthermore, feeding HM by intermittent rather than continuous gavage, as much as possible, especially in extremely preterm infants is advised.

16.5 Feeding at Breast in the NICU

Approaches to feeding at breast in the NICU vary widely and often reflect tradition, ideology, and feasibility more than evidence-based practices [27]. For example, some NICU clinicians still assert that breastfeeding is tiring for a small premature infant, or that it is impossible to accurately measure HM intake during breastfeeding, despite evidence to the contrary [306]–[310]. Other NICUs have focused on the ideology of banning bottles and using alternative feedings only, despite a lack of evidence that this approach facilitates at-breast feeding, infant feeding development, and/or parent satisfaction with the overall feeding experience [178]. From a feasibility perspective, mothers must be physically present in the NICU to feed at breast, which complicates exclusive breastfeeding particularly in countries without paid maternity leave and similar social support. Helping a mother feed a NICU infant at breast requires dedicated time and a specific skill set on the part of the nurse or lactation specialist; this assistance is usually among the first to be discontinued with NICU budget cuts. Mothers may hear that bottle feedings will hasten infant discharge, and so be reluctant to feed at breast in the NICU. This may especially be the case if they receive conflicting information about infant readiness, breastfeeding techniques, and use of lactation aids, which are often required for NICU infants due to prematurity or medical/surgical conditions [27], [169].

16.5.1 Maternal Goals and Expectations

Although generally assumed, it is not necessarily the case that a NICU mother who pumps HM wants to feed at breast. A National Institute of Health-funded prospective cohort study of 352 VLBW infants showed that during early NICU hospitalisation (first 14 days post birth) the majority of mothers stated that their goal for HM feedings at discharge was either exclusive (62.9%) or partial (33.9%) HM, with only 3.2% electing to use exclusive formula [163]. However, of those mothers who wanted their infants to receive HM, only 10.6% wanted to feed exclusively at the breast and 8.3% wanted to feed exclusively pumped HM (e.g., no feeding at breast). The remaining mothers (81.2%) indicated that they wanted to feed HM through a combination of breast and bottle during the NICU hospitalisation and post-discharge period [163]. These data underscore the importance of tailoring protocols and messages to individual mothers' goals for feeding at the breast rather than implementing a general approach. Similarly, some NICU infants are unable to consume oral feedings safely due to congenital anomalies, surgical conditions, and/or chronic sequelae of prematurity [169], [311], [312]. Every attempt should be made for HM feedings away from the breast to be as special as feedings at breast for NICU families. Previous studies have shown that NICU mothers derive great pleasure seeing their infants enjoy, thrive, and gain weight on their HM, regardless of how it is fed [162], [171], [200], [201], [311]–[314].

16.5.2 Developmentally-Based Breastfeeding Processes

Developmentally-based approaches to feeding premature infants at the breast in the NICU have been previously reviewed [27], [200], [315]–[319]; their major principles are summarised below. Nearly all experts propose a pathway that starts with skin-to-skin care for the smallest, sickest infants [27], [172], [320]–[322]. Multiple studies have demonstrated that the first developmental stage – skin-to-skin care – has many physiologic advantages for premature infants and their mothers and should be standard of care in NICUs worldwide [323]. There is evidence to suggest that during skin-to-skin care the infant transfers NICU microbes to the mother's skin and respiratory surfaces, after which antibodies to these organisms are produced by the mother via the entero-mammary pathway [18], [324]. During this developmental stage, mothers should be encouraged to hold and/or touch infants while using the breast pump. Similarly, mothers should introduce oropharyngeal care with colostrum as soon as drops are available [27], [42], [248], [249].

Tasting HM at the breast

As soon as premature infants are extubated, non-nutritive feeds at the breast (referred to as tasting rather than drinking HM) can be initiated. Studies have demonstrated that non-nutritive sucking and/or low milk flow rates do not interrupt the swallow-breath process because ingested volumes are miniscule [325]–[329]. This key principle can be effected by the mother emptying her breast by pumping and then placing the small infant (including those with continuous positive airway pressure or high-flow oxygen) to the breast to taste HM (▶ **Fig. 16.4**). A drop of HM can be expressed onto the nipple, allowing the infant to taste the HM and suckle non-nutritively. Ideally,

▶ **Fig. 16.4** The mother has used a breast pump to remove most of her human milk (HM) and then the infant is placed at breast to "taste" HM just prior to and during the gavage feeding. (® Rush Mothers' Milk Club, 2016. All rights reserved)

these early breastfeedings coincide with the infant's intermittent gavage feeding so that tasting and suckling occur while feedings are being received [318]. While there is no evidence that infants learn to breastfeed with these early feedings, mothers learn to position and provide head and neck support for the infant, as well as techniques for expressing HM drops onto the breast [27], [318], [319].

Transition to nutritive feeds at the breast

Nutritive feeding progresses with the mother gradually pumping less HM before infant feeding, enabling the infant to master coordination of swallowing and breathing [27], [318], [319]. Several studies demonstrated greater physiologic stability during breastfeeding than during bottle feeding for premature infants who served as their own controls for the two feeding methods [306]–[308], [330]. There is neither evidence to support policies that require infants to effectively bottle feed before introducing breastfeeding, nor that gestational age alone predicts ability to feed at breast safely [27], [318], [319]. Once initiated, NICU care providers often limit the frequency/duration of individual breastfeeds due to concerns regarding fatigue and the negative impact on growth. There is no supportive evidence for this concern, particularly since infants' physiologic stability is continuously monitored in NICUs. Of importance is the implementation of a modified cue-based feeding schedule as premature infants transition from gavage to breast, with bottle feedings introduced after the establishment of at-breast feedings [27], [172], [316], [331]–[333].

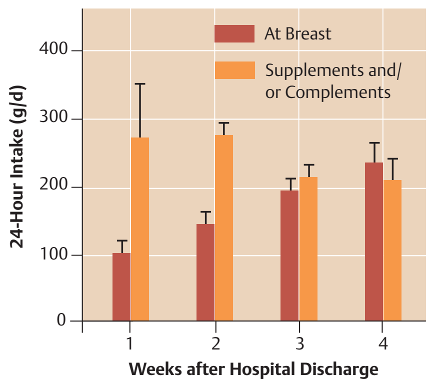
Measurement of HM intake during breastfeeding

As infants make the transition to cue-based breastfeedings, it is often important to know the volume of HM ingested during breastfeeding so that infant fluid balance and growth is maintained. Measurement of HM intake during breastfeeding can be made by test-weighing, whereby the clothed infant is weighed on a reliable electronic scale before and after the breastfeeding in exactly the same clothing and conditions [309], [310], [334]–[336]. The test-weighing procedure is extremely accurate when correctly performed by either NICU nurses or mothers [309], [310], [334], [335]. Although it is often assumed that clinical indices and assessment tools can replace test weighing, these other instruments are not accurate indicators of HM intake [309], [334], [337]. This means that while mothers and lactation experts may observe a breastfeed and score it the same way using an assessment tool, the score has no relationship to actual HM intake [309], [334], [337]. A simple clinical rule to follow is: if the volume of HM intake is not important to infant management at that time, do not test weigh; if it is important, perform test weights and do not rely on inaccurate scoring methods that are not evidence based.

16.5.3 Physiologic Immaturity

Premature infants remain physiologically stable during feedings at the breast but may consume an inadequate quantity of HM when breastfeeding exclusively, even when the mother can remove sufficient HM with a breast pump [180], [223], [224], [309], [314], [334], [338]. In a randomised clinical trial, mothers performed in-home measurement of HM intake for the first month post-NICU discharge using accurate test-weighing techniques [180]. All mothers had an adequate daily HM volume for their infants at the time of NICU discharge and intended to breastfeed exclusively, but infants could not consume all of the HM available to them (▸ Fig. 16.5). Instead, the mothers needed to pump the extra HM each day and feed it by bottle to the infants. Each subsequent week at home post-NICU discharge, infants consumed increasingly larger volumes of HM from the breast, gradually breastfeeding exclusively at an average of 42 weeks PMA. This observation suggests that infant maturation rather than lack of practice and learning to feed at breast is the most likely reason for the infant's inability to remove available HM effectively and efficiently during round-the-clock exclusive breastfeeds [27], [180].

Under consumption of HM feedings at the breast until 40–44 weeks PMA is primarily due to the fact that mature suction pressures (essential to creating and sustaining the nipple shape and to transferring HM) develop more slowly than expression pressures [27], [179]. Immature suction pressures manifest in infants' slipping off the breast and requiring repositioning repeatedly during a feeding. Neurobehavioural immaturity exacerbates the



▸ **Fig. 16.5** Mean daily intake of HM (human milk) by breast and bottle for 24 premature infants discharged from the NICU (neonatal intensive care unit) at a mean of 36±2 weeks PMA (postmenstrual age). This graphic illustrates that while infants have access to an adequate volume of HM each day, they are not able to remove it from the breast effectively until achieving approximately 40–44 weeks PMA. (® Rush Mothers' Milk Club, 2016. All rights reserved) weak suction because those infants who are still preterm on NICU discharge fall asleep early in the feeding after consuming minimal and insufficient amounts of HM [319]. In contrast, entire bottle feedings using standard commercial nipple units can be consumed by expression alone; thus, many premature infants consume more milk when bottle fed than during breastfeeding [327]. Many premature infants therefore need a bridge between NICU discharge and achieving the physiologic maturity to feed exclusively at the breast. This may be several weeks, especially in countries that prioritise early NICU discharge [27], [180]. Breastfeeding positions that provide support to the infant's head, neck, and torso (▶ **Fig. 16.6**), the use of thin silicone nipple shields (▶ **Fig. 16.7**) and use of test weights are examples of these temporary breastfeeding aids [309], [310], [334], [335], [339], [340].

Ineffective and inefficient HM removal during breastfeeding can also compromise the regulation of lactation. Many mothers will need to continue to breast pump to protect HM volume until their infants are exclusively feeding at breast [179]. For example, the infants in ▶ **Fig. 16.5** were able to progress to consuming an adequate HM volume and eventually breastfeed exclusively because the hospital-grade electric breast pump provided effective and efficient mammary gland stimulation during the weeks when infants were unable to do this independently [27], [180].

The evidence that links physiologic immaturity to effective and efficient HM removal during feedings at the breast conflicts with many of the common practices and interventions for healthy term infants and mothers. An overriding principle of planning post-NICU breastfeeding care (e.g., breastfeeding management at home) with families is to consider the premature NICU infant as not just a small healthy term baby. Families must understand that the inability of the premature infant to extract HM effectively and efficiently is not solved by NICU discharge alone (e.g., lack of physical infant-mother separation). This misunderstanding is most apparent in instructions to feed on demand and everything will be fine. Information in ▶ **Table 16.3** can be used to prepare families for the misleading and potentially unsafe advice they can receive from family, friends, and health care providers that work with healthy breastfeed-

▶ **Fig. 16.6** Use of breastfeeding positions that support the infant's head and neck can help to compensate for weak intraoral suction pressures. (® Rush Mothers' Milk Club, 2016. All rights reserved)

▶ **Fig. 16.7** Use of ultrathin nipple shields can help to compensate for weak intraoral suction pressures, thus facilitating HM intake during breastfeeding in premature infants. (® Rush Mothers' Milk Club, 2016. All rights reserved)

▶ **Tab. 16.3** Common recommendations about post-NICU breastfeeding that are inappropriate and appropriate for premature infants.

Problem	Common Recommendations	Inappropriate because	Correct Recommendation
• Infant falls asleep early in the breastfeeding with little or no effective sucking and/or HM removal	• "The baby is too comfortable" • "Unwrap the baby to help him stay awake" • "Just let him sleep. He will wake up and feed when he is hungry"	• Sleepiness is normal, not abnormal, for a premature infant. Breastfeeding must be adapted to fit the sleepiness • Premature infants are at risk for hypothermia when subjected to cold stress • Decreased adipose stores deplete quickly with increase metabolic rate, and can compromise adequate weight gain	• Start feeding immediately when infant awakens. Do not change diaper or wait for infant to become "more awake" • Reassure parents that this behaviour is normal, and that some bottle supplementation with pumped HM may be necessary temporarily
• Baby slips off the nipple easily and/or frequently, despite achieving an effective initial latch • Feedings are inefficient, taking up to 1 hour with little HM transfer • However, baby feeds from bottle quickly and consumes large volumes	• "The baby is just 'lazy' and has gotten used to a bottle-feeding nipple" • "The baby just does not want to 'work' at breastfeeding" • "Infant does not need as much milk as she consumes from the bottle" • "This is 'nipple confusion' and the infant should receive complementary cup or other alternative feeds of expressed HM"	• This is normal feeding behaviour through 40–44 weeks PMA • Strong infant suction pressure is necessary for breastfeeding, and is maturationally dependent • Bottle feeds do not require mature suction pressures, so babies can drink larger volumes more quickly • This is not "laziness" or "not wanting to work" at breastfeeding	• Use positions that support the infant's head, neck and torso • Consider the use of a nipple shield if positioning alone does not correct the problem of slipping off the nipple • Do not have mothers "triple feed" during this time due to exhaustion. Set aside breastfeeding times and bottle feed/ pumping times to protect HM volume and infant intake
• Not knowing if the infant is consuming an adequate volume of HM during breastfeedings	• "Every mother worries if her baby is drinking enough milk. So, just feed on demand and everything will be OK" • "You are pumping enough milk, so you know your baby is getting enough milk" • "You just got addicted to the numbers in the NICU" • "You can count wet diapers, bowel movements, and note if your breasts feel empty after feeding"	• Premature babies are at risk for not getting enough HM during exclusive breastfeeding, so mothers should not be reassured as if the babies were healthy and full term • Pumping enough HM does not mean that the baby can remove the same amount of HM as the pump • Numbers are important in the NICU and the early post-discharge period because the difference between enough HM and not enough HM is much smaller for a premature baby	• Reassure the family that these are universal concerns when breastfeeding a premature baby after NICU discharge • Implement test-weighing procedures in the NICU to measure HM intake during breastfeeding so mothers acquire beginning ability to match feeding behaviours with infant intake • Continue the use of test-weighing post-NICU discharge if desired by the mother in order to achieve her personal HM feeding goal

Tab. 16.3 continued

Problem	Common Recommendations	Inappropriate because	Correct Recommendation
		• These common indicators (wet diapers and bowel movements) are not sufficiently sensitive to detect adequacy of intake in premature babies	
• Suspecting that the infant consumes small volumes during a breastfeeding	• “Your baby is probably just a ‘snacker’. Lots of babies are like this” • “Just feed more frequently so that your baby gets enough milk over the day” • “Wake your baby every hour or two if necessary to feed her”	• Studies reveal that these mothers are usually right, and babies do consume small amounts per feeding • It is unsafe to wake a premature infant so frequently due to interrupted sleep and resultant fatigue and slow growth • The breastfeeding plan should be adapted to facilitate sleep, not vice versa	• Supplement at-breast feedings with pumped HM to ensure that infant “gets enough” until infants are able to feed at breast effectively and efficiently • Use ▶ **Fig. 16.5** to illustrate this concept for families
• Overwhelming desire to discontinue pumping, nipple shield, test weights, etc., and feed exclusively from the breast	• “You are home with your baby now so you do not need all of that ‘stuff’. Just feed your baby on demand” • “Look at all that milk you get when you pump. You know that’s enough for your baby” • “You want to get your baby off the nipple shield as soon as you can because it will interfere with your milk supply”	• Early discontinuation of lactation aids compromises both infant intake and maternal HM volume until infant feeds effectively and efficiently at breast • Ability to remove HM by the breast pump does not translate into infant’s ability to remove it via breastfeeding • Discontinuation of the nipple shield prior to maturation of suction pressures places the infant at risk for consuming insufficient HM volumes	• Raise this matter with families before NICU discharge so they are prepared for this wrongful advice when they return to the community • Use Figure 5 to demonstrate how continued breast pump use created the HM that the infant would not have been capable of by breastfeeding alone, enabling exclusive breastfeeding later post-NICU discharge • Emphasise that if the infant consumes more HM with than without the nipple shield, it should not be discontinued

HM = human milk, NICU = neonatal intensive care unit, PMA = postmenstrual age. ® Rush Mothers’ Milk Club, 2016 ing infants. ▶ **Fig. 16.5** may help families to comprehend the gradual increase in HM intake with each successive week post-NICU discharge; clinicians should emphasise that each infant is different with some making this transition sooner than others. Plans to supplement feedings at breast with pumped HM in the home until exclusive breastfeeding is achieved have been previously reported [27].

16.5.4 Summary – Feeding at Breast

Developmentally-based at-breast feeding focuses on a trajectory of events that includes skin-to-skin care, pumping HM at the infant's bedside; tasting HM at the breast, and nutritive feeding of HM. Maternal breastfeeding goals are highly individual, and may include exclusive HM feeds at breast, exclusive HM feeds via bottle, or a combination of the two methods. Ascertainment of these goals is a critical component of NICU lactation care. While preterm infants remain physiologically stable during at-breast feeding, they typically consume less HM volume than is required for hydration and growth until approximately 40–44 weeks PMA. During the period between NICU discharge and achievement of full at-breast feedings, lactation aids such as test weighing, nipple shields, at-home pumping, and bottle (or alternative) feedings are frequently necessary so that mothers can achieve their individual HM feeding goals.

16.6 Overall Summary

For the premature infant, HM represents a safe, cost-effective strategy for reducing the risk of many morbidities and their associated costs during and after NICU hospitalisation. This protection is related to HM dose. It is provided by the multiple HM components that function synergistically to selectively grow and protect developing body organs from NICU stressors including inflammation, oxidative stress, and improper/inadequate nutrition. Donor HM does not provide the same protection as HM for reasons that extend beyond pasteurisation. Despite this knowledge, NICU mothers struggle to achieve their personal HM feeding goals and their infants receive a lower lifetime HM dose as a result of inadequate HM volume.

Mothers do not routinely receive state-of-the-art lactation care provided by NICU specialists with expertise in managing breast pump-dependency, coming to volume strategies, HM compositional analyses and modification, test weights, nipple shields, and other lactation aides. Substantial evidence exists to standardise best practices for the care and feeding of HM in the NICU, but individual provider preferences and cost concerns frequently take priority. Specifically, evidence supports the feeding of fresh (e.g., never frozen, never pasteurised) HM, prioritising early feeding of colostrum over mature HM, and storing all pumped HM in commercial refrigerators and freezers in the NICU. HM routine culturing and pasteurisation, and use of water baths to thaw and/or warm HM should be avoided. Developmentally-based approaches to at-breast feeding include skin-to-skin care, pumping at the NICU infant's bedside, tasting HM, and feeding nutritively at the breast. Evidence worldwide suggests that premature infants are vulnerable to consuming inadequate volumes of HM directly from the breast until approximately 40–44 weeks PMA. The overarching priority for optimising HM feeding in the NICU is to implement standardised protocols and best practices that translate the evidence into NICU practice.

Key Points

- Human milk from the infant's own mother should be the feeding method of choice for all infants in the neonatal intensive care unit with the aim to administer fresh mothers own milk and frozen milk as the next best option
- Human Milk from the infant's own mother has been found to reduce the risk and/or severity of multiple serious, potentially handicapping and costly morbidities in premature infants
- Protection by human milk is provided via its many components, which function synergistically to selectively grow and protect developing body organs. This protection has been found to be directly proportional to the quantity of milk received
- Standardised protocols and best practices are required to support mothers of pre-terms infants to achieve their personal human milk feeding goals

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17 A Collective View of Human Milk Banking

João Aprigio Guerra de Almeida, Prof; Ben Hartmann, PhD; Kiersten Israel-Ballard, DrPH; Guido E. Moro, Prof, MD/PhD

Expected Key Learning Outcomes

- Definition of a human milk bank
- The importance of human milk banks
- Important considerations when setting up a milk bank
- Cost implications
- Guidelines and standards to support the set up and running of a milk bank

17.1 Introduction

Human milk banks are becoming more popular as the importance of human milk, especially for vulnerable infants, is increasingly highlighted. However, there is no defined way to set up or run a milk bank, no standard global guidelines, and many cultural and regional elements come into play. This chapter provides opinions from key professionals who are highly respected in the field of milk banking:

- Professor João Aprigio Guerra de Almeida, Fernandes Figueira National Institute for Women Children and Adolescent Health, Brazil
- Dr Ben Hartmann, King Edward Memorial Hospital for Women Neonatology Clinical Care Unit, PREM Milk Bank, Australia
- Dr Kiersten Israel-Ballard, PATH, USA
- Professor Guido Moro, Italian Association of Donated Human Milk Banks (AIBLUD), Italy

Some sections of this chapter provide a collective opinion while most are direct interview responses (interviewer: Janet Prince, Lactation Consultant at the Family Larsson Rosenquist Foundation).

17.2 Interviewer: What is Human Milk Banking?

17.2.1 Defining Human Milk Banking

Kiersten Israel-Ballard: There is no official definition for human milk banking, but, in my view, human milk banking can be defined in a number of ways. The historical definition is that it is a facility only, a room in a hospital where milk is processed and treated. There is a safe system for screening and recruiting donors, for storing, pasteurising, screening, and re-storing the milk, and for facilitating its distribution to the wards.

Human milk banking can also be seen as an opportunity, and not just a processing centre. The physical space for processing provides the opportunity to create a safe place for women to come for support, providing a support centre for mother and child. This is how we see a human milk bank – a place where mothers can go to get help on anything related to breast feeding; support can be accessed whether they want to be a donor or not. Having some kind of link to kangaroo mother care is important. This package is called The Mother-Baby Friendly Initiative plus (MBFI). When we talk about a milk-banking programme, we refer to the MBFI plus programme – the plus being the milk bank. The milk bank is there, but it's part of a much bigger, holistic approach to newborn care.

Guido Moro: Human milk banking is a service with the purpose of selecting, collecting, screening, storing, and distributing donated human milk. It is to be utilised, particularly for premature infants but also for sick infants, when there are specific requests from doctors in the health system.

Ben Hartmann: Human milk banking is difficult to define as practice varies internationally. However, a very simple definition that covers almost every situation is "a service that stores human milk to use when required." This may sound very simplistic, but it also allows us to think about the questions that can be raised by such a definition. Firstly, "What is the definition of an appropriate donor and what duty of care does the milk bank have to their donor?" Secondly, regarding the last part of the sentence, "for use when required", "What is the definition of an appropriate recipient (so for what reason do we provide donor milk) and what is the duty of care the milk bank has to the recipient?". I am not entirely sure that milk banking clearly defines this, but certainly it is something that we need to consider.

João Aprigio: According to the Brazilian Ministry of Health and the Ministries of Health of the 23 countries that make up the Global Network of Human Milk Banks (Angola, Argentina, Bolivia, Belize, Cape Verde, Colombia, Costa Rica, Cuba, Guatemala, Ecuador, El Salvador, Spain, Honduras, Panama, Peru, Mexico, Mozambique, Nicaragua, Paraguay, Portugal, Dominican Republic, Uruguay, and Venezuela), the official definition of Human Milk Banks is: specialised service responsible for actions to promote, protect and support breastfeeding and to carry out activities of collection of the nursing mother's lactic production, its processing, quality control, and distribution.

17.2.2 History and Future

Interviewer: How did milk banks develop?

Kiersten Israel-Ballard: When you understand that wet nurses are described in the Koran, the Bible, and other religious books, you realise that the concept of sharing milk to support infants' needs has been around since the beginning of civilisation. A more formalised approach through human milk banks has been in place for over a 100 years, as a clinical approach for safely providing human milk to infants in need.

Guido Moro: Wet nurses are the first example of human milk banks. When a mother was not able to give her milk to her baby, there were women who were breastfeeding a baby and who had a lot of excess milk. The mother who did not have milk took her baby to this "nurse", and the nurse was able to give milk to her baby and to the other woman's baby. These wet nurses were very well paid in the 17th and 18th century and, at this time, it was the highest paid work for women. They earned a lot of money by giving their milk to other women's babies. However, also in the 18th century, wet nurses became less popular after they began to strike for higher wages; when money became involved, things deteriorated. At the beginning of the 20th century, in Europe, wet nurses were not so popular and were substituted by regular human milk banks. The first milk bank was opened in 1909 in Vienna, the second opened one year later in 1910 in Boston, and from then onwards there was a rapid increase in the number of human milk banks, particularly in Europe. They became less popular with the HIV crisis, but are now starting to increase in popularity all around the world, as people more and more realise how vital human milk is to these vulnerable infants.

Ben Hartmann: As we understand, the very first milk banks were established in Europe. Milk banks arose out of two things coming together, research and clinical experience demonstrated that human milk was essential for hospitalised infants and technology became available to collect, store, and process human milk.

If we look to more contemporary milk banking, and certainly in Australia ten years back when we started a milk bank here in Perth, we were working in a country that hadn't had milk banks for over 25 years. We were therefore in the position of being able to ask ourselves about what sort of service we wanted to deliver, and define a solution to a very specific problem that we intended to address by re-establishing milk banking.

João Aprigio: Human milk banks have been one of the most import strategic elements in public policy favouring breastfeeding in the last two decades in Brazil. Nevertheless, social perceptions and construct concerning human milk banks have witnessed ups and downs in their history. Since the first such service was implemented in Brazil, social actors and groups have ascribed meaning to human milk banks that have characterised them as both support structures for the exceptional situations involved in commercially-induced weaning and units at the service of direct breastfeeding, depending on the specific moment in history.

The first human milk bank in Brazil was founded in October 1943 under what was then the National Institute for Child Care, now the Fernandes Figueira Institute (IFF), belonging to the Oswaldo Cruz Foundation (Fiocruz). Its main objective was to collect and distribute human milk to meet what were considered special cases, like prematurity, nutritional disorders, and allergies to heterologous proteins. Taking this same approach, five more human milk banks had been created in Brazil by the early 1980s. The trend was constant from 1943 to 1979, with an average of one new human milk bank per decade. But over the course of the 80s, particularly beginning in 1985, human milk banks expanded tremendously in Brazil, with 47 new units. An additional 56 human milk banks were opened in the 1990s, giving a total of 104 milk banks in operation in the country according to an estimate presented at the 1st Brazilian Congress of Human Milk Banks, held in the national capital of Brasília in July 1998.

The history of human milk banks in Brazil can be divided into two phases. The first began in 1943, with the creation of the human milk bank at the Fernandes Figueira Institute, and lasted until 1985, when there was a break with the original paradigm and a new model was established, still operating today.

The main prospect for human milk banks is to spawn a new approach to breastfeeding issues. Three levels of investment can be proposed: to build channels to facilitate access by health care professionals to new knowledge on human milk, seeking to interconnect its unique biological properties to the ecological perspective of human development; to define ways to foster the development of scientifically-based expertise, capable of counteracting the scientific vanguard informed by formula milk marketing; and to replace dogmatic and ideological breastfeeding discourse with scientifically-based positions informed by various fields of knowledge.

Training health personnel must be a priority for human milk banks in the new millennium, since they will be the key to consolidating centres of excellence in breastfeeding, focusing not only on service activities but also reflecting the dynamics in the scope of human milk banks that shape breastfeeding as a nature-culture hybrid.

Interviewer: What is the situation today?

Kiersten Israel-Ballard: The current human milk bank system globally is disjointed and inadequate to fully meet the needs of infants around the world. It is shocking that this is an evidence-based approach, a World Health Organization (WHO) recommendation, and that there are entire regions of the world that are without a milk bank. East Africa, and indeed most of Africa, are without a milk bank, India has very few to meet the massive need in that region. These most needy places have no provision for supporting their most vulnerable infants. Brazil has a highly effective, nationalised network for human milk banking, but even under this optimal model there are still infants without access to a human milk bank.

Interviewer: Why are there so few?

Kiersten Israel-Ballard: In the 1980s, HIV was discovered in breast milk and trust in human milk banks was compromised due to fear of transmission. As a result, many human milk bank systems were impacted.

However, fear of HIV transmission is not the only reason for lack of effective scale-up of human milk banks. In the absence of global standards on safety and quality control, developing appropriate guidelines and operating procedures can be challenging. Additionally, alignment of global and regional newborn and nutrition policies is needed to prioritise use of human milk for neonates – through promoting mothers own milk or donor human milk when needed. Also, strengthening of systems is needed to ensure effective integration of human milk banks as a mechanism for protecting, promoting and supporting breastfeeding. And finally, innovation is critically needed to improve the quality and safety of donor human milk processing – novel technology approaches could reduce cost and increase global access.

Guido Moro: Today the number of human milk banks has increased a lot; we almost have more than 500 human milk banks distributed worldwide, but mainly in Europe, USA, and Brazil. Brazil has the most, with more than 200 human milk banks.

Looking at Europe, France has 36 human milk banks and was the first country to develop a law to regulate human milk banks. Italy follows with 33 milk banks, which in 2014 also became regulated by national law. The number of human milk banks is increasing all over Europe, including Russia that opened its first human milk bank in 2015. In the 70s and 80s, there was a large number of milk banks in Russia, but these were closed due to the problem of HIV. After many discussions, the government gave permission to trial a milk bank in a large hospital in Moscow. With such positive results in terms of increasing breastfeeding rates and decreasing cases of necrotising enterocolitis (NEC) and sepsis, I am hopeful that there will be agreement to open more milk banks throughout Russia. Poland and other countries in eastern Europe are also starting to open milk banks, which can only be positive.

Ben Hartmann: I think it is a really interesting time for milk banking. We find ourselves in a time where there is a huge range of activities that operate under the banner of human milk banking. We certainly find in Australia that in general there is some uncertainty of what constitutes a milk bank and what service it provides. We also find that there are many other sorts of activities: human milk sharing, human milk buying, and human milk selling. All these sorts of activities are bundled together under the banner of human milk banking. I think this is creating an identity problem for milk banks that is, at the moment, somewhat unresolved. This, I think, could potentially impact the credibility of the clinical service of human milk banking.

Interviewer: How do you see the future?

Kiersten Israel-Ballard: We see increased focus globally on essential newborn care that goes beyond survival and special attention on thriving. As a result, policies such as the Every Newborn Action Plan includes breastfeeding as an essential intervention for optimizing health of vulnerable neonates. This is an exciting time because human milk banking has an opportunity to leverage this increased momentum on nurturing care for the newborn. It is critical though that human milk banking be implemented as a part of this package for early and essential newborn care, not as a separate intervention only focused on provision of donor human milk. There appears to be an ever-increasing awareness around the importance of donor human milk in general. You hear Ministries of Health wanting to prioritise milk banking in their countries and this was not heard two or three years ago. That's progress. On a country level basis, certainly we see more demand, and that's what is needed – demand for United Nations International Children's Fund (UNICEF), WHO, and the major organisations and funders to build milk banking into their list of priorities.

There also needs to be better communication and links between programmes, especially in this modern world where technology can enable this. We have some conferences, but they are more localised and small. In this field, people don't have the funding to travel to these conferences. One solution would be a global network, where policies, best practice standards, research, case studies, and education can be shared. There are some very useful resources available, but not nearly enough. There is no easy platform and, in today's world of technology and communication, that shouldn't be the case. There should be a global society, a group of passionate people with a common aim to collaborate, provide transparency, and support to each other without feeling threatened.

Guido Moro: I think that the future is very interesting and positive. The number of human milk banks is increasing all over Europe; I refer to Europe because I know the situation there much better than in other countries. The number of milk banks will increase and therefore the number of babies who receive donor human milk will also increase, which can only be good. Two years ago, we did a survey in Italy and were able to establish that with the amount of milk that we are collecting now, we are able to cover the needs of one third of all the very low birth weight (VLBW) infants (birth weight < 1,500 g) born in our country. What we now need to establish is whether we should increase the number of milk banks or increase the volume of work of the existing ones. Sometimes it is better to increase the work load, because opening a new bank is very costly.

Through the Associazione Italiana Banche del Latte Umano Donato (AIBLUD), which was established in 2005, it is becoming possible to provide human milk to infants all over Italy. Of course, the first choice for feeding VLBW infants is human milk from the mother, but if mother's milk is not available or it is not enough, the second option is to have human milk from a bank. So the future in Europe is one where formula or artificial milk are not even considered. The future is to provide only two options – mothers milk or milk from a human milk bank – and this can happen by really looking at the countries' need: new milk banks or increasing workload in existing ones.

Ben Hartmann: There is a great future for human milk banking. I think that there is a need for human milk banks to demonstrate that they are a safe service. I think we have already done this quite well, but also we need to demonstrate that we are also effective, ethical, and sustainable, and that we understand very clearly who requires this service and when. I am not entirely sure that this is clearly defined, but that's certainly something we need to consider. It is also important to acknowledge that each jurisdiction that practices milk banking may have different issues to address and one universal practice of milk banking may not be achievable.

17.3 Why Human Milk Banks?

Interviewer: What is the benefit of having a human milk bank, and how can they save lives, money and improve health outcomes?

Kiersten Israel-Ballard: We know that breastfeeding saves lives and improves general health; anything ranging from allergies to cancer prevention, from obesity to IQ. Making the link between milk banks and that they can benefit those infants who can't access their own mother's milk is important, particularly when these infants are extremely vulnerable, when they are preterm, low birth weight, orphaned or abandoned. Provision of human milk is the optimal first food, it should be viewed as an essential medicine and protected as a basic child right. When mother's own milk is not possible, the WHO clearly recommends donor human milk as superior to infant formula. Ultimately we need to do all we can to help mothers breastfeed. Are there systems in place for supporting mothers when their babies are in the NICU? Too often babies receive formula – or even donor human milk – when they should have received mothers own milk. The proper role of a human milk bank is to provide safe donor human milk; when implemented properly donor human milk should displace formula use, not mothers' own milk.

When human milk banks exist as part of a comprehensive breastfeeding promotion program, then the actual indicator of success is increased breastfeeding rates in the facility and in the community. The overall perception of the value of human milk increases and all of the babies in the community should benefit. This in turn results in improved health outcomes and reduced burden on the health system. Implemented correctly, this is a life-saving and cost-saving intervention.

Guido Moro: It is internationally recognised that human milk is the best nutrient for infants, not only term infants but also preterm infants. We know that many mothers who deliver preterm infants don't have the possibility to give their milk, because they do not have milk or do not have enough milk. In this case, it has been shown that human milk, donated from another mother and given to the bank, processed by the bank, and administered to premature infants is the best option after own mother's milk. The main purpose of human milk banks is to deliver human milk to premature infants and to sick infants.

Interviewer: How does a human milk bank save lives?

Guido Moro: There have been many papers published in the last few years showing that human milk is protecting premature infants from several diseases, particularly NEC; for example, the rate of

NEC in premature infants receiving formula is 7%. This percentage is from the Vermont Oxford Network, which takes into consideration data from neonatal intensive care units (NICU) all over the world. However, the rate of NEC in infants receiving human milk, either mother's milk or donor human milk, is between 1% and 2%. This is a big reduction in the rate of NEC. It has also been demonstrated that donor human milk protects against both early and late sepsis, bronchopulmonary dysplasia, and retinopathy of prematurity. These are short term advantages, but there are also long-term advantages as prevention of metabolic diseases. It is clear that if you are able to prevent such type of diseases, you are able to save money.

Saving lives is the priority, because the mortality rate of infants with NEC is approximately 30%. Secondary to this, there are also monetary savings. Based on data reported in literature and in Italy, I calculated that for each infant with a birth weight below 1,500 g receiving human milk instead of formula, there is a saving of more than 8,000 US Dollars. The number of all very low birth weight infants in a country can also be calculated. In Italy, we have approximately 8,250 very low birth weight infants every year. If 8,000 US dollars are saved for each newborn infant, the total saving is 67 million US dollars, equivalent to 52 million Euros, each year. This is very impressive. These are numbers that can be used to persuade politicians and hospital managers to support breast feeding and the use of human milk in every premature infant, particularly in VLBW infants. These are therefore extremely important calculations.

Interviewer: How important are human milk banks?

Ben Hartmann: I have a problem with the word "important" with reference to human milk banks. From a biologist's view, it's a simple physiological fact that we evolved to milk feed our young, and it's important that everything is done to ensure that the mother can successfully feed her own baby. Where this is not possible, there might be situations where feeding donor milk provides some advantages, over other milk alternatives. However, it's clear that donor milk is also an alternative to the biological normal model of feeding for humans. I think that a donor human milk bank certainly has a place, but it is a very defined place, and this has to be made very clear.

Things have really changed since we first started our milk bank here in Perth. At first, we were focused on producing as much donor milk as we possibly could. My feeling, certainly about milk banking, has become more nuanced; that the primary function should be to focus on maximising mum's success. In our situation, in neonatal intensive care in Australia, I think that once we have done everything we can to support a mother, then donor milk banking is a solution, but only in very specific instances. These are identifiable by the existing clinical literature, and future research may no doubt show more potential uses of donor milk. It is a fine line that milk banks have to walk, and it's a challenge, but it's something they have to be really very conscious and aware of.

Now that we have had milk banking for ten years, registrars and senior registrars have trained in situations where it is quite easy to get donor milk. Therefore, we always have to make sure that we maintain that emphasis on supporting mums first and then using donor milk as an option if that isn't working.

Interviewer: How can human milk banks help vulnerable infants?

Kiersten Israel-Ballard: The data is there, about the impact of human milk on NEC and sepsis, and the whole outcome is significantly different if infants are fed formula. The need ranges anywhere from needing that milk for 24 hours, to mothers recovering while her breast milk is coming, or to the longer term if the baby has been abandoned or the mother is very sick or has died. There is a significant gap here and why it is not addressed by most infant and child nutrition programmes, I don't know.

Perhaps we will get some idea why from the following example. We were in South Africa and asked "How many babies? How do we justify a milk bank when we are not talking about all babies?" In the NICU, which is our primary target, we put these questions to the neonatologist. For a couple of days during her rounds, she asked the other nurses and doctors "How would a milk bank help these infants? Of all the babies in the ward, how many would potentially be impacted if there is a milk bank?", regardless of whether they needed milk for a short while or a longer period.

The neonatologist found that 40% of the babies in her unit ward could have used donor milk, whether it was for the short or long term. That was an unbelievable task. Historically, we usually see 15% as the quoted proportion at any given time in a NICU, indicating that about 15% of babies need donor human milk, whether it be for 24 hours or two months. So, any number from 15% to 40% of infants need donor human milk, depending on your location and the scenario in your facilities. We also have to keep in mind that South Africa has a very high HIV prevalence, so those babies might have been very special cases. However, the numbers are there, and there is a real demand for donor milk. Looking at the health outcome, let's say 15% of those babies don't receive donor milk, they are fed formula, and they have complications as a result. They stay in the unit ward for an additional two weeks, perhaps they die. In this situation, there is not only the health outcome, the lives lost that can't be quantified, but there is a cost. The policy maker will ask how much does a milk bank cost and where is the cost benefit, but by reducing the stay in a unit ward, the facility saves some money.

Guido Moro: If you are able to reduce the number of infants with NEC, you are able to increase the number of infants who survive. I did some calculations relating to the number of deaths that you can save and the economic advantages. For example, based on the data in Italy, we have 7% of NEC in premature infants receiving formula, between 1% and 2% of NEC in infants receiving human milk, and the mortality rate for NEC is 30%. For every 1,000 premature infants, we have 21 deaths from NEC in infants who receive formula and between 3 and 6 deaths in infants receiving human milk. This means that we can save between 15 and 18 newborn-infant lives by using human milk. That is a very impressive saving of lives, and with this there are also economic advantages.

Ben Hartmann: I can only speak in the context of an Australian NICU (obviously there are many different contexts where milk banks operate internationally). We have approached the questions of what is the benefit and what's the requirement of donor milk by acknowledging the available clinical literature that suggests that NEC can be reduced by providing pasteurised donor milk to very low birth weight babies as an alternative to infant formula feeding.

That was principally what we were trying to deliver when we provided the milk banking service to the King Edward Memorial Hospital. With ten years of milk banking experience at this hospital, we can compare the incidences of NEC in our unit with those from the rest of the country. In Australia we still don't have many milk banks operating, so there is a big difference between the care here in Western Australia compared to the rest of the country. We have a national data collection on babies born at less than 28 weeks. The incidence of NEC in Australia pre milk banking, so pre 2005, in the entire country including in the community, was between 8% and 11% in babies born at less than 28 weeks. Since we started milk banking in 2005, we have seen the incidences of NEC decrease. The latest national data is from 2012. At the King Edward Memorial Hospital, the incidence of NEC sits between 2% to 5% in a 28-week population. The rest of the country still remains at the 2005 level, between 8% and 11%. While not a randomised controlled trial, certainly the biggest different between the care in Western Australia and the rest of the country is access to donor human milk, and there does seem to be a marked difference between the incidence of NEC in our hospital and in the rest of the country.

Taking the 2012 data across the whole country, if the rest of the country was operating at the levels of King Edward Memorial Hospital PREM Milk Bank, there would have been about 40 fewer diagnoses of NEC in 2012. Based on the outcomes after a diagnosis of NEC in Australia, we would have seen 16 fewer deaths, 16 fewer surgically-managed NEC cases, and 8 fewer medically-managed NEC cases had there been access to donor milk across the whole country and the same outcomes as at the King Edward Memorial Hospital. Then, add the cost of care to that. So if there was equitable access to donor milk across the country, we would have expected a saving of about 3.5 million

Australian Dollars due to donor milk banking or access to donor milk, plus the potential prevention of 16 deaths.

This only puts a value on the immediate cost of care of babies in the NICU. There are a lot of other potential implications. Poor neuro-developmental outcomes are associated with a diagnosis of NEC, so there is potentially quite a high long-term cost saving of having donor human milk in a NICU. This saving is not really captured by this sort of comparison, but even very conservative estimates suggest that there is a huge benefit in terms of clinical outcomes, costs, and broader public health outcomes of having access to donor human milk banking in Australia.

Interviewer: Those are pretty impressive figures. It is also quite startling when you hear those figures and think about all those infants who could have been saved.

Ben Hartmann: Yes, it is and there will be a different equation in every country. In Australia, we have very high breastfeeding rates in all NICU, and quite low incidences of NEC even in our high-risk babies across the whole country, in areas with and without a milk bank. The equations are different if we look at the cost benefit of human milk banking. In Australia, we have to run a very focused service and provide it to the most at-risk patients, because of the very low incidence of NEC and the small population; still very significant, but only a small number of patients where we can see the benefits. The costs of running a service versus the potential benefits is a relatively fine line, so this dictates that we have to be quite specific to that high-risk preterm population. In other countries, where there might be a higher incidence of NEC, there may be a bit more flexibility on who might be a beneficiary of donor human milk. These are questions that every milk bank needs to define.

Returning to the definition that I mentioned, and the question of identifying when donor milk is required, this is unique to every project and to every jurisdiction. These decisions, about the actual outcome that you are trying to deliver, have to be made in the planning stages of a milk bank.

It is likely there is always going to be a need for milk banking, particularly within neonatal intensive care. At the moment, it appears that where early and aggressive enteral nutrition is practiced, most physiologically normal mothers will not be able to produce the milk volumes that the doctor might prescribe for their baby, and certainly there will be a need of donor human milk in those situations. We have to make sure that we minimise the use of donor milk in our unit. That is certainly our goal now – to support mothers to reach their full potential for milk production and therefore use as little of the donor milk as we possibly can.

João Aprigio: Human milk banks can reduce the length of hospitalisation of newborns in NICU; reduce the cost of care, improve quality of life, lower the rates of hospital infections, and eliminate enterocolitis, both septic and microbial. In some countries, the results are even more striking. For example, in Asuncion, Paraguay, 6 or 8 months after introducing milk banking, baby formula was not being used anymore. In the first year of having a milk bank in operation, Cape Verde reduced the death of newborns in the NICU by 55%. Positive results for the practice of breastfeeding among mothers of premature babies and in the post-discharge period also increased significantly.

17.4 The Selling of Breastmilk

17.4.1 Expert Collective Views

Interviewer: What are the issues surrounding the selling of breast milk?

Private and public institutions view milk banks differently; the former consider the economic aspects of donor milk and expect a return on their investment, while the latter consider the health implications. The selling of breast milk negatively impacts the credibility of the clinical service of milk banking.

In the past, in some countries, donors were paid for their milk according to quantity, which led to its dilution with water or with cow's milk. In Italy, legislation stipulates that milk donation must be free of charge and that no money should be involved in the donation of human milk in any breastfeeding activity.

In Italy, there are no private milk banks, but there is an association between some private and public institutions. As such, the private institutions finance the opening of human milk banks and the public institutions provide the staff. The joint venture works because donors are not paid and, while they cover the costs, the private institutions gain from the publicity of their activity. There are two examples of such an association; one in Bologna and the other in Vicenza. Both are funded by the private dairy companies, Granarolo and the Centrale di latte di Torino, respectively. The public institutions gain as they now have human milk banks in these cities, and the private companies benefit from increased returns on their dairy produce. The balance is critical, but can be done if approached judiciously.

The practice of selling milk on the Internet is a big problem in the US, but not yet in Europe. However, as with everything emanating from the US, it is only a matter of time before it becomes a concern in Europe. Because of this, the European Milk Bank Association published an opinion statement against human milk sharing on their website, which was written jointly with the Human Milk Banking Association of North America (HMBANA). Associations in Italy and France share this same statement.

Advising against milk sharing is unlikely to influence the amount of milk available to mothers. Mothers need to be convinced that this is not the correct strategy to get human milk for their baby, and that donor milk from a milk bank is by far the safer option. Importantly, to reduce Internet milk sharing, mothers also need to be persuaded to breastfeed their babies. Increasing the rate of breastfeeding increases the rate of milk donation, enabling those infants who need donor milk to benefit. Without such action, a mother will sell her milk rather than donate it to a milk bank, with all the dangers that are connected to this practice.

In Australia, the general community frequently asks about how to access donor milk from milk banks and the safety of informal milk sharing. This presents a challenge for milk banking, because it needs to be separated from the many different activities (including milk sharing) that are grouped under that banner. A clear definition of exactly what is meant by a human milk bank is necessary, but is difficult to master. However, this raises two very different issues. The first is a public health concern, where donor human milk banks are seeking to address a particular public health problem such as reducing NEC in a NICU. The second is in developing countries, where there are no safe alternatives to mother's breastfeeding and human milk feeding.

It is clear that the difference between milk banking, milk sharing and milk selling needs to be defined, that these practices are not grouped together, and that human milk donors are not paid for their milk.

17.5 Legal Aspect: Guidelines, Standards, Regulations, and Governing Bodies

Interviewer: What is in place to support human milk banks from guideline, regulatory and standardising point of view?

Kiersten Israel-Ballard: Guidelines present a challenge – there are guidelines, and the National institute for Health and Care Excellence (NICE) guidelines are probably the most robust. They are also accessible, available online, and some are interactive, but they are designed for the UK. There are different guidelines around the world, such as those from HMBANA, the Italian Association, Australia, and Norway, but generally they are not very accessible for new policy makers. In 2012, professionals from around the world assembled at a global technical advisory group meeting. This was at a time when we were still learning about milk banking and when, naïvely, we thought that we could help create global guidance and make it accessible, such as on the WHO website. Quickly, we learned that this is not so easy – every country and every setting has different risks, different needs, and different resources. Overarching guidelines just won't work, they need to be adapted. Instead, what can be done is to provide the tools to help countries to adapt guidelines and establish quality control principals. The quality principles that guide the processes selected for each setting originate from Ben Hartmann. We have an online framework guideline document and we hope people find it useful, although it needs more work in terms of getting clear guidance and resources in an accessible way.

Interviewer: Is there a governing body for this framework guideline?

Kiersten Israel-Ballard: Not globally, but regionally, and even then they are not everywhere and are very disassociated. For example, in South Africa, there is a human milk banking association that is not a government-based organisation, but it provides technical assistance to the government. Brazil is an incredible model globally with a nationalized network and a robust communication and mentorship platform.

In the absence of global guidance on human milk banking, a mechanism for sharing best practices and collaboration is needed. PATH has been working to establish a systematic approach for building ownership and sustainability through learning exchanges to foster collaboration and connections. An increase in regional associations who could serve a robust mentorship role would be useful. Ideally, there would also be a global body to work with technical and policy leaders to establish standards and policies.

Guido Moro: In Europe, there are two countries with legislation. The first country to regulate the activity of human milk banks by law was France where legislation was passed between ten and 15 years ago. A year ago, Italy passed a law to regulate the activity of human milk banks. Regulation is the way forward or things will be done differently. There must be a regulation to be followed for all human milk banks: the rules and what should be checked and performed have to be specified. There has to be some type of control over the activity of human milk banks or it will be a disaster. Italy provides such an example; here, there are a few human milk banks collecting 15–20 litres of milk per year while others collect more than 2,000 litres per year. Imagine the cost of a small bank working for 20 litres in one year: it's a nonsense! You should have the possibility to constrain low production banks to increase their activity or to close

Interviewer: Who (i.e., which governing body) controls this?

Guido Moro: This is the next step after getting the legislation. The ministry has sent a form to all milk banks in Italy to collect information about the activity of the banks. Now we are checking the data to create a picture of the situation in our country. After that, our association (AIBLUD) will send some members of the Board to the milk banks, control their activity, see if they are performing according to the legislation, and, if necessary, give suggestions on what to change and how to change it. The most important aspect is that we do not want to go to a milk bank to inform people that they are not performing well and consequently they have to close. We must have a positive impact: tell them that they are working well, but can work even better, and give suggestions on how they can improve the quality of their service. It is extremely important to involve other milk banks in this activity.

Interviewer: In Italy, do you know all the human milk banks that are there?

Guido Moro: Yes.

Interviewer: How could this be done in other countries where there are milk banks that may not be registered or that the government or the health ministries are unaware of; how would you deal with these sort of situations?

Guido Moro: I think that there is the need of a local association. The local association should have a knowledge of all the banks and give support to people who want to open a new human milk bank. This centralises the control. The association can act as an interface between the milk bank and the Ministry of Health or local politicians. Otherwise, for people responsible for a single bank it will be very difficult to get attention to their requests. An association is more powerful: on the milk banks behalf, it can interconnect with the Ministry of Health or the local politicians. This is my advice.

Interviewer: You have national guidelines in Italy, are there any international guidelines? Where can people go to develop their own national guidelines?

Guido Moro: Many countries in Europe have their own guidelines: Italy, France, UK, Germany, and Switzerland have guidelines, and several are published in English. These are similar and different at the same time. The main aspects are similar, with only small differences, such as, for example, the number of bacteria taken into consideration before pasteurisation. The most important things are common to all human milk banks in Europe. If you want to open a human milk bank, at least for the baseline requirements, you have to follow some of the guidelines published in Europe. Otherwise, go to PATH. PATH has published a booklet, which is available from their website, comparing similarities and differences between all existing guidelines around the world. Look at these tables, starting with the aspects that are similar and common to all the human milk banks. PATH did a good job; so, if you want to know how to set up a human milk bank, this is the simplest and least expensive way to work.

Ben Hartmann: A lot of people certainly have published guidelines, as there are national guidelines for milk banking, but how useful these are in other projects or jurisdictions is questionable. There is no real governing body ensuring safe practice in milk banking. There are all sorts of guidance but no real accreditation or validation available for milk banks; this is something that could potentially give milk banking a lot more credibility. There are groups working towards this, but I think it is clear that there isn't one universal approach to this in milk banking at this stage. In Australia, we certainly didn't see the Australian Government or State Government having the appetite to create regulatory certainty for milk banking, which is still a very open question in this country.

We have a separate regulator for food and for therapeutic goods, and this has been really problematic for milk banks, which fit the definitions of both. Over the last ten years, there has been constant argument as to whether human milk is a food or therapeutic. I don't necessarily say that this is a problem, it is just semantics. I think it's more important for milk banks to choose the best regulatory outcome in any particular jurisdiction. In Australia, we have always been very clear to suggest it is our view that the suitable regulator for human milk banking is the Therapeutic Goods Administration, as we think this provides the better regulatory structure to ensure safety. For the milk banks themselves, that might mean that they have more onerous regulatory requirements and it may make milk banking slightly more expensive. But, from the perspective of the safety for the recipient of the donor milk, which is really the only perspective we should have here, the Therapeutic Goods Administration is much better outcome, given the significance and type of clinical risks that require management. We certainly make more than just nutritional claims about our products and the benefits of donor human milk banking in the NICU, and as such as the Therapeutic Goods Administration seems a more sensible option.

As the Government have not put any legislation in place to regulate human milk banking, it is something that we need to facilitate as it has been a barrier to the development of human milk banks in Australia. Since the interview, we have seen commercial milk banks move into the Australian market. These are unregulated at present and are a concern.

Interviewer: Do you think that it will be possible to develop international guidelines?

Ben Hartmann: Absolutely, but I think we have to be really clever about the way it is done, because there is no single recipe for a human milk bank. There is no single practice that is appropriate for all situations, because outcomes and goals of a milk banking service differ in almost every jurisdiction. However, the way that we approach milk banking should be consistent. I think that we can almost universally agree that human milk banks should be run in a way that is safe and effective, so that they do no harm and deliver what they say they will deliver. These outcomes should be defined by each project and be measurable.

I also think we agree that milk banks should be ethical and sustainable clinical services. They should support some broader public health benefits and they should be sustainable. Milk banks need a business model that allows them some certainty of continuing into the future. If international guidelines were built around that sort of assessment, around how you design a milk bank to achieve specific goals, both clinically responsible and socially responsible, they could adapt to differences in specific practices internationally. This accepts that there will be some variation in practice from jurisdiction to jurisdiction, where a milk bank is providing donor milk to a different patient and where there are different costs driving the service. It is entirely valid to assess this differently in different jurisdictions. I certainly think it's possible, but we should focus on how milk banks are designed, developed, run, and managed rather than on the particular steps or workflows involved in donor human milk banking, which may well differ from jurisdiction to jurisdiction.

Interviewer: You have mentioned classification, that breast milk is classified as different things – sometimes food, other times tissue, and is sometimes unclassified. Why is this?

Ben Hartmann: Globally, there has to be flexibility. Maybe, there is the need for third party accreditation for milk banks to be able to demonstrate and justify their own practices to suit their own situation. I don't know that there is a desire to develop a single "method" for the operation of milk banking internationally – but I can't see this being successful. Where I have worked with other projects in different jurisdictions, I see that it is very common for people to look at the practice in another country and try to use it in their situation; quite often this works but in many circumstances it does not. It can also be that there are underlying assumptions that are defining practice that don't hold somewhere else. Take donor screening as an example; here we are looking to manage the risks of particular blood-borne viruses and these may vary from country to country. We have to be able to tailor our practice to a particular situation. I certainly don't think there is a single rule for milk banking or a single way to approach milk banking that is safe when the focus is on effective outcomes.

We really have to think about how we design these projects. Is there a way to design a milk bank for a particular situation? This is something that is becoming more of an issue. We don't yet have a good toolkit to design the right solution for the problem.

João Aprigio: In Brazil, several issues hampered legislation and guidelines. Firstly, there was no benchmark against which to evaluate. In collaboration with the hospital's Department of Psychology, we developed a form of care that focused mainly on the mothers. It offered support so that she could focus on and reconnect with her baby, help her to understand that she was not responsible for not being able to breastfeed directly, and express her milk. However, our human milk banks were also designed to collect milk from other mothers, process it safely, and perform quality control to provide milk to premature babies who temporarily could not receive their mothers' milk.

Secondly, donor milk protocols had to be developed. Since Fiocruz provides research and technological development for the Brazilian Ministry of Health, we turned problems into research projects to find technological solutions. For example, due to the high cost of packaging, we investigated the packaging of milk in special bottle glasses, analysing the chemical, physiochemical, and microbiological characteristics, which became our "gold standard".

Thirdly, at great expense, equipment had to be imported from the US, Germany, or France to pasteurise human milk. Thus, we adapted a technique using an ultra-thermostatic water bath produced in Brazil for about $1,000.

Fourthly, quality control. The European model is very safe, doesn't pose a risk to the child, and, considering human milk to be a human fluid, it is fully clinically tested to ensure product quality. However, we preferred to work with the references of food technology. On the understanding that milk is a functional food and that its composition has numerous variations, we created processing protocols and quality controls (chemical, physicochemical, nutritional, and microbiological) to ensure the quality of all milk in favour of the child. Bacterial analysis to determine the presence and identify the species of bacteria evaluates the risk of that product. This model means that samples that are suitable for consumption may be rejected, but milk that is not suitable for consumption is never accepted.

Based on these solutions, we developed our quality control system, protocols, and legislation. The accumulated knowledge from academically validated research formed a guideline, which was disseminated among other hospitals all over Brazil. Regional centres of excellence for human milk banks were set up to ensure they reached all the different regions.

In 1987, the Ministry of Health began funding the implementation of these centres, and the WHO and the Pan American Health Organization (PAHO) created protocols and legislation. In 1988, WHO accredited the Brazilian protocol as being safe from HIV in human milk and the guideline became a regional reference model. By the end of the 1990s there were 150 units operating in Brazil. In 2000, the WHO committee made an assessment of the initiatives undertaken around the world in the "Health for all in the year 2000" – health for women, children, and the elderly. The effort for establishing the Brazilian network of human milk banks was regarded as one of the projects that contributed most to the reduction of worldwide child mortality in the 90s. The work of the Brazilian human milk banks earned international visibility, and the international cooperation in human milk banks began.

By 2005, Brazil was ready to start international cooperation. Common principles were established to build a human milk network in Latin America. This resulted in a document known as the Letter of Brasilia, where countries would commit to building a human milk bank network. Thirteen Ministries of Health from different countries signed the letter, which was also signed by UNICEF, PAHO, IBFAN (International Baby Food Action Network) and WABA (World Alliance for Breastfeeding Action). The Brazilian government decided to bring the human milk bank to the international agenda and the milk bank became part of the foreign-Brazilian Portfolio initiative. The cooperation projects started to be established and we began to work with other countries in the same manner as we had been working with the Brazilian states.

In September 2015, 20 countries met in Brasilia in order to evaluate the results achieved in the period 2010–2015, according to the commitment made by the signatories of the Letter of Brasilia in 2010. The result of the meeting highlighted the contribution of human milk banks for the health system of countries to achieve the Millenium Development Goals 4 and 6 as well as the construction of a common strategy to meet the demands of the Agenda 2030 for Sustainable Development.

Finally, it is worth mentioning that the main result of the event was the creation of the "Global Network of Human Milk Banks" formalised in the Letter of Brasilia 2015, with the signatures of representatives of Ministries of Health of the 20 countries, World/Pan American Health Organization Health (Opas/OMS), UNICEF, Ibero-American General Secretariat (Segib), and the Brazilian Cooperation Agency (ABC).

17.6 Opening a Milk Bank

17.6.1 Expert Collective Views

Interviewer: What are the main challenges when considering opening a human milk bank?

Perhaps the greatest challenge worldwide is that milk banks are set up without a foundation of breastfeeding support and promotion. As a result, milk banks struggle to achieve sufficient donors and thus don't have the supply to meet the demand. The model to be implemented is a "slow down" model; to establish a milk bank quickly would mean doing so without the necessary support.

In Brazil, the entire thinking around the value of human milk was changed by putting breastfeeding support and promotion first. Taking this more holistic approach, by first ensuring that the necessary foundation of breastfeeding support and promotion is in place, may mean waiting several months before a milk bank is opened, but this is the culture that makes it work and it requires government backing.

Another challenge is the acceptance of milk banks in certain areas where milk sharing (which is what most people see it as) is taboo. In the Kwa

Zulu Natal province of South Africa, the department of health sees milk banks as a priority. They have been ahead of the game globally, having had to deal with HIV and complex feeding issues for years. However, like in Brazil, their vision is not just a milk bank, but to change the face of what breastfeeding means. Using social media and a community drama group that presents to the kangaroo mother unit and the community, breastfeeding is promoted as a priority but also mothers learn about donor milk and milk banking.

Milk safety cannot be overlooked and there has to be efficient quality control.

Costs are one of the greatest disadvantages of opening a milk bank. Particularly significant at a time of general economic crisis, it is not an easy task to convince people to spend money on a new milk bank. To demonstrate its worth, it is imperative that the advantages gained in terms of health outcomes and cost effectiveness are presented to offset the high costs of opening a milk bank.

The procedure for opening a milk bank is far from clear. The first steps are to determine that milk banking is the solution to the particular problem and then to design the appropriate milk bank for that problem. However, experts at PREM Milk Bank are frequently asked for advice about safety and efficiency once the decision to establish a milk bank has been made and the bank is functioning. In these cases, the vital first steps in the process have been missed. For each project, we first need to ask: What is the problem that we are trying to address in this situation, is milk banking actually the solution to that problem and, then, what design of milk bank will solve that particular problem? This is a common oversight. All too often it is assumed that a milk bank is a pasteuriser, a freezer, pieces of equipment, and screening for donors, without thought as to what is trying to be achieved by this process.

Interviewer: Is it always relevant to open a milk bank or should it be on a needs assessment basis?

An assessment of the need for a milk bank is appropriate worldwide. In most cases, there is a need for a milk bank, but this need has to be defined. Defining the problem and solution first was the approach taken in Perth, which was a business planning process. In the developed world, the focus is on the high-risk preterm baby and reducing the risk of NEC; in other situations, safe alternatives to mothers' own milk may not be available or there may be a broader public health benefit for breastfeeding support. By defining the need there is greater understanding of the potential recipient, who might vary from project to project, and this tailors the risk environment and the required outcomes. The responsibilities of the service provider should be defined as an evaluation of whether the milk bank is operating safely, operating ethically, effective, delivering the desirable outcome with a sustainable business model. These are common responsibilities across all milk banking services.

A milk bank is not simply a facility requiring equipment such as a pasteuriser and freezer. Assessing needs in terms of resources and equipment specific to the setting is the minor consideration, which should follow the more important overall system assessment. To be effective, the entire system has to be carefully designed and assessed, including breastfeeding promotion and milk bank integration into care of the newborn and breastfeeding. Ideally, that requires establishing a foundation, calling stakeholder meetings, and a government supporting the neonatologists, microbiologists, lactation support staff, dietitians, and infection control to produce guidelines specific to the setting. Local advisory groups are required long before the milk bank is set up, and with breastfeeding promotion in place, the milk bank will have donors. A communication strategy is needed to assess the perceptions surrounding human milk and milk banking and to make people aware of the advantages. In Brazil, the marketing is highly successful, with the community inundated with milk banking messaging.

Only then can the actual facility slowly begin to be set up. Documenting change once the milk bank is in place is also important, particularly if it is the first one in a region and likely to expand. Getting baseline data and documenting changes in breastfeeding practices, in the neonatal unit, and in outcomes are the challenges because most facilities do not have funding for this.

However, as more groups go through the process of setting up milk banks, it is becoming increasingly obvious that a good framework for designing a milk bank is lacking. Tools or workshops are needed to define a structure for a process for opening milk banks. This would enable the right milk banks to be set up and assessment that the process that's been developed is appropriate for the particular situation. Moreover, provision of data collection and evaluation tools to assess what can be done in a facility and to analyse the data would be very useful.

Interviewer: Are there key processes and procedures that need to be considered?

The safety of human donor milk is paramount. An important part of the assessment process is to have the milk bank take responsibility for safety, that being to clinically risk assess their donor and recipient populations and the entire procedure including donor human milk collection, storage and processing. This safety assessment is an absolute requirement because every process differs, and thought is going into developing tools to help milk banks conduct those risk assessments. Much of this is already known. For a group looking to set up a milk bank, PREM Milk Bank among others can make a risk assessment in the context of the particular project, depending on who is going to receive the product. However, this process would be made a lot easier by providing a template for the design of milk banks, although it then has to be tailored to the specific project.

The pasteurisation method currently used in all human milk banks is thermal pasteurisation, which heat-treats the milk at 62.5 °C for 30 minutes. At this temperature, all viruses in the milk are inactivated and all bacteria are destroyed. At the end of the process, the milk is microbiologically safe for the infant. However, heat treating the milk is not without some disadvantages because some components of the milk are inactivated or destroyed at high temperatures, such as some immunological and nutritional components. New technologies to improve the quality of human milk produced in a milk bank are therefore under evaluation. One such procedure is high temperature, short time pasteurisation (HTST), which treats the milk at 72 °C between 5 and 15 seconds. HTST has been shown to provide better quality milk in terms of immunological and nutritional components compared with other pasteurisation methods.

Screening of human milk is very important when selecting donors for human milk banks. Mothers wishing to become a donor have to complete a form regarding their medical history, diet, and lifestyle. They then have a clinical examination and must present negative blood tests for Hepatitis B, Hepatitis C, and HIV. While pasteurisation destroys these viruses, this is a necessary precaution to minimise the risk of infected milk contaminating milk at the bank. With regard to bacteria, guidelines permit up to a certain number of microbes; above that and the milk has to be discarded. Most guidelines stipulate to do a bacteriological check at the first donation, before and after pasteurisation, and at regular intervals thereafter.

There are two different scenarios with regard to the pooling of human milk. Some banks pool the milk from one donor only, while others mix the milk from two to a maximum of six donors. The advantages of having one donor only is that you know the exact donor and the milk characteristics. The milk from more than one donor will have different characteristics, but the protein and nutritional content of the milk is more balanced than when taken from a single individual. The process of microbiological screening of donors is the same for either strategy.

Interviewer: Where does funding for milk banks come from?

Kiersten Israel-Ballard: This is a real challenge. I think it is critical to ascertain a level of government commitment. If we talk about a milk bank in a facility like a hospital, it probably has to rely on public facility and funding. Hospital staffing are key; you are going to make sure that systems are in place. If it is a private hospital, then you will ensure that the facility wants a milk bank and will help support the staffing. Staffing is a basic operational constraint. In a public facility, often staff share their duties.

In the short term, groups are turning to international organisations for funding to set up a milk bank, such as the Rotary club. There could also be private donations from corporate or private sectors, and the donors could be recognised. This could be appropriate for the initial set up while putting things in place, but the ongoing upgrading costs have to be assumed to be borne by the facility, private or public. Funding has to be put in place before policy makers can understand the potential impact; it is then an easy decision for them to place it under other budgetary items because it's not that expensive.

Guido Moro: We calculated how much it cost to produce one litre of human milk in our human milk bank at Macedonio Melloni Hospital in Milan. The figure is very similar to that calculated for the human milk bank at Meyer Hospital in Florence, the first human milk bank to be set up in Italy in 1971. This cost is between 80 and 100 Euros per litre. By taking the number of litres of human milk processed in the bank and the volume of human milk utilised for feeding premature infants, you can calculate the total cost of running a milk bank. That includes the equipment, the staff, and the materials used in the human milk bank.

Interviewer: These are the sorts of figures to throw at health ministers or people implementing the change. They will be extremely impressed, there is no question.

Guido Moro: These are the calculations I made for our country to show to politicians. After the survey, we also had data showing that two-thirds of premature infants born in Italy were not receiving human milk. We took these figures to the ministry management and told them that they could save both lives and money by supporting us to achieve this result. The Ministry of Health management agreed and, henceforth, our association and the ministry staff started to work together. Within six months the collaboration had set up a new milk bank.

Interviewer: The idea would be to then use the information to empower governments to make changes?

Guido Moro: Yes, in every country, you can collect data and calculate the figures for local situations.

Interviewer: What sort of resources and equipment would be needed to set up a milk bank?

Guido Moro: When you talk about outcomes, you have to think about the cost. This will be the first question that is asked when you go to the manager of a hospital asking to open a human milk bank because of its advantages. However long it takes to explain the advantages, the first question will always be the cost of the bank. You have to evaluate the cost of what is necessary to open the milk bank – the pasteuriser, the freezer, the refrigerator, and the staff – and it will cost approximately 50,000 Euros. But, you must then calculate that while paying this cost, you are saving both lives and money. There will be fewer infants with NEC, with reduction of the cost of therapies and surgery for NEC, fewer antibiotics needed because of the lower number of sepsis, and shorter stays in the NICU for infants. One of the main positive advantages from a human milk bank is that money is saved immediately from the time the baby is admitted to the NICU, and because the rate of NEC and infections will be lower. When talking about the expenses of setting up a milk bank, you have to estimate 50,000 Euros at the beginning to buy equipment and for the staff involved in the activity, but you must consider the advantages deriving from utilisation of donor human milk in feeding VLBW infants.

Ben Hartmann: The first question I am always asked is about costs, and I always respond by saying that I can only tell them what our milk bank costs. We have to think about milk banks as businesses to be able to design them as efficiently and effectively as we possibly can. We should be providing milk banks with better tools to make those cost decisions, because I don't think that a third party can answer those questions. I find it very difficult when contacted by someone in a country that I know very little about, who wants to set up a milk bank and asks how much it will cost. In our hospital, we know our patient population. We know how many deliveries there are by gestation period (i.e., how many babies are born at 23 weeks, 24 weeks, etc.) so we know how much milk is needed at these times. However, birth rates and times will vary from country to country. We have a good understanding of how our milk banking service is used by a recipient, according to our inclusion criteria for receiving human donor milk, but this will not necessarily apply in other jurisdictions.

Fundamentally, equipment has a dollar value, but we have found that fund raising for equipment doesn't seem to be challenging. The human resources to run milk bank are always going to be the most difficult to acquire, and this is something that I have seen in milk banking around the world. It is often the case that milk banks are developed by people who are very well meaning and care about having a milk bank, and these people often spend a lot of their own time delivering the milk banking service. I have been very lucky to have the opportunity to focus my energy on running a milk bank in Australia.

Coming back to your question about the costs, I think we need to design a milk bank to understand what a milk bank will cost, and to understand what we are trying to deliver. Then we can consider the cost appropriate for the benefit that we are trying to demonstrate. There is a business argument for a milk bank in most cases.

Interviewer: Maybe like a cost assessment, you first have to look at the investment needed and the outcome you are going to achieve. We don't know that though, and so it is a long-term investment – the return is not so fast!

Ben Hartmann: Yes, it depends on the business model for the milk bank. In Australia, we are a public hospital and government funded. I think that our milk bank has a responsibility to use taxpayer money effectively, and to provide a service that benefits clinical outcomes of patients. We therefore feed a very specific group of patients where we have clear evidence of benefit. But we also should be providing a benefit to the community and reducing the cost of health care in Australia. Our service can demonstrate both those goals. We developed our inclusion criteria to focus on patients with a high risk of NEC. However, if we allow wider access to donor milk and provide it more generally, we would lose the cost benefit of the service, because we wouldn't be able to show benefits to patients outside of those criteria. This is difficult for a milk bank to even contemplate, because idealistically, we would like to provide access wherever a mother's milk is not available. This is simply not feasible or practical, so we have to link the service to the most appropriate patient.

Interviewer: From this last question I realise that opening a milk bank is not an easy, quick fix as first thought. It requires careful consideration, needs assessment and overall a good supportive network for mothers to ensure its sustainability. This all necessitates buy-in from hospital management, community and governments.

Interviewer: There are milk banks set up around the world. What do you think of this?

Kiersten Israel-Ballard: I think it is fantastic as long as people understand what they are doing. Many groups do not have any concept of what it takes to set up a milk bank! It is good that milk banks are being set up so long as those doing so understand that the level of effort to ensure that it is sustainable and monitored, quality control is in place, and that it is integrated with the system, is not a minimal thing. There is often underestimation and disconnect between the set up being easy and fast, and doing it the right way. A critical first step is to assess the actual needs of the facility. Is a milk bank what is most needed? Or first should there be improvements to strengthen the support systems for breastfeeding? Establishing a human milk bank may be a highly visible and exciting event, however establishing the solid foundation upon which it will operate requires effort and planning. Often it is the integration that is most challenging, not the actual operationalisation of the milk bank. It's good that milk banks are being set up, but we are also afraid of things going too quickly; it may only take one negative outcome to impact milk banks negatively on a global scale. There is excitement and fear at the same time.

Guido Moro: The European Milk Banking Association (EMBA) is trying to create a network among human milk banks in Europe. The majority of human milk banks are connected to this association. If you want to start a human milk bank in a European country, there are several possibilities. The first option is to get in touch with an expert in your country. If you are a policy maker or head of a hospital, you can get in touch with local experts, and find a solution for when to start, how to start, and where to start. The second option is to go to a local association, such as the one we have in Italy. The association gets in touch with the Ministry of Health, and a co-operation is started. The third possibility, if you have neither an expert nor an association, is to get in touch with the European Milk Bank Association for support. We are able to provide support because we know most of the experts in the field working in Europe. So, one of these three strategies should be followed.

Ben Hartmann: We should always be the ones asking milk banks whether milk banking is the solution for the particular problem: Is it effective, and how are they able to demonstrate and measure the outcomes that they intend to deliver? Milk banks should not only be able to answer these questions, but should be the ones asking themselves these questions.

My observation is that if we aren't prepared to ask those questions, then the credibility of milk banking can suffer. For example, in Australia, if we can't demonstrate the particular outcomes that are intended or we can't articulate the outcomes that we intend to deliver, it is very difficult to then go to the government and say that this service should be funded. This is a challenge, but there certainly is also a lot more guidance and support milk banks could offer each other to achieve those goals. There is an enormous amount of value from having milk banking more closely aligned internationally, and from sharing information, support, and resources. There is a lot of information associated with human milk banking that is unvalued. By working together rather than working separately, milk banking can potentially be a lot more.

Interviewer: What are your key challenges then?

Ben Hartmann: I think a significant challenge is to recognise that two different milk banking services can operate in different jurisdictions and be different in how they are constructed, because they are entirely appropriate for the particular situation they are designed for. That's a challenge, because there isn't just one single set of rules for how you run a milk bank, and we need to be a bit smarter in how we go about designing and assessing them.

17.7 Low-Middle Income Countries

17.7.1 Expert Collective Views

Interviewer: What are some general considerations when looking at milk banking in low-middle income countries?

Milk Banks are being set up all over the world. In developed countries, milk banks are regulated from the beginning; every initiative has to follow the regulations created specifically for the opening a milk bank. In contrast, those in some low-middle income (LMIC) countries may not be regulated and lack the necessary infrastructure. At the start, every attempt to increase the possibility of providing human milk to a needy infant is seen as a positive initiative. Thereafter, activity of the milk bank has to be regulated to ensure the safety of the recipients.

However, of primary importance is to educate mothers on the advantages of breastfeeding, and put all significant efforts into increasing the breastfeeding rate. Human milk banks and donation of milk are secondary. While generally, orphan infants will need milk, the importance of milk banks should also be tailored to the country such as in areas with very high rates of HIV.

Interviewer: Is it possible to start a milk bank on a minimum budget?

All milk banks must be designed to serve their specific purpose. It is certainly possible to define the problem, decide whether milk banking is the solution and, if it is the solution, consider what type of milk bank is required and how it would operate.

Low-cost milk banking can be as appropriate as a high-cost milk bank, and the approach to both is the same. The focus is on safe, ethical, effective, and sustainable services. Milk banks' actual services might differ, but these fundamental goals of what milk bank services should try to achieve are consistent wherever they are operating.

A key to milk banking is simplicity. PATH has considered how to simplify the process. Firstly, it can be low cost for small skilled milk banks as well as large facilities with huge budgets. In South Africa, PATH, together with the Human Milk Banking Association of South Africa, developed the FoneAstra, a low-cost, smart phone-based monitoring device that has been adapted to guide the operator through the pasteurisation process and record and transmit pasteurisation temperatures. While a traditional pasteuriser takes about two hours to complete its cycle and to prepare bottles, this system takes 17 minutes including the cooling. A small facility does not always need large numbers.

Secondly, PATH is looking towards rapid diagnostics instead of sending samples to microbiology laboratories, which are expensive. Laboratory costs present one of the largest challenges. However, if you had a rapid diagnostic test where the milk bank technician did the test directly at the milk bank then this would save money.

Thirdly, savings can be made by scheduling correctly and sharing staff, which are the greatest cost. In Brazil, there are different models, but there is always a lactation support person who is part of your key milk bank staff, and a technician. One small milk bank has a staff of two, with both working half days.

In addition to the human milk bank itself, other facilities can be installed when considering setting up a milk bank. A project in Mozambique has installed a library on woman's, child's, and adolescent's health for educational purposes, and a laboratory of health telecommunications to enable a process to be followed in real time. The library is an extension of the institute library at the Maputo Central Hospital, Mozambique; joining the library system at the Maputo Central Hospital comes with an automatic entry to the library in Rio de Janeiro, with access to its books and journals. A team of trained librarians has full autonomy. Because of these facilities, the cost of the Mozambique project was higher than the cost of the usual projects undertaken. Additional funds were provided by Define and the Brazilian Cooperation Agency. Together these bodies made the project financially viable, keeping the commitment already established with Mozambique and without intervening with the principles underlying the technical cooperation.

Importantly, the collective performance of the network is monitored among the countries. International benchmarks for global health are adopted, and in 2010 the network was operated as a food and nutrition safety strategy, taking the goals of the millennium as a reference.

17.8 Key Considerations

Interviewer: Finally – What are some key considerations when setting up a milk bank?

Kiersten Israel-Ballard:

- Establishing a human milk bank is an opportunity to change the culture; to enhance breast feeding promotion and the thinking around the value of human milk in your facility.
- A milk bank must have a sound foundation, with the support of infrastructure around breast feeding promotion.
- It should be developed using an integrated approach, with an established network and links to kangaroo mother care, dietitians, and breastfeeding promotion, rather than by using a vertical model of a milk bank that processes milk.
- It is critical that milk banks develop guidance specific to their area and facility, by talking to technical experts and thinking through the risks and resources specific to the facility. This leads to sustainability; by doing things right to begin with, then there is a high chance your operating procedures will be right for your resources – you won't run out of things or place unnecessary orders.
- The way forward is to come together as a community, by better linking, by transparency, and by providing an interactive platform for sharing resources, materials, and information. We need to give more support to our global community by providing these things as they try to establish their own networks and milk banks. We have to think innovatively around how this can be done.
- Engage with policy makers. Even the smallest milk bank has the job of advocating milk banks in its region for the global community, and part

of that is documenting and quantifying any differences. For example, it would be useful to have more data about the different models that work and don't work in certain situations. There is more information around this than about outcomes, and perhaps what it needs is a call to action for a bank programme to collect and publish this data so that people can learn.

Guido Moro:

- Breastfeeding is the gold standard for all infants, both term and preterm. If the mother has no milk for her infant, particularly when the infant is premature or sick, human milk from a bank has to be used. The government has to invest money in milk banks and in opening new ones, so that these banks can provide an alternative to breastfeeding.
- Availability of donor human milk is mandatory when mother's milk is not present. That means no incentive and no publicity for formula or other substitutes of human milk. This should be an extremely important local initiative, for single hospitals where there are doctors that are not involved or interested in human milk activity. Such doctors inform mothers that if they don't have milk, then there are many formulas that are good enough, and that many infants grow up with formula and so they should not worry. Pediatricians, scientists, administrators, and policy makers all over the world should fight against this way of thinking.
- The activity of human milk banks must be supervised, because otherwise the results could be extremely negative. I refer to the example previously described where, in Italy, there are human milk banks collecting only 20 litres of human milk per year and others collecting 2,000 litres. Banks with small volumes of milk collected have to increase their milk volume or have to be closed.
- It must be kept in mind that there is a cost in giving human milk: it costs a lot, but you can save far more money by giving human milk than by giving formula in terms of health and quality of life later in life.
- Associations are important for all countries considering establishment of new human milk banks. This is because they can check the activity of the existing banks and suggest where and how to set up new ones, and can more easily gain direct access to administrators, policy makers, and governmental bodies which take the final decision.

Ben Hartmann:

- The term human milk bank is used to describe quite a wide range of practices and it is often that these practices are designed to achieve quite a range of outcomes. Milk banking means different things to different people.
- A human milk banking service should be designed to be safe, effective, ethical, and sustainable.
- Milk banking services should clearly define the service that they are trying to deliver and their intended benefit. The primary goal should be to maximise a mother's own breastfeeding success.
- A challenge for milk banks is a range of practices that potentially have a detrimental impact on the credibility of human milk banking as a clinical service. This happens with some of the less evidence-based uses of donor milk, or informal milk sharing, which get associated with human milk banks.
- One potential solution to unifying milk banking where practices differ across jurisdictions might be to design and assess milk banks rather than the end practices. This solution would be one that can recognise the unique aspects of every jurisdiction that might result in differences in practice. These differences must be demonstrated to be appropriate for a particular purpose. By focussing on how a milk bank is designed and developed and what it is trying to achieve we can move away from focusing so much on practice differences.

17.9 Conclusions

A mother who is breastfeeding her own infant is biologically normal; anything else is suboptimal. Human milk from a donor milk bank is the next best option for mothers who cannot breastfeed or who cannot supply sufficient milk for her infant, and for preterm and sick infants where necessary. Only when these options are exhausted should other milk alternatives be considered.

The goal is to run milk banks to support the biological norm of a mother breastfeeding her baby. These should be the smallest possible so that the focus is on the mother breastfeeding naturally. There should be support for mothers to succeed in feeding her own infant, using donor milk from milk banks only where it is indicated and where it is necessary.

Key Points

- Human milk banks provide a safe, secure service for the collection, screening, storing and distribution of donated human milk. Donated human milk should always be seen as bridging a gap until mother's own milk can be used
- Practice demonstrates that the benefit of human milk for sick and vulnerable infants is disproportionately high
- Prior to setting up a milk bank it is paramount to evaluate the requirements to ensure it is adapted to the local necessities and at the same time being sustainable. Furthermore, an integrated approach with the provision of lactation support, will greatly enhance its long-term value to the community
- The initial outlay to set up a milk bank as well as its running costs should be contrasted against the immediate return on investment in reducing NICU costs for therapies and surgery for illnesses prevented by administering human milk
- The integration of the many different national guidelines into unified global standards and tools will greatly facilitate the set-up of integrated, safe, effective, ethical and sustainable milk banks

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18 Pasteurisation

Lukas Christen, PhD

Expected Key Learning Outcomes

- Definition and the reason human milk need to be pasteurised
- Discussion of the most commonly used pasteurisation method and its effect on human milk
- Negative aspects of alternative pasteurisation methods

18.1 Introduction

Human milk is beneficial to the preterm infant due to its bioactive components, such as immunological and developmental proteins, digestive enzymes, and cellular components [1], [2], [3]. However, many mothers are unable to produce a milk supply adequate to meet their preterm infants' needs while in the neonatal intensive care unit (NICU) [4]. Efforts to initiate lactation and/or increase milk volume are most desirable but next best is the use of donor human milk [5], [1], [3].

Worldwide, milk banks are providing donor human milk to NICUs, where recipient safety is the highest priority. However, safety is approached very differently between and within countries. For example, all (but one) hospitals in Norway use unpasteurised donor human milk in NICUs. Use of raw donor human milk has a long tradition but requires strict control and frequent donor screening during the donating period. Additionally, all milk is analysed for bacteria and destroyed if it contains pathogens or a total bacterial count of > 100,000 colony-forming units (CFU)/mL. Milk containing a count of < 10,000 CFU/mL is used for the smallest preterm infants [6]. Interestingly, Norway has one of the lowest incidence rates of necrotising enterocolitis and late onset sepsis [7], which may be partly due to the use of raw not pasteurised donor human milk.

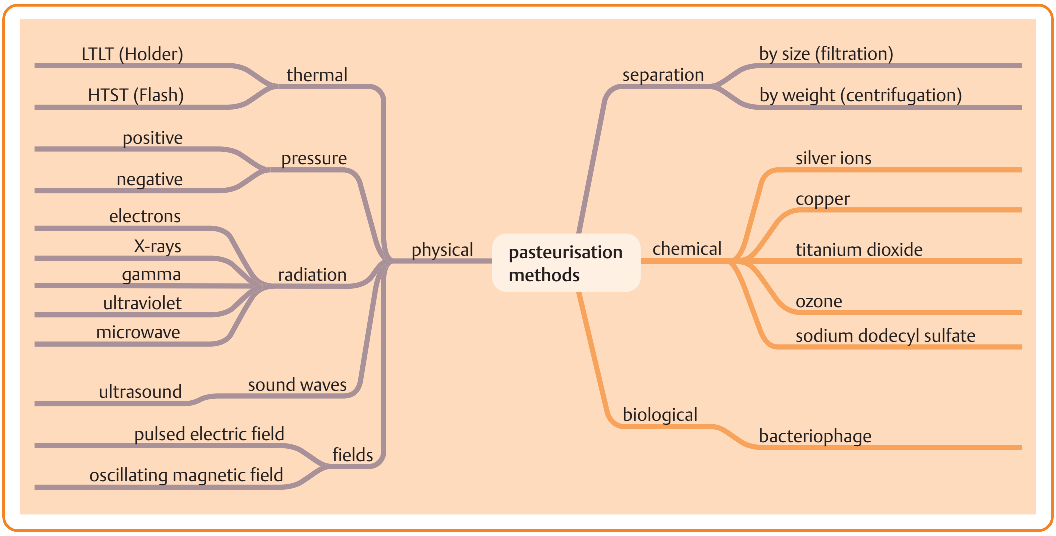
Most milk bank and NICU guidelines require donor human milk to be pasteurised [8], [9], [10]. This process prevents disease transmission from donor to preterm infant by eliminating bacteria and viruses [11], [12], [13]. The most common pasteurisation method used worldwide is a heat treatment called Holder pasteurisation [8], [14], [9], [10]. This treatment reduces vegetative bacteria sufficient to meet milk banking guidelines (MBG). However, the process results in significant loss of activity of important bioactive components [15], [16], [17].

Since most MBGs require pasteurisation as a main safety step, a treatment is required to increase the pasteurised donor human milk quality, which might improve the health outcomes of preterm infants. The alternative must meet the same safety standard as Holder pasteurisation when reducing micro-organisms in human milk but increase its bioactive component retention.

18.2 Pasteurisation Methods

18.2.1 Pasteurisation of Human Milk

Pasteurisation is a process whereby food, usually a liquid, is partially sterilised, making it safe for consumption and extending its shelf-life. Thermal treatments are most common in the food industry, although other treatments that reduce nutritional damage but maintain taste, smell and appeal during processing are of increasing interest [18]. Alternative pasteurisation methods have been studied using bovine milk but the results are not always applicable to human milk. This is primarily because the main focus of the dairy industry is to extend the shelf-life while maintaining food safety and optimising processing costs. The dairy industry inactivates digestive enzymes to increase shelf-life of the milk. However, in human milk, retention of digestive enzymes such as bile salt stimulated lipase (BSSL) may be a high priority to improve pre-



▶ **Fig. 18.1** Overview of possible treatment methods for human milk to reduce microbial contamination.

term infants' nutrition [19], [20]. High retention of immunological and developmental components in human milk is desirable to enhance the infants' immature immune system and support physiological development. Thus, the selection criteria for pasteurisation methods differ for human and bovine milk.

Pasteurisation methods include chemical, biological, physical, and separation methods (▶ **Fig. 18.1**). Since adding chemical or biological agents to human milk is generally considered not to be safe or appropriate, processing should be restricted to physical and separation methods.

18.2.2 Thermal Pasteurisation

This method requires human milk to be heated at a specific temperature for a set time. The two major thermal pasteurisation methods are the low temperature, long time (LTLT) and the high temperature, short time (HTST) treatments. Both methods equally destroy the most heat resistant of the non-spore-forming pathogenic organisms, Myco-bacterium tuberculosis and Coxiella burnetii [21].

Ultrahigh temperature (UHT), whereby milk is heated at > 135 °C for 1–2 seconds, is considered to be a sterilisation method and therefore has to be distinguished from pasteurisation.

Heat alters a wide variety of biological components within micro-organisms, thus inactivating them by multiple mechanisms. The main effects of heat are DNA strand breaks, enzymes inactivation and protein coagulation. Cell death is also caused by thermally-induced membrane damage, which results in loss of nutrients and ions. A minor cause of thermal inactivation is ribosome degradation and ribonucleic acid (RNA) hydrolysis [22]. Many mechanisms of inactivation may be an advantage when inactivating a broad spectrum of micro-organisms. However, a major disadvantage of thermal pasteurisation is that its enzyme inactivation and protein coagulation is not specific to micro-organisms but also affects bioactive components in human milk.

MBGs define thermal pasteurisation by holding temperature and holding time. However, the full temperature profile is not specified. The time taken to heat or cool the milk depends on many variables, including milk volume, heat exchange surface-to-milk volume ratio, heat transfer rate of human milk (depends on milk density and composition), and heat transfer rate of the bottle (depends on bottle wall thickness and glass/plastic material) [23], [24]. Milk can therefore be treated differently even when using the same MBG, which can lead to pasteurised donor human milk of differing quality in terms of bioactive components.

18.2.3 LTLT or Holder Pasteurisation

The most common pasteurisation method for human milk is the LTLT or Holder method, which is used in milk banks worldwide. Bottled human milk is heated in a water bath at 62.5 °C for 30 minutes [8], [9], [10]. This method can reduce vegetative bacteria by 5 log_{10} [9] but Bacillus endospores are very heat resistant and not inactivated by this method [25]. Common viruses found in human milk are also eliminated, including human immunodeficiency virus type I (HIV-1) [26], cytomegalovirus (CMV) [13] and human T-lymphotropic virus type I (HTLV-1) [27]. However, HTLV-1 studies were not in human milk. Unfortunately, Holder pasteurisation inactivates a wide range of human milk components [15], [16], [17].

Increasing bioactive component retention with Holder pasteurisation has been investigated. Two independent studies suggested reducing holding temperature and/or holding time. Changing parameters to 62.5 °C for 5 minutes, 56 °C for 15 minutes, or 57 °C for 30 minutes increased the retention of immunological proteins to above 90% while reducing vegetative bacteria by 2-log_{10}, 2-log_{10}, and 3-log_{10}, respectively [12], [28]. However, bacterial reductions do not meet the requirements of all MBG, and the essential enzyme BSSL is likely to be lost completely with such parameter changes.

18.2.4 HTST or Flash Pasteurisation

HTST is a treatment whereby milk is heated to 72 °C for 15 seconds. A short treatment time is preferred by the dairy industry to reduce energy consumption while maintaining better milk colour and flavour compared with LTLT pasteurisation.

HTST pasteurisation has shown to eliminate HIV, hepatitis B virus, hepatitis C virus [29] and CMV [13]. However, some researchers reported no change in BSSL, lactoferrin, and secretory immunoglobulin A (sIgA) while others found a reduction in immunological proteins and complete BSSL inactivation [30], [31], [32], [33]. One study found differences in immunoglobulin retention when milk was treated at different flow rates, and concluded that this was due to variations in heating apparatus, sample size, conditions before/after pasteurisation, and analyses [34]. Future studies should track pre- and post-bacterial counts, temperature profiles, and biomarkers such as alkaline phosphatase (ALP) to reduce such discrepancies.

Overall, optimising bioactive component retention, e.g., lactoferrin, lysozyme, and sIgA, is possible by altering pasteurisation temperature and time. However, BSSL retention is not possible with thermal pasteurisation as its degradation starts at around 45 °C, which is below the bacterial inactivation temperature [35]. As such, cold pasteurisation is necessary to protect enzymes such as BSSL.

18.2.5 Pressure Pasteurisation

Liquids placed under a high pressure result in damage to cell membranes of micro-organisms. Bacterial reduction in milk similar to that after thermal pasteurisation can be achieved by applying a pressure of 400 MPa for 15 minutes or 500 MPa for 3 minutes [36]. Reduction of vegetative bacteria occurs above 100 MPa depending on bacterial species and food treated. Gram-negative bacteria are generally more pressure sensitive than gram-positive bacteria [37]. Spores tend to have a high-pressure tolerance of over 1200 MPa [38], although the pressure can be reduced with additional heat application. Pressure-damaged proteins differ from heat-denatured proteins, which may have nutritional and biological consequences [39]. Additionally, pressures above 230 MPa reduce casein micelle size in bovine milk, changing their viscosity and turbidity [36]. High pressure also causes alterations in crystallisation behaviour [40] and a phase change in bovine milk fat [39]. Along with low reductions of *Escherichia coli*, such alterations to bovine milk indicate that pressure pasteurisation is unlikely to be a suitable method for human milk.

18.2.6 Ultrasound Pasteurisation or Ultrasonication

Power-ultrasound (20–100 kHz) is an emerging technology in food preservation [41], [42], [43]. Power-ultrasound creates cavitation, that is the formation, growth, and implosive collapse of bubbles in liquids [44]. Pressure changes from these implosions create shock waves that disrupt bacterial cell membranes resulting in cell lysis [45], [46].

Studies using bovine milk and fruit juices have shown that ultrasonication can eliminate various food-borne pathogens at least as well as thermal pasteurisation [43], [47]. One study showed that the growth of Trichophyton mentagrophytes was significantly reduced after ultrasonication. Feline herpes virus (an enveloped virus) was also significantly reduced, although there was no effect on feline calicivirus (a non-enveloped virus), suggesting damage to the viral envelope [48].

Additionally, a study has shown that ultrasonication of human milk can reduce *E. coli* while keeping the BSSL retention > 90%. However, waste heat increased the human milk temperature to above 50 °C. However, to protect BSSL, human milk must be kept at a low temperature during sonication [49].

18.2.7 Ultrasound and Thermal Combination or Thermo-Ultrasonication

Synergistic effects between ultrasound and other processing technologies are used to optimise food quality or reduce treatment time and energy [50], [51], [52]. Thermo-ultrasonication appears promising due to improved energy efficiency and bacterial reduction [47].

Thermo-sonication of human milk has been found to inactivate *E. coli* and *Staphylococcus epidermidis* by 3 $\log_{10}$ with a greater retention of sIgA (91%), lysozyme (80%), lactoferrin (77%), and BSSL (45%) than with Holder pasteurisation. Thermo-sonication also reduced mean particle size of human milk fat globules from 4.6 µm to 0.6 µm after 5 minutes. However, the effect of smaller milk fat globules and on fat absorption by preterm infants is unknown [53].

18.2.8 Ultraviolet Irradiation

Ultraviolet (UV) is part of the electromagnetic spectrum and subdivided into UV-A (320–400 nm), UV-B (280–320 nm), UV-C (200–280 nm) and vacuum-UV (100–200 nm). UV-C 250–270 nm has the most germicidal effect and is capable of destroying micro-organisms, such as bacteria, viruses, protozoa, yeasts, moulds, and algae [54], [21]. At this wavelength DNA bases, mainly pyrimidine and purine, absorb UV-C energy promoting chemical reactions. Common products of these reactions are pyrimidine dimers, other pyrimidine adducts, and pyrimidine hydrates, sometimes involving cross-links with proteins and breaks in DNA strands [55]. Such DNA damage prevents micro-organisms from reproducing and eliminates risk of disease [54]. Bacteria and viruses are inactivated at a similar UV-C dosage but protozoa and fungi need up to a 4-fold and 10-fold greater dosage, respectively [55].

UV-C is commonly used in surface sterilisation of fruit and vegetables, and treatment of water for drinking and swimming pools. The depth of UV-C penetration in liquid is dependent on soluble solids and suspended matter [56], [57], [58]. UV-C treatment of opaque liquids such as human milk is impeded due to its fat and casein content. Consequently, at 254 nm, the absorption coefficient for milk is greater (300 cm^{-1}) than for beer (20 cm^{-1}) or water (0.1 cm^{-1}) [55]. However, a turbulent flow of opaque liquids (e.g., fruit juice or bovine milk) around a UV-C source can enable its UV-C treatment [59], [60]. Turbulence apparently results in transport and exposure of micro-organisms to photons at the interface between the opaque liquid and UV source.

However, UV-C can damage human milk components by direct oxidation (type 1 photo-oxidation), where amino acids absorb the light, and by indirect oxidation (type 2 photo-oxidation), where reactive oxygen species damage human milk components [61]. Little UV-C-induced protein damage in protein solutions and bovine milk was found compared to damage caused by thermal pasteurisation [62], [63]. However, UV-C irradiation has also been shown to cause loss of apo-α-lactalbumin milk protein structure and function potentially limiting its use for milk pasteurisation [64].

A human milk study showed that UV-C irradiation can reduce vegetative bacteria by 5-$\log_{10}$, achieving a higher protein retention than with the Holder method. BSSL and ALP activity were not reduced and retention rates of lactoferrin, lysozyme, and sIgA were 87%, 75%, and 89%, respectively. No changes in fatty acid profile or bacteriostatic property of human milk were reported [65], [66].

18.2.9 Electron, X-Ray, and Gamma Irradiation

The ability of ionising radiation, including electron, x-ray, and gamma irradiation, to reduce microbial load in industrial sterilisation of products is well known. Due to its high energy density, it is highly potent in micro-organism reduction. However, equipment used to generate ionising radiation is not only expensive, but the operator needs specific training as well as sophisticated protection.

Gamma radiation is reported to damage the nutritive quality of bovine milk, with severe effects on vitamin A, C, and E, moderate effects on carotenoids and riboflavin, and little effect on ALP [67].

Unlike the sterilisation of medical devices and industrial products, use of electron, gamma, and x-ray irradiation for food is limited and not generally recommended for liquid foods.

18.2.10 Microwave Irradiation

Microwaves are a non-ionising, heat-generating radiation, which can be used for thermal pasteurisation. Equal heat distribution throughout the liquid is important to ensure effective pasteurisation. However, microwave pasteurisation is known for its non-uniform heat distribution, producing hot and cold spots in the liquid [68]. Flow-through systems are less prone to heterogeneous heat distribution [69]. As such, microwave irradiation is just another thermal method with the same advantages and disadvantages as the Holder pasteurisation method.

18.2.11 Pulsed Electric Field

This method applies high voltage (20–80 kV/cm) pulses to contaminated liquid for > 1 second. This causes permeability of cell membranes resulting in lysis. The method is effective in inactivating vegetative bacteria, yeast, and moulds [70] but also reduces lipase by 70–85%, peroxidase by 30–40%, and ALP by 5% [71]. However, these were not human milk studies and therefore the findings may not be directly applicable. Pulsed electric field technology is still in development and has not been tested for commercial use.

18.2.12 Oscillating Magnetic Field

In this technique, a strong magnetic field of 2–100 T is applied for 25 µs to 2 ms at a frequency of 5–500 kHz. The antibacterial mechanism is unknown but may involve alteration of ion fluxes across the cell membrane [72]. A 2 $\log_{10}$ reduction of vegetative bacteria was achieved in bovine milk and orange juice but bacterial spores were not affected [73]. Currently, the equipment is very expensive and its potential appears to be limited.

18.2.13 Bactofugation (Separation by Weight)

Bactofugation is the removal of microbial cells from milk using high centrifugal forces. This method is most efficient against microbial cells of high density, especially bacterial spores (1.2–1.3 g/l) and somatic cells. The method can remove around 98% of anaerobic spore-forming organisms and 95% of aerobic spore-forming organisms. Vegetative bacteria are more difficult to separate due to their much lower density, and reductions of about 89% can be achieved [74]. For dairy milk, bactofugation is used mostly in combination with thermal pasteurisation due to its relatively good effectiveness against spores but weakness in non-spore bacterial removal [75].

18.2.14 Filtration (Separation by Size)

Human milk consists of a large variety of components that range in size. Sizes of targeted micro-organisms and human milk components mostly overlap, making it difficult to separate micro-organisms by size without loss of human milk components.

18.3 Potential Alternative Pasteurisation Methods for Human Milk

Thermal pasteurisation of human milk is well researched and its impact on micro-organisms and bioactive components is well known. To optimise the retention of bioactive components, the temperature profile can be changed. However, bacterial reduction and bioactive component retention are closely but inversely related to each other. This may be solved using pasteurisation methods where this relationship is less specific. The most promising alternative pasteurisation method is irradiation. By targeting DNA and RNA directly, electron, x-ray, gamma, and ultraviolet irradiations have a different inactivation mechanism to heat treatment. Of the four, ultraviolet irradiation has the lowest energy density making the costs of the treatment device and safety and protection equipment significantly lower than those of other irradiation types. Furthermore, ultraviolet, specifically UV-C, has been shown to be highly germicidal with less damaging effects on bioactive components in human milk than thermal pasteurisation [65], [66]. These findings show promise to improve the quality of pasteurised donor human milk while maintaining the safety standard of Holder pasteurisation.

Key Points

- Pasteurisation a process whereby food, usually a liquid, is partially sterilized by eliminating bacteria and viruses, making it safe for consumption
- The most common pasteurisation method is Holder pasteurisation which reduces vegetative bacteria sufficient to meet safety standards but does result in significant loss of many important bioactive human milk components
- Alternative pasteurisation methods can also damage important milk components, are very expensive or may not be reliable enough to safety standards
- Ultraviolet irradiation meets safety standards than Holder pasteurisation but shows higher retention of bioactive components; however, this method needs further investigation

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19 Human Immunodeficiency Virus (HIV)

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Expected Key Learning Outcomes

- The safety of breastfeeding for HIV positive mothers
- Recommendations for antiretroviral (ARV) treatment
- Considerations for decision makers

19.1 Research Perspective

19.1.1 Development of Infant Feeding Guidelines

Since the first report in 1985 that Human Immunodeficiency Virus (HIV) could be transmitted via breast milk there has been considerable debate, controversy and confusion around breastfeeding by HIV-infected women. The initial response from the US Centers for Disease Control and Prevention recommended that HIV-infected women should not breastfeed but instead make use of replacement milk feeds [1]. This caused problems for poorer countries, which were unlikely to be able to follow this guidance without putting their infants at considerable risk of mortality. The World Health Organization (WHO) and other agencies then faced the dilemma of dual guidelines, one for rich countries and one for poor. WHO finally advocated a shorter duration of breastfeeding (3–4 months) as the safest option, or the complete avoidance of breastfeeding if it could be done safely [2].

Considerable efforts were leveraged to provide "safe" replacement feeding to HIV-exposed infants, and several countries and international agencies distributed free formula milks to HIV-infected mothers to reduce HIV transmission through breastfeeding. Several calls were made to review these policies [3], [4] but these generally went unheeded with governments and non-governmental organisations choosing to concentrate on minimising the risks of environmental contamination during the preparation of formula milk feeds. They ignored the fact that no matter how "hygienic" the formula milk feed, excluding breast milk from the infant's diet also excluded vital immune components that confer the protection [5] needed to reduce the risk of infectious disease mortality.

During this time, a surprising observation was documented in a study in South Africa. This study reported that mothers who had exclusively breastfed their infants for at least 3 months had a significantly lower risk of transmitting HIV to their infants during the breastfeeding period compared to mothers who had not exclusively breastfed [6].

These findings were soon replicated in several other African studies, and the information was incorporated into the revised WHO guidelines in 2006 [7]. These revisions recommended 6 months of exclusive breastfeeding for women in whom replacement feeding was not considered to be acceptable, feasible, affordable, sustainable or safe. In recognition that risk associated with formula feeding was variable and dependent on many factors, including access to clean water and health services and other maternal and social factors, WHO recommended that replacement feeding should be considered only when it was deemed to be "acceptable, feasible, affordable, sustainable or safe".

As these guidelines were put into place, many programmes were reporting that mothers and health care workers were interpreting the guidelines to recommend 6 months exclusive breastfeeding only. This resulted in early cessation of all breastfeeding when the period of exclusive breastfeeding ended. A randomised controlled trial in Zambia reported that early cessation of breastfeeding resulted in increased mortality of all infants but especially of those infants who were HIV infected [8]. Country reports and several studies also began to detail increasing diarrhoeal and pneumonia deaths by excluding breastfeeding to prevent HIV transmission [9], [10], [11].

With the reminder of the important role that breastfeeding plays in child survival, researchers turned their attention to ways of preserving breastfeeding while making it safer by reducing HIV-transmission risk. It had been clearly established that the risk of transmission by breastfeeding is closely associated with the mothers CD4 cell count and viral load. Thus, it followed that antiretroviral drugs (ARVs), which are effective in reducing HIV viral load, could play a role in reducing HIV transmission during breastfeeding (as for *in utero* and *intra partum* transmission). Studies showed that when mothers were provided with a combination of ARV drugs or when children were provided with single or dual drug prophylaxis, the risk of transmission was reduced to < 2%. Several studies in the years 2000–2009 [12] showed that such drug use resulted in significant reductions in HIV transmission during breastfeeding.

Following these studies, further revision of the guidelines became necessary. In 2010, WHO recommended ARVs to prevent postnatal transmission of HIV through breastfeeding [13], [14]. In addition, the WHO recommended a public health approach that member states should principally promote and support a feeding practice for all HIV-infected women who accessed public health facility care. Previous guidelines had been dependent on health care workers as they encouraged an individualised approach of counselling HIV-infected women on feeding options dependent on each woman's individual household and social circumstances.

The new guidelines called for a change from this individualised approach to a public health approach, where countries were encouraged to consider the socio-economic and cultural contexts of their populations and then choose to support either breastfeeding or formula feeding in their public health services. It was recommended that women should breastfeed for about 12 months and that those women with CD4 cell count ≤ 350 should be prioritised for ARV treatment. For women with CD4 cell count > 350, WHO recommended that either infants received Nevirapine (NVP) prophylaxis for the duration of breastfeeding (known as Option A) or mothers received ARV prophylaxis with three drugs (known as Option B).

Again, new research findings necessitated reformulating guidelines. Some studies were extrapolated to suggest that if HIV-infected pregnant or lactating women were started on ARV treatment at CD4 cell counts < 350, it would improve their health and make them less likely to transmit the virus to their sexual partners. In view of the potential added benefit to maternal health, WHO recommended that countries adopt an Option B approach instead of Option A [15].

When the United Nations International Children's Fund (UNICEF) published the Clinton Health Access Initiative Business Case [16], there was strong encouragement that countries extend their programmes and adopt the newly coined programme, Option B +. This option recommended that all HIV infected women started ARVs early in pregnancy and stayed on them for life; thus, women with higher CD4 cell counts were no longer expected to discontinue ARVs after cessation of breastfeeding. Consequently in 2013, when WHO published Consolidated Guidelines on the use of ARV drugs for treating and preventing HIV infection they included the Option B + recommendation on the use of ARVs for prevention of post-natal transmission [17]. In 2016, the WHO Guidelines were updated again and of note was new guidance recommending that the period of breastfeeding should increase from 12 to 24 months [18].

There is now considerable evidence that transmission of HIV during breastfeeding over 6–12 months is negligible, particularly when mothers begin ARV prophylaxis during pregnancy from 14 weeks, are adherent to their ARVs during pregnancy, intra-partum and breastfeeding, and have an undetectable viral load. This has been confirmed in a recent study that reported a transmission rate of 0.28% through 12 months of breastfeeding [19].

Although ARV interventions seem to be a guaranteed method for reducing HIV transmission, two major problems to the prevention of transmission by breastfeeding are particularly common in the developing world:

- **Late presentation for antenatal care**, resulting in mothers commencing ARV late in pregnancy and therefore entering the delivery and breastfeeding periods with inadequately suppressed viral load, which is a major risk factor for transmission.

- **Inadequate adherence to ARVs** during the breastfeeding period, with the infant probably most vulnerable during the early breastfeeding period. Inadequate adherence to ARVs is a major problem in the developing world. There are many reasons for this: stigma, lack of social support, food insecurity, lack of understanding of the dangers of non-adherence, and health system failures resulting in depleted drug stocks.

19.2 Risk Factors for Transmission

19.2.1 Non-exclusive Breastfeeding

As discussed, non-exclusive breastfeeding is a risk factor for HIV transmission. This resulted in calls to encourage exclusive breastfeeding in the first 6 months of birth. Similarly, high HIV viral load was identified as a major risk factor. Programmes were therefore implemented to provide ARVs to mothers and/or infants to lower their viral load, including that in breast milk, and thus reduce transmission.

The extent to which exclusive breastfeeding and ARVs are independent variables of HIV transmission is not clear. Currently, there is no clear answer as to whether the risk of non-exclusive breastfeeding is eliminated by ARV use. However, it is clear that even with ARVs it is important to promote and encourage exclusive breastfeeding because of its independent effects on preventing morbidity and late-onset metabolic disorders.

19.2.2 Breast Pathology

Before the use of ARVs to prevent HIV transmission during breastfeeding, mothers with mastitis and other breast pathology were reported to be at increased risk of transmitting HIV to their infants. Women with any breast pathology were encouraged not to feed from the affected breast but to express and discard breast milk from the affected side while continuing to feed from the unaffected side. As with non-exclusive breastfeeding, there is insufficient information to clarify whether the risks of breast pathology are eliminated by ARVs; as such, the current recommendation is to use the old guidelines until new data become available.

19.2.3 ARVs in Breastmilk

Waitt et al. conducted a systematic review and meta-analysis of 24 studies investigating the concentrations of ARVs in breast milk [20]. Relatively low ARV penetration into breast milk was found when compared to levels in maternal plasma, although there was considerable variability in methodologies of extraction. Overall, studies appeared to indicate that nucleoside reverse transcriptase inhibitors (NRTIs) have higher and more variable breast milk penetration than non-NRTIs or protease inhibitors (PIs). Accumulation of PIs in breast milk was found to be minimal. Transfer of these drugs to the infant is also variable; lamivudine (3TC) and NVP appear to have higher transfer rates (5–10%) while Efavirenz had a much lower rate (2–3%).

A concern is that transfer of low levels of individual drugs to the breastfed infant would potentially confer high rates of drug resistance should the infant later become infected. However, given the negligible risk of infection, this may not be an over-riding issue. Other risks associated with transfer of ARVs to the infant are minimal, and usually include increased risk of anaemia and neutropenia.

19.3 Remaining Research Questions

19.3.1 ARV Prophylaxis

Questions remain unanswered about which combination of ARVs to use, whether providing ARVs to mother or infant give better outcomes overall and in terms of pregnancy, infant and maternal side effects. Over the last few years there have been reports of associations between anaemia and Zidovudine (ZDV), neutropenia and NVP, and cardiac toxicity and adrenal dysfunction and Kaletra. A systematic review suggested that extended ARV prophylaxis does not have a negative impact on the growth and incidence of non-HIV infections in HIV-exposed infants [21], although more data are needed. The recently published PROMISE study [53] has provided valuable information to answer the question as to whether ARV prophylaxis should be given to mother or infant. The study with approximately 2400 breastfeeding mother-infant pairs, randomized the pairs either to mother receiving ARV prophylaxis or infant receiving prophylaxis with nevirapine for the duration of breastfeeding (median time 16 months). The results showed that both strategies were safe and resulted in similarly low breastfeeding transmission rates (0.57 and 0.58%).

19.3.2 ARVs and Breastmilk Components

Recent high-quality research has shown that HIV infected and uninfected mothers have similar concentrations of serum and breast milk immunoglobulins and cytokines [22]. However, additional information on the impact of ARVs on the immunological and nutritional components of breast milk is required.

19.3.3 Role of Vaccines

Immune therapy and vaccination are currently being investigated as possible strategies to reduce HIV transmission during breastfeeding [23]. Data are needed on whether the vaccine should be administered to mothers or infants. A variety of trials has been conducted and several vaccines have been tested, which show the strategies to be well-tolerated (efficacy data are still awaited). Preliminary studies using human monoclonal antibodies (mAb) are promising. Currently, studies are investigating use of VRC01, a human mAb targeting the CD4 binding site of HIV-1 gp120, which has broad neutralising activity against viruses [24].

19.4 Safe Breastfeeding Strategies

As detailed above, using ARVs in mother and/or infant is the mainstay of making breastfeeding safer for infants born to HIV-infected mothers. However, there are two other important strategies, exclusive breastfeeding and pasteurisation of breast milk.

19.4.1 Exclusive Breastfeeding in the First 6 Months

It is well established that exclusive breastfeeding compared to non-exclusive breastfeeding reduces HIV transmission to infants. Smith and Kuhn, 2000, discussed the physiological mechanisms to explain this robust finding [25]. Of importance is that exclusive breastfeeding has been found to be associated with a significantly lower risk for breast pathology [26], which would account for its reduced risk for HIV transmission.

Exclusive breastfeeding is also known to influence the establishment of the microbiota of primate infants, which in turn influences the development of the immune system. A recent study reported that exclusively breastfed rhesus macaques developed robust populations of memory T cells and T helper-17 cells within the memory pool, unlike their formula-fed counterparts, which would explain the differences in protection against infection [27].

19.4.2 Breastmilk Pasteurisation/Heat Treatment

Early work from South Africa showed that heating a single bottle of breast milk in a pot of water to 62.5 °C for 30 minutes was effective in destroying HIV. This methodology was based on the Holder pasteurisation method, which is used widely to pasteurise breast milk in human milk banks. In 2000, Chantry and colleagues simulated a different method known as flash pasteurisation or high temperature, short time heating, using temperatures of 72 °C for 15 seconds to destroy HIV in breast milk [28].

Using this methodology, Chantry's group was able to demonstrate that such "flash-heating" was capable of inactivating spiked cell-free HIV-1, as detected by reverse transcriptase activity [29]. Additionally, flash-heating was shown to inactivate HIV in naturally-infected breast milk samples collected from HIV infected mothers in South Africa [30]. Importantly, the researchers showed that flash-heat methodology inactivated cell-associated HIV as well as cell-free HIV [31]. Pilot data suggested limited negative impact of flash-heating on vitamins and proteins [29]. Work on naturally infected breast milk samples from women in South Africa showed similar limited negative impact [32].

Flash-heating is capable of eliminating pathogenic and non-pathogenic bacteria and an 8-hour storage period outside the refrigerator does not result in a significant increase of bacteria [33]. Furthermore, the heat treatment did not diminish the bacteriostatic activity of breast milk [34]. Importantly, the majority of breast milk's immunoglobulin activity survives the heating, suggesting flash-heated breast milk is immunologically superior to breast milk substitutes. Additional studies showed that flash heating resulted in a decrease of 20% in total immumoglobulin (Ig) A and 33% of total IgG. Similar decreases were seen in anti-HIV-1 gp120 IgG, anti-pneumococcal polysaccharide and anti-poliovirus IgA. Although the latter was most affected, 66% of the unheated antigen-binding ability was still retained. In contrast, the binding capacity of IgA and IgG to influenza increased after heating [35]. This flash-heating method has been shown to be feasible for use in neonatal intensive care units in developing countries [36] and in older infants where ARVs are not available [37].

19.5 Infant Feeding Options

As much as policy makers strive to have one policy for all, two different scenarios have evolved for infant feeding by mothers with HIV, divided mainly by the degree of country development.

19.5.1 Developed Countries

Historically, mothers with HIV in the developed world were discouraged/prohibited from breastfeeding their infants and there are reports of mothers in the UK and US facing prosecution for such action. Following clinical evidence of reduced HIV transmission when a mother was receiving ARV therapy, the British HIV Association (BHIVA) and the Children's HIV Association published a revised position paper in March 2011 [38]. The default recommendation still remains as formula feeding but, additionally, it now allows after careful consideration a virally-suppressed woman on effective ARVs to choose to exclusively breastfeed for the first 6 months, provided that she is fully adherent to her ARV therapy and remains virally suppressed.

In 2013, the American Academy of Pediatrics (AAP) applied a similar rationale and reversed its previous stance against breastfeeding [39]. The revised AAP guidelines recommend formula feeding by HIV-infected mothers but, similar to the UK, they encourage clinicians to support mothers if they express any interest in breastfeeding.

19.5.2 Developing Countries

As discussed earlier, in developing countries, replacement feeding resulted in unacceptable rates of infant and young child morbidity, mortality, and malnutrition [4], [40]. Even before ARV use in developing countries with high infant mortality rates, modelling showed that breastfeeding carried an improved infant HIV-free survival relative to formula feeding. It was therefore no surprise that with the introduction of ARV prophylaxis, breastfeeding together with ARV therapy resulted in a significantly greater infant HIV-free survival than replacement feeding.

The importance of a different default feeding option in developing countries is highlighted by the renewed emphasis on breastfeeding as a strategy to improve household food security and protection from infectious disease. Re-positioning of good breastfeeding practices is key to attaining the second goal of the United Nations [41] Sustainable Development Goals (i.e., to end hunger and improve nutrition and by 2030 to end all forms of malnutrition with special attention to stunting and wasting in children under 5 years of age).

For the few infants who escape the protection afforded by ARVs and are infected with HIV, there is considerable scientific evidence confirming that HIV-infected infants who receive breastfeeding for 2 years or more have a better health outcome than those who receive replacement feeding. As such, WHO recommends that HIV-infected infants are breastfed.

It is vital that HIV-infected infants are identified as early as possible. Point-of-care, same-day results for an HIV diagnosis in infants is becoming widely available, allowing HIV-infected infants to be identified soon after delivery. This is to be encouraged to ensure that mothers do not discontinue breastfeeding without knowing the HIV status of their infants.

19.6
Policy Implications of Infant Feeding Recommendations

Scientific evidence on the risk factors associated with HIV transmission during breastfeeding and the efficacy of ARV drugs given either to the mother or infant to reduce this risk, has given mothers the confidence to breastfeed. This is vital considering the strong maternal drive to feed their young, and to nurture the mother-child bond. Since lack of confidence is known to influence a mother's ability and resolve to breastfeed, health care workers play an important role in continuing to supply mothers with up-to-date information to guide and encourage them. Support is needed to encourage mothers to exclusively breastfeed during the first 6 months and to continue for 24 months or longer depending on the setting.

A key strategy to promote breastfeeding is encouragement of the UNICEF Baby Friendly Hospital Initiative in all baby delivery facilities [42]. It is also imperative to engage communities and household members as supporters of breastfeeding. Each community is unique, so policy makers/health care workers need to work with communities to try to elucidate the constraints and facilitators for supporting breastfeeding mothers [43].

Policy makers also need to engage multi-sectors and advocate for laws to protect breastfeeding mothers, allowing them sufficient maternity leave to enable 6-months exclusive breastfeeding followed by a place and time at work to express milk to ensure a continued milk supply. Other important policies are those for HIV-infected women (and others) who have problems such as difficult deliveries, which prevent them from producing sufficient breast milk for their infants.

Breastmilk is especially important for low birth weight and/or preterm infants. Strategies need to be in place to ensure that vulnerable infants can be provided with donor breast milk, which imparts gut protection. There is evidence that low birth weight infants who receive formula milk instead of breast milk are at increased risk of necrotising enterocolitis, which increases their risk of HIV infection. Additionally, recent evidence of exclusive breastfeeding in older infants, as measured using the deuterium dilution method, suggests that higher percentages of breast milk intake are associated with lower levels of gut inflammation. Those infants whose intake was 100% breast milk had the lowest levels of inflammatory markers as measured in faecal samples [44].

Donor human milk banks supplying donor milk are quite common in Brazil, US, Canada, Europe, and Australia but their use in the developing world is severely limited. This is an important strategy for protecting infants, especially HIV-exposed infants during vulnerable periods. One developing country (South Africa) has made progress by introducing simple technology to enable human milk banks to be set up in neonatal intensive care units. Thus, vulnerable infants who cannot access their own mother's milk are able to access donor milk in the early vulnerable period to afford gut protection [45], [36]. Internationally, there has been renewed commitment to promote breastfeeding, particularly using human milk banks as a strategy for child survival. A framework for countries to set up human milk banks was recently developed at an International Milk Bank Technical Advisory Group meeting convened by PATH [46].

Additional to the importance of mothers maintaining optimum breastfeeding practice, equally important is that mothers adhere to their ARV regimens in spite of side effects. Many of these side effects may not be sufficiently serious to warrant a clinical decision to discontinue or change an ARV regimen. It is therefore vital that policy makers consider strategies for facilitating ARV adherence, especially among disadvantaged and disempowered mothers who may not have sufficient support to motivate drug adherence. Ways of using community structures, faith-based institutions and other "safe" places to distribute ARVs, and providing counselling need to be established. Policy makers in developing countries, e.g., in Africa, also need to consider the increasing burden of food insecurity and the problems experienced by mothers taking ARVs when hungry [47].

WHO, UNICEF, and countries continue to look for simple algorithms to improve access to ARVs. Seen to hold great promise, the introduction of Option B + has not been easy to implement because one drug is not always possible and because severe side effects from the combination pill may be attributed to one or more of its three drugs.

Lack of adherence to ARVs, which exposes the infant to an increased risk of infection by transmission, also poses a problem. Health care workers may be under the misconception that all mothers issued ARVs are virally suppressed. It is therefore important for countries to consider monitoring viral loads rather than CD4 cell counts. In cases where mothers are not adherent or started drugs late in pregnancy, additional prophylactic cover is recommended for infants during the breastfeeding period. Instead of providing only 6 weeks of prophylaxis with NVP, infants should receive 12 weeks of dual prophylaxis (NVP and ZDV). Where mothers are not able or refuse to adhere to prophylaxis because of side effects, the option of providing infants with prophylaxis for 12 months or for the duration of breastfeeding should be considered. A recent study reported that 12 months prophylaxis with either Kaletra or 3TC to infants resulted in the very low transmission rate of 1.4–1.5% at 12 months [48].

This welcome change in infant feeding guidelines will now result in many HIV-exposed infants receiving the benefits of breastfeeding for longer periods with a negligible risk of HIV infection. This change has now brought into focus another policy, which is in need of re-examination viz. the daily cotrimoxazole prophylaxis policy for HIV-exposed uninfected infants. This policy was initially implemented by WHO [49] almost 15 years ago based on evidence of its effectiveness in protecting HIV infected infants. It was believed that given the risk of HIV infection through breastfeeding, infants were at considerable risk of HIV infection and therefore would benefit from the known benefits in the case of their becoming infected. However, with the new infant feeding guidelines, the risk of HIV infection is negligible and the risks of daily antibiotic administration may likely outweigh the small purported benefits especially with prolonged breastfeeding [50]. A recently published study from South Africa has confirmed that breastfeeding, HIV exposed, uninfected infants derive no health benefits from cotrimoxazole prophylaxis and the investigators have consequently called for a discontinuation of this policy [51].

Finally, the foundation to prevent transmission during breastfeeding must surely be primary prevention, as re-iterated in the first two of the four United Nations' recommendations [52] for elimination of mother-to-child transmission of HIV (i.e., primary prevention of HIV infections in young women and prevention of unplanned pregnancies in HIV infected women).

Key Points

- In mothers that adhere to the recommended antiretroviral prophylaxis, the transmission of HIV through to 12 months of breastfeeding is negligible
- In countries that have opted to promote and support breastfeeding with ART, HIV-infected mothers should be encouraged to be adherent to ART; practice exclusive breastfeeding for 6 months and then add complementary feeding while continuing to breastfeed until 24 months or beyond
- Review of policy frameworks around HIV and breastfeeding needs to be done on a global basis in order to optimise infant feeding practices in regions with high HIV infection rate

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20 Breastfeeding and the Use of Medications

Thomas W. Hale, Prof, PhD, RPh, and Teresa Ellen Baker, MD, FACOG

Expected Key Learning Outcomes

- The risks of medication transfer to human milk
- Considerations and recommendations for clinicians when prescribing medication to lactating women
- Measurement of infant exposure to medications
- Where to get further help and advice

20.1 Introduction

Human milk provides the infant's first and finest choice for protection against infectious organisms because it is perfectly suited to the infant's gastrointestinal (GI) tract. The numerous growth factors in human milk enhance growth and maturation of the infant's relatively permeable GI tract.

Medication use by pregnant and breastfeeding women has risen enormously over the last few decades, and it is estimated that between 40% and 90% of pregnant women take at least one medication during pregnancy [1], [2]. This increased frequency in medication use during pregnancy is likely to result in even more medications used during the postpartum period while the mother is breastfeeding.

A population-based study conducted during 1998–2002 found that while the prevalence of medication use decreased from 72% prior to pregnancy to 56% during pregnancy, it rose again to 78% in the postpartum period [3]. Several studies have found that the use of medication during the time from delivery of the placenta through the first few weeks after the delivery (puerperium) is high, ranging from 98–99% of all mothers [4], [5].

Inevitably, the use of medications during lactation involves a level of complexity not usually encountered by most clinicians. In these instances, the risk-to-benefit analysis must include not only the health of the mother but that of the infant, who may or may not receive benefit, untoward side effects, or overt toxicity secondary to the mother's treatment.

We are now aware of many of the currently available medications that are significantly hazardous to the foetus or to the breastfed infant, and we universally try to avoid them. However, almost all drugs pass into human milk, with the potential to produce untoward side effects in the infant. This continues to occur today, even though we have more extensive knowledge of this area. The risk is generally less in older infants as they are generally less susceptible to most drugs present in milk and are more metabolically able to eliminate virtually any drug.

Fortunately, the human breast is relatively efficient at preventing high concentrations of many drugs and chemicals from entering into their compartments. Thus, the relative number of medications that are truly hazardous to a breastfeeding infant is rather low. This chapter discusses the entry of medications into human milk and their relative risks.

20.2 Evaluating the Age of the Infant

The age of the infant is one of the more critical elements in determining the sensitivity of the infant to various medications. In the first 2–3 days postpartum (the colostral phase), the alveolar structure of the breast is quite open and porous, thus permitting almost complete access of maternal proteins, lipids, immunoglobulins, and medications into the milk compartment. During this period, most drugs in milk reach equilibrium with the plasma compartment. However, at 4 days, as the alveolar epithelial cells begin to swell, the intercellular gaps close and the alveolar system becomes increasingly less porous. This results in dramatically lower drug levels in the milk compartment after the first week postpartum. Regardless of porosity, even during the early porous stage, the volume of milk produced and transferred to the infant is so small that the absolute clinical dose of medication transferred is often miniscule.

Premature infants are highly sensitive to medications and thus the risk to the infant is much higher. In instances where the infant is still in a neonatal intensive unit, some risks are acceptable because the nursing staff is closely monitoring the infant. If the infant has been discharged, mothers should be cautioned about potential side effects, such as apnoea and respiratory depression, that the parents must monitor at home.

In infants older than 6 months, most drugs pose less risk because the infant has developed significant renal function and respiratory control, and is more able to metabolically eliminate the drug. As the infant ages past 6 months, milk production in most mothers tends to wane with a decline in the volume of milk, thus less drug is delivered to the infant. After 18 months, the volume of milk is often negligible as is the risk of most drugs.

20.3 Neonatal Pharmacokinetics

Paediatric patients are generally referred to as "therapeutic orphans" due to the lack of pharmacokinetic studies in infants and young children. Less than 1% of all therapeutic agents have recommended dosing guidelines for the premature infant. Thus, in infants, comparing the dose of medication delivered via milk to a normal clinical dose is exceeding difficult because dosing regimens for this age group are often unavailable.

Oral medications present in milk must be absorbed via the GI tract. However, there are little or no data on the absorption of drugs in infants. A state of relative achlorhydria exists in the stomach in the first week postpartum. During the first few weeks of life, the pH of the stomach rises to a pH of 4.0, after which it slowly declines towards adult values over the next two years. Weak acids (e.g., phenobarbital) may have reduced absorption, while weak bases may have enhanced absorption. Since the infant's exposure is by the oral route, oral bioavailability of the medication is of paramount importance. As in adults, drugs with high first-pass clearance (e.g., morphine) are rapidly cleared from the portal circulation by the liver. Drugs with poor stability in the gut (e.g., aminoglycosides, insulin, heparin) are rapidly degraded in the stomach or intestine. Poor biliary function subsequently leads to poor lipid absorption and relative steatorrhea in premature infants, so lipid-soluble drugs presented in milk are likely to have poorer bioavailability.

Compared to adults, gastric emptying time is greatly prolonged in premature infants and in some cases may completely alter absorption kinetics; total body water content is higher in infants; protein binding is decreased in neonates; and the capacity of the liver for oxidative and conjugative metabolism is greatly reduced in neonates [6]. While the metabolic capacity of the liver is limited in the newborn, it rapidly increases and actually supersedes adult capacity in subsequent months [7]. Ultimately, the evaluation of the safety of drugs in breast milk depends on three major factors:

- Amount of medication present in milk
- Oral bioavailability of the medication
- Infant's ability to clear (remove from the body) the medication, thus preventing high therapeutic levels

While the amount present in milk has been published for some drugs, the ability of the infant to clear the medication renally and hepatically is highly variable and should be the subject of clinical evaluation. Infant clearance has been estimated to be 5%, 10%, 33%, 50%, 66%, and 100% of adult maternal levels at 24–28, 28–34, 34–40, 40–44, 44–68, and > 68 weeks postpartum, respectively [8].

20.4 Maternal Drug in Human Milk

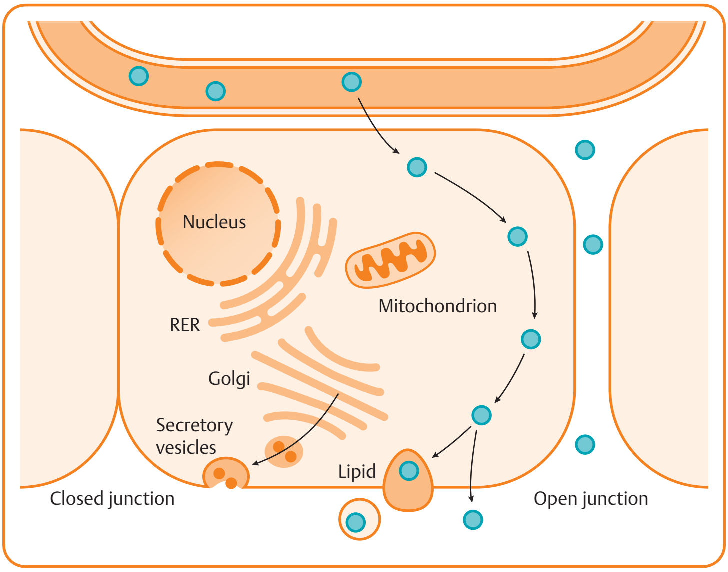
The maternal plasma compartment is the only source of medications to breast milk. Hence, the transfer of drugs to human milk is carefully controlled by the alveolar epithelial cells (lactocytes or milk-producing cells) present in the alveoli of the breast. Each drug must exit the maternal plasma compartment, pass through the alveolar basement membrane, and enter the milk either through or between lactocytes. Once the drug reaches the milk, its physicochemistry will determine if it stays or is transferred back into the maternal plasma and excreted.

As such, most drugs attain equilibrium between the plasma of the mother and the milk compartment, thus entering and exiting the alveolar compartment depending on the plasma levels of the drug. At peak maternal levels, the concentration gradient is greater and higher levels of medications are generally forced into the milk compartment. The degree of equilibrium also depends on the lipid solubility, molecular weight, protein binding, and pKa of the drug. The relative ratio of drug in milk to plasma is called the milk to plasma ratio (M/P ratio). Often misused and misunderstood, this term simply describes the relative ratio between these two compartments and should not be construed to describe the absolute dose of medication transferred to the infant. Drugs, such as ranitidine and bupropion, with high M/P ratios and low plasma levels still deliver small doses of the medication.

The transfer of medications into milk is a dynamic process with medications entering and exiting the milk compartment largely as a function of the maternal plasma level (▶ **Fig. 20.1**). Most drugs are not “trapped” in milk, but maintain a dynamic equilibrium to and from the maternal plasma. As such, advising mothers to “pump and discard” is not usually required to assist drug elimination; just waiting a few hours for the maternal plasma level to drop is equally efficacious. Advising mothers to breastfeed before taking the medication often works with medications with a short half-life but not with those with a long half-life.

20.5 Bioavailability

The bioavailability of a medication generally refers to the amount of drug that reaches the systemic circulation after administration. Depending on the route of administration (oral, intravenous, intramuscular, subcutaneous or topical), medications must ultimately pass into the systemic circulation prior to reaching their intended site of action or the milk compartment. The poor bioavailability of many products reduces their level of exposure to breastfed infants. In some instances, some medications are unstable in the gastric milieu or are incompletely absorbed by infants. Most, but not all, topical medications are poorly absorbed transcutaneously, so they seldom attain significant plasma levels. The liver sequesters or metabolises many



▶ **Fig. 20.1** Transcellular distribution of drugs across the lactocyte.

orally-administered medications preventing their entry into the plasma compartment. Because infants receive drugs via the mother's milk, oral bioavailability is of major importance in evaluating the potential risk to the infant. The absolute dose of a medication the infant receives via milk is a function of the drug's oral bioavailability; drugs with poor bioavailability are therefore preferable for breastfeeding mothers as their absorption by the infant is likely poor.

20.6 Calculating Infant Exposure

One of the simplest methods of determining the safety of the medication is to relate the weight-normalised dose the infant receives via milk to that administered orally during infant therapy (where specific data are available). However, the most useful and accurate measure of exposure is to calculate the relative infant dose (RID), as follows.

The RID is generally expressed as a percentage of the mothers' dose. Its calculation provides a standardised method of relating the infant's dose to the maternal dose. In full term infants, Bennett [9] recommends that a RID of > 10% should be the theoretical "level of concern" for most medications. However, in premature infants, the "level of concern" may be lower depending on the medication. In this respect, it should be understood that neonates may have been exposed in utero to drugs taken by their mothers, and that in utero exposure may be an order of magnitude greater than that received via breast milk.

Finally, all medications enter the milk compartment. However, the vast majority of drugs do so at levels so low that the amount present is clinically irrelevant. Without exception, the use of medications by breastfeeding mothers automatically implies that some of those medications will transfer to the infant. The degree of risk to the infant requires an understanding of the pharmacokinetics of drug transfer into human milk. This review summarises what we presently understand and don't understand about the entry of drugs into human milk, and its clinical implications to newborn and premature infants. Knowing when to discontinue breastfeeding and when to support continued breastfeeding is of major importance to the mother and infant dyad.

20.7 Review of Important Selected Drug Classes

20.7.1 Analgesics

Analgesic drugs are the most commonly used medications by breastfeeding mothers, particularly in the early postnatal period. Consisting primarily of non-steroidal analgesics and opiates, millions of mothers annually use these drugs during breastfeeding. ▶ **Table 20.1** provides an overview of analgesics in human milk.

Nonsteroidal anti-inflammatory drugs (NSAIDs)

Numerous NSAIDs exist, and many of them have been studied in breastfeeding mothers. However, ibuprofen (Advil) is perhaps the most preferred drug in this group. Ibuprofen is an ideal analgesic for breastfeeding mothers as the levels found in milk levels are very low. Less than 0.7% of the maternal dose is transferred daily to the infant [10]. The use of ketorolac (Toradol) is controversial. Previously, ketorolac was criticised for impeding platelet function. However, more recently, there is concern about the risk to the mother of acute renal injury, particularly in early postpartum or volume constricted patients. While ketorolac (Toradol) may cause bleeding problems in some postpartum women due to the inhibition of platelet aggregation, its drug levels in milk are insignificant. In a study of lactating women who received ketorolac 10 mg orally four times a day, milk levels of ketorolac were not detectable in four of the 10 subjects [10]. In the remaining six subjects, the ketorolac concentration in milk 2 hours after dosing ranged 5.2–7.3 µg/L on day 1 to 5.9–7.9 µg/L on day 2. In this study, ketorolac was administered orally rather than by intramuscular injection, which would avoid some of the first-pass effect, but even so, ketorolac may be considered moderately safe analgesic for breastfeeding mothers.

▶ **Tab. 20.1** Analgetics in human milk.

Drug	Relative infant dose (%)	Lactation risk category*	References
Acetaminophen	8.8–24.2	Compatible	[65], [66], [67], [68]
Aspirin	< 2.5–10.8	Compatible in low doses. Prolonged use could be problematic, so other analgesics are preferred	[69], [70], [71]
Celecoxib	0.3–0.7	Compatible. Observe infant for diarrhoea	[11], [12]
Ibuprofen	0.1–0.7	Compatible	[72], [73], [74]
Ketorolac	0.2	Compatible	[10]
Naproxen	3.3	Compatible. Avoid chronic use. Observed infant for diarrhoea	[75], [76]
Indomethacin	1.2	Probably compatible. Avoid chronic use. Observed infant for diarrhoea	[77], [78]
Morphine	9–35	Probably compatible. Observe for sedation, constipation, and apnoea	[13], [79], [80]
Hydromorphone	0.67	Probably compatible. Observe for sedation, constipation, and apnoea	[81]
Hydrocodone	2.21–3.7	Probably compatible. Observe for sedation, constipation, and apnoea	[82], [83]
Oxycodone	1.0–8	Probably compatible. Observe for sedation, constipation, and apnoea	[17], [84], [85]
Codeine	0.6–8.1	Possibly hazardous. Observe for sedation, constipation, and apnoea	[71], [16], [86]
Fentanyl	2.9–5	Probably compatible	[87], [88], [89]

*Lactation risk categories derived from Hales' Medication and Mothers' Milk, 2016

Older studies of celecoxib (Celebrex) suggest it is a safe analgesic for breastfeeding mothers. In a study of women receiving 200 mg daily, celecoxib levels in milk averaged 66 µg/L [11]. The daily intake by an infant has been estimated to be approximately 20 µg/kg/day [12]. Using these data, the RID was 0.34% of the maternal dose. Plasma levels of celecoxib in two infants studied were undetectable (< 10 ng/mL).

Opiates

Opiates for pain control include mild to strong opiates, such as hydrocodone, oxycodone, oxymorphone, fentanyl, sufentanil, and morphine. Opioids are often used for acute pain after cesarean section or for other procedures in breastfeeding mothers. Morphine is generally the preferred opioid used in breastfeeding mothers because it has poor oral bioavailability (26%) in the infant and a low RID of 9.1% [13]. However, hydrocodone and oxycodone are more commonly used worldwide. Hydrocodone is minimally transferred into milk. In a more recent study, hydrocodone and hydromorphone levels were measured in 125 breast milk samples obtained from 30 women receiving hydrocodone 0.14–0.21 mg/kg/day (10–15 mg/day) to alleviate postpartum pain [14]. Neonates received 1.6% of the maternal weight-adjusted hydrocodone dosage; when combined with hydromorphone, the total median opiate dosage from breast milk was 0.7% of a therapeutic dosage for older infants. Standard postpartum dosages of hydrocodone were considered to be acceptable for women nursing newborns. However, there are reports of adverse events in infants exposed to hydrocodone via breast milk, and all opioids should be used with caution in newborns [15].

Since 2005, use of codeine has declined due to the death of an infant whose mother was taking codeine while breastfeeding [16]. Both codeine and oxycodone are less favourable opioids because they have unpredictable metabolism (via CYP 2D6 enzyme), produce active metabolites, and cause CNS depression in infants [17]. In a cohort of mothers using oxycodone, codeine, and acetaminophen for pain during lactation, reports of infant sedation were 20.1%, 16.7%, and 0.5%, respectively [17].

All opioids should be used with caution in breastfeeding mothers, particularly women with premature or unstable infants, with close monitoring of the infant for sedation and apnoea. Doses should be moderate to low and used for short periods only.

20.7.2 Anti-Infectives

Antibiotics

Virtually all antibiotics have been studied to some degree in breastfeeding mothers (▶ **Table 20.2**). The most commonly used drugs are the penicillins and cephalosporins. Due to high polarity, this drug group is largely excluded from the milk compartment and RIDs are generally quite low. The macrolide family, such as erythromycin, azithromycin, and clarithromycin, produce low levels in breast milk. Following a dose of erythromycin 2 g daily, drug levels in milk varied from 1.6–3.2 mg/L of milk [18]. Azithromycin transfer to milk is minimal and produces a clinical dose to the infant of approximately 0.4 mg/kg/day [19].

Data have suggested an association of the macrolide, azithromycin with pyloric stenosis in the newborn infant following postnatal maternal ingestion [20]. As a group, macrolides are probably compatible with breastfeeding, particularly after 6 weeks postpartum. Some caution is recommended with erythromycin early postnatally.

Antifungals

Nystatin, commonly used for candida infections, is poorly absorbed orally, and thus its transfer into milk is nil. Fluconazole transfers significantly into human milk with a relative infant dose of 16.4% to 21.5% [21] although this is still subclinical in infants. While this RID is higher than the 10% notional safety range, fluconazole has proven relatively safe in many cases, and the dose received via breast milk is far less than clinical doses commonly used directly in infants.

Sulphonamides

Sulfamethoxazole, is commonly used in combination with trimethoprim for various infections, particularly urinary tract and resistant staphylococcus infections. The RID of sulfamethoxazole and of trimethoprim is 2.3–6% [22], [23] and 9% [22], respectively. These doses are lower than clinical doses typically used in infants. However, sulphonamides should not be used in infants with hyperbilirubinemia or glucose-6-phosphate dehydrogenase deficiency.

20.7.3 Antidepressants

Almost all current antidepressants have been studied in breastfeeding mothers. Numerous studies suggest that levels of these agents in milk are low and that they are probably acceptable during breastfeeding (▶ **Table 20.3**).

Tricyclic antidepressants (TCAs)

While useful this group of antidepressant is poorly accepted by patients due to anticholinergic symptoms, such as xerostomia, blurred vision, and sedation. As such, TCAs are less often used than other antidepressant drugs. The RID of amitriptyline is less than 1.5% of the maternal dose [24]. Studies to date have been unable to detect amitriptyline in the infant's plasma. Doxepin should be avoided due to reported hypotonia, poor suckling, vomiting, and jaundice [25].

Selective serotonin reuptake inhibitors (SSRIs)

SSRIs are presently one of the most commonly used medications in breastfeeding mothers, and the most commonly studied drug group in breastfeeding mothers in the last decade.

The many published clinical studies on the use of sertraline, fluoxetine, and paroxetine by breastfeeding mothers clearly indicate that the transfer

▶ **Tab. 20.2** Antibiotics in human milk.

Drug	Relative infant dose (%)	Lactation risk category*	References
Amoxicillin	1	Compatible. Observe infant for diarrhoea or thrush	[90]
Cephalexin	0.4–1.47	Compatible. Observe infant for diarrhoea or thrush	[91]
Cefotaxime	0.4–0.3	Compatible. Observe infant for diarrhoea or thrush	[91]
Dicloxacillin	0.4–1.4	Compatible. Observe infant for diarrhoea or candida diaper rash	[90]
Azithromycin	5.9	Compatible. Observe infant for diarrhoea or thrush	[19]
Clarithromycin	2	Compatible. Observe infant for diarrhoea or diaper rash	[92]
Erythromycin	1.4–1.7	Compatible. Use postnatally associated with infantile hypertrophic pyloric stenosis. Observe for diarrhoea or thrush	[90], [20], [93]
Ciprofloxacin	0.4–6.34	Compatible. One case of pseudomembranous colitis reported. Observe for diarrhoea or candida overgrowth	[94], [95], [96]
Doxycycline	4–13.3	Compatible for short term use (< 3 weeks). Avoid chronic dosing. Observe infant for diarrhoea or candida overgrowth	[97], [98]
Tetracycline	0.6	Compatible for short-term use. Oral absorption low. Observe infant for diarrhoea or candida overgrowth	[90], [99], [100]
Clindamycin	0.9–1.8	Compatible. One case of pseudomembranous colitis reported. Observe infant for diarrhoea or candida overgrowth	[101], [90], [102], [103]
Metronidazole	12.6–13.5	Compatible with moderate transfer. No adverse effects reported in exposed infants. Dose via milk less than therapeutic dose. May impose bitter taste to milk. For 2 g single oral dose, discard milk for 12–24 h	[104], [105]

*Lactation risk categories derived from Hales' Medication and Mothers' Milk, 2016

of these medications into human milk is low and uptake by the infant is even lower. Side effects in infants include withdrawal following intrauterine exposure, although there are few reported problems following use of these drugs by breastfeeding mothers.

Sertraline appears to be the preferred SSRI. More than 50 infants have been evaluated across the many studies, which indicate that sertraline levels in breast milk and infant plasma are low to undetectable.

Fluoxetine has also been studied in at least 50 breastfeeding infants. Fluoxetine transfers into human milk in relatively higher concentrations, with reported levels as high as 9% of the maternal dose [26]. Clinically relevant plasma levels in infants have been reported due to the long half-life of fluoxetine's active metabolite. Consequently, with

▶ **Tab. 20.3** Antidepressant drugs in human milk.

Drug	Relative infant dose (%)	Lactation risk category*	References
Bupropion	0.11–2.0	Compatible	[106], [107], [108], [109], [110]
Citalopram	3.5–5.4	Compatible. Observe for somnolence	[111], [112], [27], [113], [114], [115], [116]
Escitalopram	5.2–7.9	Compatible	[117], [118], [28]
Fluoxetine	1.6–14.6	Compatible	[119], [120], [121], [122], [26], [123], [124], [125]
Fluvoxamine	0.3–1.4	Compatible	[126], [127], [128], [129], [130], [131]
Paroxetine	1.2–2.8	Compatible	[132], [133], [134], [135], [136], [137], [138]
Sertraline	0.4–2.2	Compatible	[139], [140], [141], [142], [143], [144]
Trazodone	2.8	Compatible	[145]
Venlafaxine	6.8–8.1	Compatible	[146], [147]

*Lactation risk categories derived from Hales' Medication and Mothers' Milk, 2016

its higher RID (versus sertraline), fluoxetine is not as preferable unless lower doses are used during pregnancy and early postpartum. In reality, fluoxetine is associated with a low incidence of untoward effects, and mothers who cannot tolerate other SSRIs should be maintained on this drug while breastfeeding.

There is moderate transfer of citalopram and its new congener, escitalopram to breast milk. In a study of seven women receiving an average of citalopram 0.41 mg/kg/day, the average RID was 3.7% [27]. Low concentrations of citalopram were found in the infants' plasma (2 and 2.3 µg/L). While no untoward effects have been noted in published studies, two cases of somnolence have been reported to the manufacturer. In another study of eight breastfeeding women taking an average of escitalopram 10 mg/day, the total RID of escitalopram and its metabolite was reported to be 5.3% [28]. Currently, escitalopram is probably preferred over citalopram for breastfeeding mothers.

Neonatal withdrawal symptoms have been commonly reported in infants (30%) exposed in utero to SSRIs with a shorter half-life (paroxetine, sertraline). With fluoxetine [29], [30], sertraline, and paroxetine [31], these symptoms, which occur early postnatally, consist of poor adaptation, irritability, jitteriness, and poor gaze control. Most clinicians do not treat neonatal withdrawal symptoms unless they are severe. For a mother taking SSRIs, breastfeeding the infant is certainly advised. However, the antidepressant concentration in the milk is usually too low to be effective in treating the withdrawal symptoms.

20.7.4 Immune Modulating Agents

The use of immunosuppressants and immune modulating agents in breastfeeding mothers is poorly understood. While there are few studies on these agents and their transfer to human milk, this does not preclude their use in breastfeeding mothers. The newer monoclonal antibody preparations are becoming increasingly important.

Methotrexate

Methotrexate is a potent and potentially dangerous folic acid antagonist used in immune diseases, particularly rheumatic disorders. It is also used as abortifacient in tubal pregnancies. Methotrexate is secreted into breast milk at low levels. Following an oral dose of 22.5 mg to a single patient, the methotrexate concentration in breast milk two hours post-dose was 2.6 µg/L of milk [32]. The cumulative excretion of methotrexate in the first 12 hours was only 0.32 µg in milk. Based on these findings, it was concluded that methotrexate therapy in breastfeeding mothers would not pose a contraindication to breastfeeding. However, methotrexate may be retained in human tissues (particularly neonatal GI cells and ovarian cells) for long periods (months). While the methotrexate concentration in human milk is minimal, it is recommended to pump and discard the mother's milk for a minimum of 4 days after dosing is stopped. Due to the toxicity of this agent, the length of time that the milk should be discarded is dependent on the dose level and duration.

Methylprednisolone

Pulsed dose methylprednisolone is one of the mainstays of therapy in multiple sclerosis (MS). Fortunately, the transfer of corticosteroids into human milk is poor at best. Studies of radiolabelled prednisolone have found that the total dose after 48 hours was only 0.14% of the maternal dose [32]. However, in cases of multiple sclerosis, massive intravenous doses (e.g., 1–2 g) may be used. Data suggest levels in milk reduce rapidly, and that mothers can safely breastfeed as early as 8–12 hours following intravenous use of high dose methylprednisolone [34].

20.7.5 Monoclonal Antibodies

Engineered immunoglobulins are becoming more common in the treatment of autoimmune and neoplastic diseases. These drugs target specific proteins, such as tumour necrosis factor, while leaving others untouched. The molecules are very large (> 100 kilodaltons) and consequently have a low RID in the order of 1–2% [35], [36], [37]. These drugs should theoretically have poor oral bioavailability due to destruction by proteases in the infant's stomach. However, several researchers have postulated that monoclonal antibody drugs might be absorbed via the immunoglobulin G-transporting neonatal Fc receptor (FcRn) that is expressed in intestinal cells of adults and foetuses [37]. Knowledge in this area continues to evolve, but the current evidence suggests these products are probably compatible with breastfeeding.

20.7.6 Recreational Drugs

Drugs that enter the central nervous system (CNS) readily cross the blood brain barrier, which is similar to the lactocyte barrier. Hence, most CNS active drugs will enter milk to a higher degree. Women are strongly advised to avoid using these medications while breastfeeding, as they all pose some risk to the infant. The more relevant question of whether a woman who uses these drugs should even consider breastfeeding needs to be evaluated on a case-by-case basis. However, some drugs used for recreational purposes are also of clinical use. For example, amphetamine drugs used for hyperactivity disorders are similar in structure to methamphetamine and other amphetamines used recreationally. In cases of drugs approved for clinical use, mothers can continue to breastfeed with some caution.

Alcohol

Alcohol readily enters the milk compartment and produce milk to plasma ratios of 1.0 or equivalent to the plasma compartment. While equal to levels in the plasma, the absolute clinical dose to the infant is still quite low. For example, a study of twelve breastfeeding mothers who ingested ethanol 0.3 g/kg exhibited an average maximum ethanol concentration of 320 mg/L in their milk [38]. Importantly, ethanol has been shown to strongly inhibit oxytocin release and decrease milk delivery to the infant [39]. A woman of average size will reduce her milk alcohol level by 15–20 mg/dL/hour, which equates to metabolising a 'standard drink' (14 g of pure ethanol) in about 2 hours [40].

Tobacco

Aside from tar and other combustion products, tobacco smoking results in high maternal plasma levels of nicotine and its metabolite cotinine. With a longer half-life than nicotine, pharmacologically active cotinine is much less potent than nicotine [41]. Cotinine levels are useful for tracking nicotine metabolism but are not necessarily representative of second- and third-hand contact with tobacco residues, of the relative safety of using nicotine replacement products, or of exposure to the many other dangerous chemicals in tobacco.

Studies have demonstrated a linear relationship between smoking rates in the mother, nicotine levels in milk, and urine cotinine levels in the breastfed infant [42], [43]. Urine cotinine levels can be up to 5-times greater in breastfed infants of mothers who smoke than in non-breastfed infants whose mothers smoke [44]. Even second-hand smoke can increase the risk of otitis media, respiratory tract infections, and asthma in the baby [45]. The benefits of breastfeeding offsets some of this risk and the current recommendations are for the mother to continue regardless of her smoking habits, but never to smoke in the presence of the infant.

Marijuana/cannabis

Small to moderate secretion of marijuana into breast milk has been documented [46]. In one study, milk levels of the principal psychoactive compound in marijuana THC were 340 µg/L in one mother who consumed marijuana 7–8 times daily, and 105 µg/L in another mother who consumed marijuana once daily [46]. Analysis of breast milk from a chronic heavy marijuana user revealed an 8-fold accumulation of THC in breast milk compared to plasma, although the dose received was apparently insufficient to produce significant side effects in the infant.

Studies have shown significant absorption and metabolism of marijuana in infants, although long-term sequelae are conflicting. In a study of 27 women who smoked marijuana routinely during breastfeeding, no differences were noted in the growth and mental and motor development of their infants compared to the norm [47]. Conversely, in another study, maternal use of marijuana during first trimester of pregnancy and during breastfeeding was shown to be associated with a slight decrease in infant motor development at one year of age, especially when used during the first month of lactation [48]. Interestingly, in this study, the use of marijuana during pregnancy and lactation had no detectable effect on infant mental development at one year of age, suggesting that the behavioural advantages of human milk may offset some of the detrimental effects of marijuana exposure.

Significant new evidence has begun to emerge suggesting that exposure to THC in pregnancy or chronic use in adolescence and early adulthood may result in changes to the endocannabinoid system in the brain [48], [49]. This system is partially responsible for regulating mood, reward, and goal-directed behaviour. Adverse neurobehavioral effects have not yet been demonstrated in infants exposed to THC exclusively through breast milk [47]. Nevertheless, mothers should be strongly advised to not use marijuana during pregnancy or breastfeeding.

Heroin and methadone

While morphine is generally a preferred analgesic for breastfeeding mothers, its diacetyl derivative, heroin is relatively dangerous. Heroin doses can in some instances be extraordinarily high, thus leading to high plasma levels and potentially significant transfer of morphine into the milk compartment. As with other opiates, tolerance follows from chronic use, and addicts may end up using extraordinarily large doses. It is the high dose of heroin that poses the greatest risk to the breastfed infant.

Heavily dependent heroin users should be advised against breastfeeding and their infants transitioned to formula. Methadone is a potent and very long-acting opiate analgesic used primarily to prevent withdrawal in opiate addicts. Unlike heroin, methadone produces only inactive metabolites. A large volume of distribution results in a low RID (2–6%) and infant exposure is further reduced by its moderate oral bioavailability [50], [51], [52], [53]. Many methadone-maintained women on extraordinarily high doses (> 150 mg/day) have breastfed their infants successfully. Infants become quite tolerant of these doses via milk. However, they also become quite dependent, so sudden withdrawal should be avoided by the mother.

Cocaine

Cocaine is a potent CNS stimulant that is likely to readily transfer to human milk, although there are no available substantiating data. Estimates vary regarding the degree of cocaine contamination in the breast milk, ranging from 1–10% of the maternal dose [54], [55]. Cocaine is rapidly metabolised to several inactive metabolites, and drug screens generally detect these for days following use. Mothers who are drug-screen positive may be able to breastfeed safely if a long enough time period has occurred following exposure. Inactive metabolites are excreted in the urine and breast milk for up to 7 days following initial exposure to the drug. Breast milk is likely to be free of cocaine after 24 hours, but infants can become drug-screen positive due to metabolite ingestion.

20.7.7 Drugs Altering Milk Supply

Milk production is highly dependent on the timing and frequency of breastfeeding. However, some mothers still produce insufficient milk despite attempting to breastfeed often and thoroughly. Any factor that interferes with adequate breast emptying, including poor infant attachment, infrequently emptying, and sleeping through the night, may ultimately lead to a drop in milk production. The cause of this is largely unknown, but a reduction in plasma prolactin levels may play a role. Frequently pumping or breastfeeding may reverse this situation, but not always, and in these cases, galactagogues may prove beneficial.

Milk production in the mother is highly dependent on elevated levels of prolactin. While not known for certain, milk production appears to wane once prolactin levels fall below approximately 50 ng/mL. The classic galactagogues used today cause the release and maintenance of higher levels of prolactin in the breastfeeding mother, thereby stimulating milk production.

Metoclopramide

Metoclopramide is a promotility drug that effectively blocks dopamine receptors in the pituitary. In some mothers metoclopramide has been shown to effectively increase milk production [56], [57], [58], [59]. While it is difficult to predict which women will respond with elevated milk production, women with low prolactin levels are ideal candidates. The prolactin-stimulating effect of metoclopramide appears to be dose-related. The standard dose of 10–15 mg given orally three times per day has been found efficacious. Response is usually rapid, with the mother noticing significant increases of milk volume within 24–48 hours. The amount of metoclopramide in milk rarely exceeds 160 µg/L, even at the highest maternal doses [56].

Unfortunately, metoclopramide crosses the blood-brain barrier, and drug-induced depression is a common side effect in mothers who use this medication. Other problems include extrapyramidal symptoms, gastric cramping, and tardive dyskinesia. Some mothers also experience a rebound drop in milk production if they discontinue the drug without slowly tapering the dose.

Domperidone

Domperidone has been successfully used worldwide to increase milk production [60], [61], [62]. This drug is also a dopamine antagonist but, unlike metoclopramide, does not cross the blood-brain barrier. Levels of domperidone in milk are extraordinarily low (around 1.2 ng/mL) and oral bioavailability is less than 20% [61].

Domperidone may in rare cases prolong the QT interval, particularly in older males. The potassium channel receptor is partially responsible for repolarising cardiac muscle cells and, thus by blocking potassium channels, the use of domperidone may cause arrhythmias. Although this side effect is infrequent, this drug should not be used in mothers with pre-existing rhythm disorders, especially prolonged QT syndrome. Importantly, the QT syndrome is dose related, and doses greater than 60 mg/day should be avoided. Data have shown that plasma levels of prolactin are almost identical following doses of 30 mg/day or 60 mg/day [63], suggesting that doses higher than 30–60 mg/day may not further increase prolactin levels.

20.8 Summary

All medications transfer into human milk to some degree, although they are almost always subclinical, and the mother should in most instances be advised to continue breastfeeding. However, certain classes of drugs, including anticancer agents, antimetabolite agents, radioactive drugs, and those that specifically inhibit milk production, present a relatively greater risk and the clinician should be aware of these.

In each case, the clinician must first evaluate the relative risk to the infant by considering the absolute or relative dose transferred via milk to the infant as well as the disadvantages to the infant of not breastfeeding. Higher rates of GI syndromes, upper respiratory tract infection, and other diseases are well-documented in infants fed formula compared with those who receive breast milk.

The infant's health status must be closely evaluated. Infants at greater risk of harm by medications include those who are premature, weak, have apnoea, or those with poor renal clearance, while older infants are at less risk. Because the milk volume decreases over time, particularly after 6 months, infants are exposed to reduced doses of maternal medicines over time. After 12 months postpartum, there is often a significant reduction in milk volume, and the infant's ability to metabolise and renally excrete drugs has developed close to that of the adult.

With most drugs, the amount of medication delivered to the infant via milk is much less than 4% of the maternal dose, and the amount the infant actually absorbs is likely less. In healthy infants, this amount is often easily tolerated without untoward effects. However, as the RID rises above 7–10%, and the toxicity of the medication increases, the clinician should be more cautious in recommending breastfeeding. Brief interruptions in breastfeeding may avoid infant exposure to high levels of drug in milk. Partial formula feeding may be used to reduce exposure of the infant while allowing the mother to continue partially breastfeeding.

In almost all situations, there are numerous medications that can be safely used for specific syndromes and the clinician should be open to choosing those drugs with lower RIDs. This is not always difficult to do, as there are now hundreds of studies concerning medications and their use in breastfeeding mothers. Almost invariably a more suitable drug can be chosen so that a mother can continue to breastfeed her infant [64].

Most importantly, breast milk is the most beneficial nutrition a mother can give her infant. The immunological and health benefits are overwhelmingly documented in the literature. Interrupting breastfeeding for unsound reasoning, such as to take a relatively safe medication, should be avoided where possible.

Key Points

- All medications transfer into human milk to some degree, although most will have little or no effect upon the infant, and the mother should in most instances be advised to continue breastfeeding
- Certain classes of drugs, including anticancer agents, antimetabolite agents, radioactive drugs, and those that specifically inhibit milk production, present risks the clinician should be aware of
- The risk/benefit analysis needs to consider the health of the mother and the infant. Clinicians should evaluate the relative risks by considering the drug dose transferred to the infant versus the disadvantages to the infant of not breastfeeding. Greater caution is needed for premature infants who are highly sensitive to medications
- Relative infant dose (RID is the standard measure of infant exposure to milk transferred drugs). In the case of an RID below 7–10%, clinicians should consider advising mothers to continue breastfeeding
- For most medical conditions, a drug is available that allows the mother to continue to breastfeed her infant. Up-to-date information for medication and lactation can be found here: http://www.medsmilk.com

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Part 4
The Way Forward

21 Introduction

Leith Greenslade, MPP, MBA

Despite decades of effort from global and national authorities and assistance from a large network of non-government organisations, foundations and academic institutions, current policies and programmes to increase breastfeeding rates have failed to meet public health goals. Just 44% of all babies are breastfed within an hour after birth and 40%, or two out of every five infants are breastfed exclusively for six months, in contrast to the global goal of at least 50%.

There are many interrelated factors that need to be considered to ensure breastfeeding support programmes are successful. While there have been numerous hospital and community-based initiatives aimed at promoting breastfeeding, these efforts have often been small in scale and conducted in isolation. Successful breastfeeding programmes require strong coordination between protection, promotion and support activities. Implementation research is necessary to develop effective programmes, and then clearly determine whether they are having the desired impact. It is critical that the behaviour of all stakeholders and their complex interrelationships are understood.

In Part IV (see Chapter 22), Professor Rafael Pérez-Escamilla, Professor of Epidemiology & Public Health at the Yale School of Public Health, discusses key components that countries must have in place to effectively expand breastfeeding support programmes. He begins by outlining the goals set out in the WHO Global Strategy for Infant and Young Child Feeding and continues with a discussion of different frameworks country leaders and decision-makers can pursue to achieve those goals. For example, the Complex Adaptive Systems (CAS) framework is a multi-disciplinary approach to understanding the ways in which multi-level, non-linear systems work together. Examples of successful CAS frameworks include the Assessing, Innovating, Developing, Engaging and Evolving Framework (AIDED) and, more specific to breastfeeding, the Breastfeeding Gear Model (BFGM). The BFGM is discussed as an innovative and critical model for breastfeeding expansion along with various indicator tools that can be used to measure success and support the scale-up process.

In the final chapter of the book (see Chapter 23), a major challenge that has been neglected for decades is comprehensively addressed – discrepancies in the terminologies used in breastfeeding and lactation. Emeritus Professor Peter Hartmann, Senior Honorary Research Fellow at The University of Western Australia, and Ms Melinda Boss, multidisciplinary group team leader developing evidence-based protocols, have developed a detailed science based glossary of breastfeeding and lactation terms to build consensus around common terminologies and the terms have been reviewed by highly respected professors and research leaders in the field of human lactation. The glossary is part of a larger project to develop an online glossary, 'LactaPedia.com', which will be available for health professionals, researchers and mothers to ensure a comprehensive understanding of breastfeeding and lactation terms.

Countries that fully embrace these new tools, and support the development of further innovations, are well positioned to capture the benefits that high and sustained breastfeeding rates offer. It is promising for the future that there is an emerging global recognition that new approaches are needed to empower mothers to exercise a real choice to breastfeed in the decades to come.

22 Scaling-up Breastfeeding Protection, Promotion, and Support Programmes

Rafael Pérez-Escamilla, Prof, PhD

Expected Learning Outcomes

- **Definition of scaling-up breastfeeding programmes**
- **Essential components for success in breastfeeding programmes scale-up**
- **The importance of implementation science initiatives to enable scaling-up breastfeeding promotion, protection and support programmes**

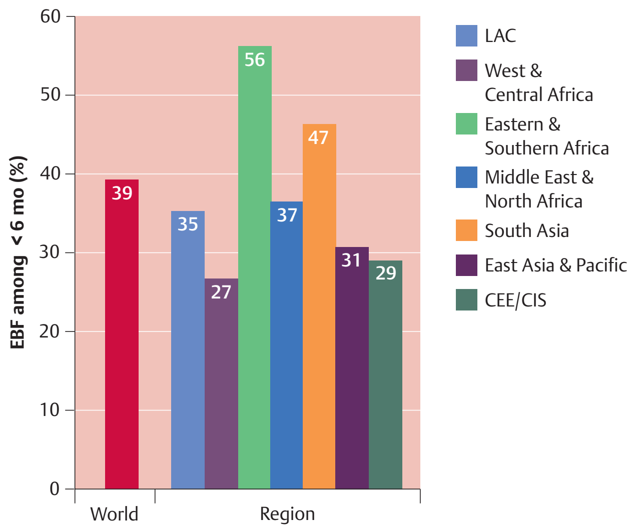
22.1 Introduction

Infant and Young Child Feeding (IYCF) practices have a great impact on the nutrition status of children under two years of age as well as on their risk for infectious diseases and mortality [1]. The World Health Organization (WHO) recommends breastfeeding to be initiated within one hour after birth, to be practiced exclusively for the first six months of life followed by the introduction of safe nutritious complementary foods, and to continue breastfeeding until the child is at least two years old [1]. These WHO guidelines are backed by a robust body of evidence indicating that optimal breastfeeding behaviours are strongly associated with lower incidence of gastrointestinal and respiratory tract infections as well as with child survival [2]. Furthermore, breastfeeding may protect children against otitis media [3], malocclusions [4], dental caries [5], obesity and type 2 diabetes [6] and has been consistently associated with improved cognitive development [7]. Benefits of breastfeeding to the mother include prolonged lactational amenorrhea and a reduced risk of postpartum haemorrhage, ovarian and breast cancer, and type 2 diabetes [8]. Thus, it is not surprising that the WHO Global Strategy on Infant and Young Child Nutrition specifically calls for strong government commitment to protecting, promoting, and supporting breastfeeding [9], and continues to be firmly endorsed by public health authorities. Indeed, the 2015–2030 Sustainable Development Goals identify increasing the prevalence of exclusive breastfeeding (EBF) in the first six months to at least 50% as a key global nutrition target [10].

Even though the goal to improve the rates of EBF for six months has been in place for almost 15 years globally, and has been strongly endorsed by international organisations and governments worldwide, less than 40% of infants younger than six months are exclusively breastfed, with wider variation within than across world regions (▶ **Fig. 22.1**). Based on nationally representative surveys collected between 2008 and 2014, EBF prevalence among children younger than six months ranges from 27% in West and Central Africa to 56% in Eastern and Southern Africa [11].

The variation in EBF prevalence across countries is indeed remarkable; survey data collected between 2000 and 2014 in 128 countries indicates that at a country level EBF rates vary widely, from 1% in Djibouti to 87% in Rwanda [11]. Thus, an important question is why is there so much global variability in EBF practice across countries? Is it because we simply don't have the know-how on what is needed to support EBF effectively? Or are there major bottle necks preventing the translation of scientific knowledge into practice? [12], [13].

The lack of progress at increasing EBF rates globally to the recommended levels is perplexing as evidence-based hospital and community-based initiatives that have been shown to be efficacious at improving EBF have been in place for decades, and case studies in a few countries have shown major improvements in EBF rates relatively soon after those initiatives are scaled-up [13], [14], [15]. Although some have attributed this lack of progress simply to lack of political will, it has recently



▶ **Fig. 22.1** Exclusive breastfeeding (EBF) prevalence among infants < 6 months of age, globally and by world region. (UNICEF Global Database, 2015)

become increasingly clear that the answer is much more complicated due to the numerous interrelated factors that need to interact in complex ways to make EBF scaling-up efforts successful [13], [16].

The objective of this chapter is to identify the key components that countries need to have in place for effectively scaling-up their EBF programmes. This has important implications for maternal-child health and wellbeing globally. Improving EBF rates has been estimated to save millions of lives and dollars [12], [17], [18], [19]. Colchero, et al. recently estimated the costs in Mexico of inadequate breastfeeding associated with paediatric respiratory infections, otitis media, gastroenteritis, necrotising enterocolitis (NEC), and sudden infant death syndrome (SIDS) to range between US $745.6 million and US$2.4 billion, with the costs of infant formula accounting for 11–38% of the total costs [20]. The economic costs of inadequate breastfeeding were estimated based on the direct health care costs associated with the increased risk of disease when infants under 6 months are non-EBF or are not breastfed from ages 6 to under 11 months, lost future earnings due to premature infant death, and the costs of purchasing infant formula. The annual number of disease cases attributed to inadequate infant breastfeeding practices ranged from 1.1 to 3.8 million and the number of infant deaths from 933 to 5796 per year, altogether representing nearly 27% of the absolute number of episodes of the diseases examined [20].

Bartick & Reinhold recently estimated that if 90% of families in the United States were to comply with recommendations to breastfeed exclusively for 6 months, savings to the United States would amount to $13 billion per year and prevent an excess 911 deaths, the vast majority being infants [21]. The authors based their cost estimates on NEC, otitis media, gastroenteritis, hospitalisation for lower respiratory tract infections, atopic dermatitis, SIDS, childhood asthma, childhood leukaemia, type 1 diabetes mellitus, and childhood obesity [21]. Bartick, et al. also recently estimated the cost of suboptimal breastfeeding in the United States with regard to suboptimal maternal health [22]. At current breastfeeding rates in the United States, their analysis indicated that suboptimal breastfeeding resulted in 4,981 excess cases of breast cancer, 53,847 cases of hypertension, and 13,946 cases of myocardial infarction compared with women who optimally breastfed. Additionally, suboptimal breastfeeding incurred a total cost of $17.4 billion to society resulting from premature death (95% confidence interval [CI], $4.4–24.7 billion), $733.7 million in direct costs (95% CI, $612.9–859.7 million), and $126.1 million in indirect morbidity costs (95% CI, $99.00–153.22 million) [22].

Given the urgency to address the global suboptimal prevalence of EBF and that we do have the know-how about how best to support women EBF [13], the primary objective of this chapter is to present the required key elements for the successful scaling-up of breastfeeding programmes. The chapter introduces and defines key concepts and frameworks, followed by specific descriptions of key components identified as essential for successful scaling-up. The chapter then presents approaches and tools available for policy makers to guide their scaling-up efforts and concludes with reflections on the required improvements in policy tools and future directions for the field.

22.2 Key Principles for Scaling-up of Breastfeeding Programmes

There is strong international consensus that global scaling-up of breastfeeding protection, promotion, and support should be guided by the principles outlined in the Global Strategy for Infant and Young Child Feeding (IYCF) [9]. The Global Strategy is based on nine operational targets related to both breastfeeding and complementary feeding. The first four are drawn from the operational targets of the 1990 Innocenti Declaration on the Protection, Promotion, and Support of Breastfeeding [23]. The principles outlined in this declaration are very relevant as they were adopted by the World Health Assembly (WHA) in 1991 through resolution WHA44.33 as "a basis for international health policy and action" regarding the implementation of recommended IYCF practices. These four principles directly address scaling-up of national breastfeeding programmes as they call for:

- Appointing a national breastfeeding coordinator and establishing a multi-sectoral national breastfeeding committee
- Ensuring that every facility providing maternity services fully practices all the "Ten steps to successful breastfeeding"
- Implementation and enforcement of the International Code of Marketing of Breast-milk Substitutes (the WHO Code) [24]
- Enacting legislation to protect the breastfeeding rights of working women

The second set of five indicators of the Global Strategy addresses issues relates to both breastfeeding and complementary feeding, including actions needed for addressing the special needs of highly vulnerable children and their families (e.g., those affected by human immunodeficiency virus and humanitarian emergencies). The principles underlying these five indicators call for:

- Developing, implementing, monitoring, and evaluating a comprehensive policy on infant and young child feeding
- Ensuring that the health and other relevant sectors protect, promote, and support EBF for 6 months and continued breastfeeding up to 2 years of age or beyond
- Promoting timely, adequate, safe, and appropriate complementary feeding with continued breastfeeding
- Providing guidance on feeding infants and young children in exceptionally difficult circumstances and
- Considering new legislation or other measures to operationalise the principles and aim of the WHO Code

Relevant to this chapter it is important to underscore that the Innocenti Declaration also called upon international organisations to:

- Draw up action strategies for protecting, promoting, and supporting breastfeeding, including global monitoring and evaluation of their strategies
- Support national situation analyses and surveys and the development of national goals and targets for action
- Encourage and support national authorities in planning, implementing, monitoring, and evaluating their breastfeeding policies [23]

These recommended actions have been proven over time indeed to be key for the successful scaling-up of breastfeeding programmes, although the focus has now shifted more for countries to establish ownership of these and not rely so much on foreign assistance to conduct them [13].

22.3 Key Concepts behind Scaling-up of National Breastfeeding Programmes

22.3.1 Breastfeeding Protection, Promotion, and Support

The global experience unequivocally indicates that optimal breastfeeding practices are the result of strong coordination between breastfeeding protection, promotion, and support activities [13], [14], [15], [25], [26]. Protection refers to policies that allow women to exercise their right to breastfeed their infants if they chose to do so. Protection policies include enforcing the WHO Code for the Ethical Marketing of Breast Milk Substitutes [24], adequate paid maternity leave legislation, nursing breaks during work hours [27] and protection against harassment while nursing in public spaces. Promotion refers to activities undertaken to foster or "sell" the benefits of breastfeeding through social marketing approaches including World Breastfeeding Week, the use of mass media including social media outlets (e.g., Facebook, Twitter, Web blogs), and behaviour change communication campaigns [25]. Support is a term used to describe actions taken to empower women to implement their decision to breastfeed. Support is needed across multiple domains including qualified lactation management as well as family and other sources of social support [13].

22.3.2 Scaling-up

Scaling-up of effective health interventions was a central theme for the Millennium Development Goals and it has now become even more central to the successful achievement of the Sustainable Development Goals agenda. From the health sector perspective, la *raison d'être* of scaling-up is for benefits resulting from new technologies and innovations to have a major and rapid impact at improving health on a large scale [28]. Although there isn't a single consensus definition of "scaling-up", a central theme to this concept is the expansion of access of quality programmes to large segments of the target population(s). Scaling-up has several dimensions, including programme demand and supply as well as impacts [28]. Scaling requires strong intention, guided by a strategic plan behind the type of scaling-up being sought, including expansion or replication of a programme into other geographical areas or target populations (i.e., horizontal scaling-up); policy, political, legal or institutional scaling-up that occurs when governments make the decision to implement a programme at the national or subnational level (vertical scaling-up); and/or diversification to add evidence based components to existing scaled-up "packages" (functional scaling-up) [28]. Sustainability of scaled-up programmes is usually the result of successful integration of vertical and horizontal scaling-up processes with the capacity to incorporate diversification or adaptation as needed.

Here we define scaling-up as "a process aimed at maximising the reach and effectiveness of a range of actions, leading to sustained impact on outcomes", as recently proposed by Gillespie, et al. in the field of nutrition [29]. Based on a peer reviewed and grey literature review, Gillespie, et al. [29] identified nine elements that are central to successful scaling-up of nutrition programmes:

- Having a clear vision or goal for impact
- Intervention characteristics
- An enabling organisational context for scaling-up
- Establishing drivers such as catalysts, champions, system-wide ownership, and incentives
- Choosing contextually relevant strategies and pathways for scaling-up
- Building operational and strategic capacities
- Ensuring adequacy, stability, and flexibility of financing
- Ensuring adequate governance structures and systems
- Embedding mechanisms for monitoring, learning, and accountability

Having a clear goal for impact calls for having clarity from the beginning as to what type and level of impact is expected, accompanied by appropriate metrics and a compelling justification of why the impact goal is important and how it can be achieved. The intervention characteristics element calls for stakeholders to have clarity on what exactly is to be scaled up to achieve large-scale impact; for example, this could be a technology, a process, and/or an innovative approach [30]. Scaling-up impact requires an enabling environment in the context of where the scaling-up process is to take place. The enabling environment is strongly driven by political and policy factors and structural factors specific to health care and community organisation systems. Launching and sustaining a successful scaling-up agenda requires the presence of champions, identifying the right mix of incentives, having a strong governance structure, and local ownership of the scaled-up programme.

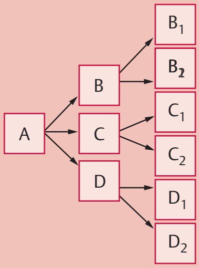
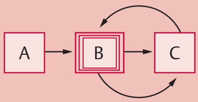
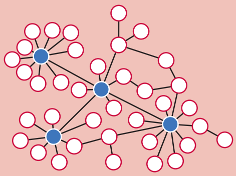
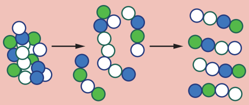
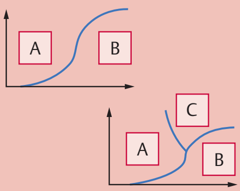
A sound scaling-up strategy is needed to operationalise clearly what will be scaled-up and how. This key element is crucial for identifying adequate context specific pathways and corresponding processes to be followed to attain sustained high coverage and quality implementation of the programme or intervention being scaled-up. Building operational and strategic capacities is needed for successful scaling-up to occur. The type of capacities needed are multi-level (individual, organisational, systemic) and include the capacity to plan, implement, and sustain the scaling-up process [28]. Attaining these capacities requires stable financial commitment. According to Gillespie, et al., 'the governance of scaling-up encompasses the structures and systems that underpin and support all stages of the scale-up process' [29]. Governance goes to the heart of the decision-making process as well as of the oversight and accountability of the resources being used for scaling-up. Governance requires a good understanding of the intersection between vertical (from national to local level) and horizontal (inter-sectoral coordination) governance structures. Finally, sound monitoring and evaluation systems are needed to steer the scaling-up process in the right direction and for the scaled-up programme or intervention to become sustainable with regards to high levels of coverage and quality.

22.3.3 Implementation Science

According to the USA National Institutes of Health (NIH) implementation science is 'the study of methods to promote the integration of research findings and evidence into healthcare policy and practice' [31]. A key goal of implementation science research is to identify and address major bottlenecks (e.g., social, behavioural, economic management) that prevent effective implementation of programmes in the "real world". A second key goal of implementation science is to find out whether the programmes being implemented are having the intended impact or not and why [32]. To achieve this goal, implementation science also seeks to understand the behaviour of healthcare professionals and other stakeholders to understand the sustainable uptake, adoption, and implementation of evidence-based interventions [31].

A recent major development in the field of nutrition is the increasing recognition that implementation science research can benefit greatly from the Complex Adaptive Systems (CAS) framework developed over the years by researchers of health care systems and defined as a "multi-disciplinary approach to understanding the behaviour of diverse, interconnected agents and processes from a system-wide perspective" [33]. The CAS health framework is well suited for guiding scaling-up of breastfeeding programmes as it is based on multi-disciplinary approaches to understanding the behaviour of diverse, interconnected agents, and processes from a non-linear system-wide perspective [16], [33], [34]. The CAS framework acknowledges that programmes are formed by many moving parts that have the capacity to self-organise and adapt as required by circumstances and learning by experience [33], [34]. CAS constructs include feedback loops, emergent behaviour, interdependence, scale-free networks, and path dependence, all of which can help understand the sustainability of implementation of programmes implemented at scale (▶ **Fig. 22.2**).

Feedback loops occur when an output of a process within the system is fed back as an input into the same system. For example, a central feature of successful national breastfeeding programmes is their ability to coordinate hospital-based with community-based efforts with both serving as re-

CAS Phenomena	Definition	Health Sector examples
Path dependence 	• Non-reversible processes have similar starting points yet lead to different outcomes, even if they follow the same rules, and outcomes are sensitive not only to initial conditions, but also to bifurcations and choices made along the way	• Health reforms such as introduction of social health insurance or quality assurance programmes may work well in one country but cannot be simply copied to another country and have similar results • Adoption of different standards for health technology in different countries
Feedback 	• Happens when an output of a process within the system is fed back as an input into the same system: ∘ Positive feedback increases the rate of change of a factor towards an extreme in one direction ∘ Negative feedback modulates the direction of change	• "Vicious circles" between poverty and ill health; or malnutrition and infection • Swings in the prices or demand for certain health services • How standardised modes of health care delivery continue to serve the same populations, but fail to reach the poor
Scale-free networks 	• Structures which are dominated by a few focal points or hubs with an unlimited number of links, following a power-law distribution	• Rapid pandemic disease transmission • The persistence of slow-spreading viruses to combat eradication • The disproportionate effect of influencing highly connected members of a sexual network on the transmission of sexually transmitted infections • The adoption of new health practices disproportionately influenced by "hub" individuals
Emergent behaviour 	• The spontaneous creation of order, which appears when smaller entities on their own jointly contibute to organized behaviours as a collective, resulting in the whole being greater and more complex than the sum of the parts	• Why health workers can suddenly organize to go on strike • How informal providers form organisations to protect practices in their trade
Phase transitions 	• Events that occur when radical changes take place in the features of system parameters as they reach certain critical points	• "Tipping points" in health services, leading to sudden changes in demand for health services or changes in referral patterns • How epidemic thresholds or herd immunity develops • Changes in collaboration-competition behaviours and referral patterns for patients within and across health facilities

▶ **Fig. 22.2** Complex Adaptive Systems key constructs. (Reproduced from Paina and Peters [33], by permission of Oxford University Press.)

ferral and counter-referral systems [35]. Indeed, randomised controlled trials conducted in Brazil and Belarus have shown that strong implementation of step 10 of the Baby Friendly Hospital Initiative (BFHI), which represents the link between facility and community efforts, is crucial for sustaining positive breastfeeding impacts in the long term. The concept of Scale-free Networks refers to structures that are dominated by a few focal points or hubs with an unlimited number of links, following a power-law distribution (▶ **Fig. 22.2**).

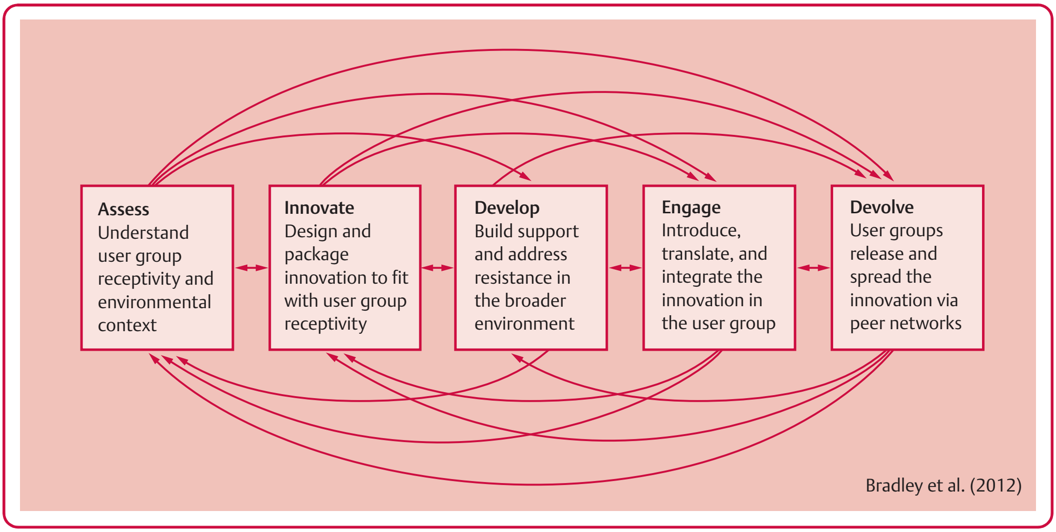
Social network analysis is a powerful tool that can be used to model the "contagion" of health-related behaviours [36]. Breastfeeding "contagion" may be strongly facilitated through the endorsement of highly visible individuals or role models that others seek to emulate. For example, successful breastfeeding mass media campaigns have often featured famous actresses, sports stars, or other celebrities. Obstetricians and paediatricians have also been very influential forces behind successful national breastfeeding programmes.

Phase transitions occur when radical changes take place in the features of system parameters as they reach certain critical or tipping points (▶ **Fig. 22.2**). For example, it took several years after it started for the Brazilian National Breastfeeding Programme to detect substantive impacts in breastfeeding behaviours. In this instance, the initial foundation years involved strong evidence based advocacy efforts to create the right conditions for the programme to emerge. The construct of Path Dependence indicates that processes that have similar starting points may end up leading to different outcomes because of bifurcations and choices made along the way (▶ **Fig. 22.2**). Path dependence explains why national breastfeeding programmes need to be adapted to the local contexts.

Emergent behaviour refers to the spontaneous creation of order from "chaos", which appears when smaller entities on their own jointly contribute to organised behaviours as a collective. The global experience indicates that successful scaling-up emerges from the coming together of key actors and processes at the right time and place following a "perfect storm"-like scenario [13].

The Assessing, Innovating, Developing, Engaging and Devolving (AIDED) framework is an example of a CAS scaling-up framework recently developed for understanding how best to scale-up family health interventions including breastfeeding [30]. AIDED involves five key steps involving assessment, design and package of an innovation, and development of strategy, where it is crucial to identify resistance to scaling-up effort, engage key stakeholders, and to devolve to a sustainable position. AIDED is non-linear, comprises multiple feedback loops, and allows for countries to begin the process of scaling-up at different starting points (▶ **Fig. 22.3**).

Assessing the landscape involves obtaining a precise understanding of the receptivity of the user groups and of the environmental context of the user groups for programme implementation. It



▶ **Fig. 22.3** AIDED scaling-up framework. Specific descriptions of each of the AIDED framework components are provided in the text. (Reproduced from [30], with permission from BMJ Publishing Group Ltd.)

also involves examining environmental factors that may facilitate or prevent up-take of the programme.

Innovating to fit with user receptivity involves adapting the programme to local context and preferences so that receptive users would perceive the programme as being beneficial in their specific context. Adaptation assumes that it is feasible to make changes to the design and packaging of the programme to meet the needs of the local context.

Developing support refers to sensitising the environment to be supportive of increased use of the programme. Developing support involves enhancing education as well as identifying and addressing resistance to the innovation. Legal and regulatory actions as well as economic incentives are important for fostering an enabling environment.

Engaging with user groups needs to occur throughout the scale-up process and involves several key steps: (1) introduction of the innovation from outside the user group to inside the user group via boundary spanners; (2) translation of the innovation so that user groups could assimilate the new information; and (3) integration of the innovation into the routine practices and social norms of the user group. Introduction of the innovation, the first part of the engage component, refers to giving information about the innovation to the user group.

Devolving efforts for spreading the innovation is based on user groups releasing and spreading the innovation for its re-introduction in new user groups within their peer networks so that the spread and scaling-up of the programme takes a life of its own.

22.3.4 Social Marketing

An in-depth analysis of the Loving Support breastfeeding campaign in the United States provides important insights into the definition of social marketing and how this framework can be applied to protect, promote, and support breastfeeding [37]. Social marketing involves the application of commercial marketing principles to advance the public good [38]. A social marketing campaign starts with the identification of a benefit (e.g., breastfeeding) and how the target audience perceives this benefit (▸ **Table 22.1**).

Developing effective social marketing campaigns requires in-depth understanding of the determinants of the behaviour in the different contexts where it will take place and the perceived consequences of performing the behaviour or not. This understanding allows for the initial development of the campaign's brand, relevance, and positioning through an evidence-based marketing mix following the "4Ps" (product, price, place, promotion). The marketing mix is designed to maximise use of the product (e.g., breast pump), services (e.g., peer counsellors) or activities (e.g., breastfeeding support group), while taking into account

▸ **Tab. 22.1** Key concepts, definitions, and uses of behavioural change social marketing campaigns.

Key term/concept	Definition	Comment/BF examples
Social marketing	Application of marketing principles and techniques to foster social change or improvement	Social marketing is based on four inter-related tasks: audience benefit; target behaviour; essence; and marketing mix
Audience benefit	Perceived benefit of behaviour change by target audience	At the centre of the social marketing construct. e.g., How do women and society at large perceive the benefit of BF? How soon are benefits from BF to be expected?
Target behaviour	Behaviour(s) that may change as a result of production adoption and use, accessing services, and/or adopting healthy behaviours	Social marketing focuses on population-based behaviour change. e.g., What are the determinants, context, and consequences of changing or not changing infant feeding behaviours from the perspective of the target audience?

▶ **Tab. 22.1** continued

Key term/concept	Definition	Comment/BF examples
Essence	Identifying behaviours, products, and services essential for marketing desired behavioural change	Branding, relevance, and positioning strategies based on target audience preferences, e.g., What type of BF messages currently resonate with WIC women? What type of infrastructure (e.g., Baby-Friendly Hospital Initiative) services (peer counselling), activities (BF support groups); and products (e.g., breast pumps) need to be made available? How relevant are these to the needs and wants of the target population segments? Where and how can these be accessed by the target audiences? Are there policy and legislation changes needed for improving breastfeeding behaviours?
Marketing Mix	Specific design and features of campaign products, services, and activities	Referred to as the "4Ps"; refers to product, price, place, and promotion strategies for campaign implementation. Reaching this point requires having completed the audience benefit, target behaviour and essence steps based on solid formative evaluation work with target consumers. e.g., Is BF marketing mix relevant to the life circumstances of WIC participants? Do WIC participants identify well with campaign brand?
Price	Incentives and costs involved with behavioural change as perceived by target audiences	Price concept in social marketing goes well beyond monetary cost and includes the psycho-social "costs" perceived by consumers. e.g., Do WIC women perceive that they would need to sacrifice their jobs in order to breastfed exclusively for 6 months? Do women perceive that they can afford to "pay" the social stigma "price" associated with BF in public? Are WIC participants willing to go to a clinic to receive peer counselling services? Or do they strongly prefer to receive them at home? Are there enough electric breast pumps available to lend out or will women be asked to purchase their own? Do WIC women perceive the free formula to be a powerful disincentive to choose exclusive BF?
Place	Location where there is an opportunity for target audience to access the campaign products, services and activities	Consumers need to have access to the necessary tools to enact behavioural changes sought out by campaign. Crucial for the campaign to create spaces and opportunities for consumers to access, practice, and sustain healthy behaviours. e.g., Are BF promotion programs available in communities where WIC participants live? Are BF support social media and mobile technologies, and BF support efforts well adapted to the health literacy and cultural norms of different WIC population segments?
Promotion	Communication efforts to disseminate campaign behaviours, products, services, incentives and priorities among different stakeholders	Health communication is a component of social marketing that in and by itself may not be able to elicit behaviour change. Promotion need to work in an integrated way with the other three components of the social marketing model for behavioural change campaigns to be effective. Information is needed to make informed decisions regarding target behavioural change in places, points in time, and ways that are literacy and culturally appropriate, e.g., is the campaign's communication strategy taking into account the two-way communication information technologies preferred by WIC participants or is it still all based on old fashion linear (one-way) communication systems?

Adapted from Lefebvre [38] and Institute of Medicine [52] Source: Pérez-Escamilla [37], reproduced with permission.
BF = breastfeeding, WIC = Supplemental Nutritional Program for women, infants, and children.

consumers' perceptions about the price or sacrifices they will need to make to follow the target behaviour. For example, employed women may be very resistant to consider EBF if sacrificing their jobs is what it would take for them to be able to do so. Also, spouses may not be supportive of EBF if they are afraid their wives are going to be harassed when they breastfeed in public places [16]. The third component of the marketing mix involves providing access to a product or service via strategic placement through opportunity points (e.g., Baby-Friendly Hospitals, peer counselling programmes). Lastly, the product or service needs to be promoted through innovative communication campaigns and experienced by the target population [26]. Effective breastfeeding social marketing campaigns need to be developed based on mixed methods formative research that incorporates effective process and outcome evaluation systems [25], [38].

22.3.5 Key Ingredients of Successful Large-Scale Breastfeeding Programmes

Pérez-Escamilla, et al. recently conducted a systematic review of the peer reviewed and grey literature to identify the key barriers and facilitators for scaling-up effective breastfeeding programmes and to map them into the AIDED framework [13]. The data extraction process identified 22 enabling factors and 15 barriers for dissemination, diffusion, and scale-up and/or sustainability that were then mapped into the five AIDED components (▶ **Table 22.2**, ▶ **Table 22.3**).

Mapping of facilitators and barriers into the AIDED framework components led to the following classification:

Assess The empirical evidence indicates that successful dissemination, diffusion, and scaling-up of breastfeeding promotion programmes has relied heavily on baseline facility and community needs assessments, as well as operational (formative) research/pilot studies. These efforts have been particularly successful when needs assessments are conducted with the scale-up of breastfeeding promotion in mind and take into account input from key stakeholders working in different sectors.

Innovate Three innovations that have been key for effectively fitting and packaging of breastfeeding promotion programmes, resulting in successful scale-up, are: (1) communications and mass media campaigns that set the stage for the introduction of a breastfeeding promotion programme in target areas; (2) facility-based delivery systems (e.g., BFHI [35]; (3) community-based EBF promotion and support programmes that include peer counsellors, community health workers, mother-to-mother support groups, and visible community events (e.g., World Breastfeeding Week).

Develop Global breastfeeding promotion efforts have been built upon the foundation established by evidence-based international consensus meetings/declarations and global infant feeding recommendations issued by the United Nations International Children's Fund (UNICEF) and WHO. Translating this support into action has greatly benefited from the efforts of international advocacy groups (e.g., International Baby Food Action Network [IBFAN], World Alliance for Breastfeeding Action [WABA]) and local advocacy groups, as well as coalition building with various stakeholders including public opinion leaders. Before scale-up can proceed, it is crucial to elicit will and long-term commitment for scale-up from policy makers through political sensitisation based on cost/savings analyses, and civil society mobilisation and engagement. Maternity leave and work place legislation, as well as the enforcement of the WHO International Code of Marketing of Breast Milk Substitutes (WHO Code), are key for attaining the supportive environment needed for EBF promotion to succeed on a large scale. Indeed, the frequent violation of the WHO Code has been consistently identified as a major barrier for breastfeeding promotion. Key to sustainable large-scale breastfeeding protection, promotion, and support programmes is the training of administrators, health professionals, and paraprofessionals, a process that can be facilitated by improvements in medical/nursing school curricula. The physical infrastructure for the delivery of breastfeeding support at the facility and community level needs to be in place for successful large scale-up to occur. For example, a major barrier for the initial implementation of BFHI in many countries was that ma-

▸ **Tab. 22.2** Enabling factors for the dissemination, diffusion, scale-up, and sustainability of breastfeeding programmes by AIDED framework components.

Enabling Factor	AIDED framework components mapped to factor
Contextual	
International advocacy groups: IBFAN, WABA	Develop
Evidence-based recommendations: timely initiation of BF; EBF for 6 months (WHO)	Develop
International consensus meetings/declarations: Bellagio and beyond	Develop
Political support	
Cost/savings analyses	Assess
Local advocacy & coalition building, including public opinion leaders	Develop
Civil society mobilisation and engagement	Develop
Political sensitisation	Develop
Political will	Develop
Long-term commitment to scaling-up	Devolve
Process and sustainability facilitators	
Research and evaluation	
Baseline facility and community needs assessments	Assess
Operational (formative) research/pilot studies	Assess
Programme delivery	
Facility-based delivery system, e.g., BFHI	Innovate, Develop, Engage, Devolve
Community-based EBF promotion and support: baby-friendly primary health care units, peer counsellors, community health workers, mother-to-mother support groups	Innovate, Develop, Engage, Devolve
Communications/mass media campaigns; targeting opinion leaders, policy makers, mothers; simple and double messages; celebrities	Innovate, Develop, Engage
Visible community events: world breastfeeding week, other	Innovate, Engage, Devolve
Programme delivery through other existing programmes: immunisations, diarrhoeal control, family planning, and other programmes	Innovate, Develop, Engage, Devolve
Workforce development	
Training: administrators, health professionals, and paraprofessionals	Develop, Devolve
Endorsement from medical societies	Develop
Medical/nursing school curricula	Develop
Legislation	
Legislation: maternity leave, work place, WHO Code	Develop, Devolve
Programme coordination and quality control	
Intersectoral coordination: government, civil society (NGOs, philanthropists), medical societies, academic researchers, mass media	Develop, Engage, Devolve
Monitoring and evaluation, low-cost, rapid response	Assess, Devolve

Adapted from Pérez-Escamilla, et al. [13]. BF = breastfeeding, BFHI = Baby-Friendly Hospital Initiative, EBF = exclusive breastfeeding, IBFAN = International Baby Food Action Network, NGO = non-government organisation, WABA = World Alliance for Breastfeeding Action, WHO = World Health Organization.

▶ **Tab. 22.3** Barriers to the dissemination, diffusion, scale-up, and sustainability of exclusive breastfeeding by AIDED framework components.

Barrier	Number of sources citing factor	AIDED framework component(s) mapped to factor
Unethical marketing of infant formula	7	Develop, Engage, Devolve
Maternal employment	2	Engage
Unsustainable workforce development system (affects sustainability)	3	Devolve
Overburdened staff in medical facilities and in community health settings	1	Devolve
CHW investment just to promote breastfeeding difficult to justify	5	Develop, Devolve
Strong dependency on international aid (affects sustainability)	3	Devolve
Weak M&E systems	3	Assess, Develop, Devolve
Prolonged lag time before impacts can be detected	1	Devolve
Lack of community-level breastfeeding promotion and support	3	Develop, Engage, Devolve
Unpaid “volunteers”: high turnover	3	Develop, Devolve
Cultural beliefs: “insufficient” milk, other	5	Innovate, Engage
Lack of multilevel incentives	1	Assess, Devolve
Program “fatigue”	2	Devolve
Lack of referral system for lactation management problems	1	Engage
Poor interpersonal communication skills among peer counsellors/community health workers	2	Assess, Develop, Engage

Adapted from Pérez-Escamilla, et al. [13]. CHW, community health workers; M&E, monitoring and evaluation.

ternity wards were not designed to accommodate rooming-in. Lack of community-level infrastructure for lactation management support continues to be a major barrier for EBF promotion globally.

Engage Breastfeeding promotion programmes ultimately seek to engage the mother in considering practicing optimal infant feeding behaviours, including EBF. There are many factors that influence a mother’s infant feeding decisions, including the advice from health care providers, family, neighbours, friends, media, and others. Small trials have shown that women across cultures are significantly more likely to practice EBF when they are presented with innovative approaches that take into account the contexts in which they live. The key for the success of these interventions has been addressing cultural beliefs surrounding their infant feeding choices, such as the often unfounded belief that a high porportion of women are not able to produce enough milk for EBF their infants [39]. This pervasive belief has consistently been identified as one of the strongest risk factors for the early introduction of replacement infant feedings including infant formula. Once infant formula is introduced, the likelihood that the mother will revert to EBF is exceedingly low, and breastfeeding duration becomes shortened as a result. Hence, it is crucial to understand the roots of this pervasive belief in different cultures to address it effectively. A key barrier for the scale-up of breastfeeding protection, promotion, and support programmes is the lack of adequate communication skills among health care providers and peer counsellors/community health workers. Thus, developing a work force that is well trained on the technical aspects of lactation management and breastfeeding promotion is essential, but not a sufficient condition for successful scale-up. Scale-up requires developing the communication, and counselling non-judgmental skills of individuals providing breastfeeding support to women. Good receptivity is most likely when women and individuals in their circle of influence fully engage in the decision-making process; otherwise, efforts to engage target individuals successfully are compromised and scale-up eventually fails. Innovative facility and community-based breastfeeding promotion and support approaches delivered through, for example, peer counsellors, community health workers, or mother-to-mother support groups are indeed crucial for proper engagement of target individuals.

Devolve Once a comprehensive breastfeeding programme has been successfully scaled-up and EBF uptake is widespread among the initial users, efforts to devolve for continued spread among the next generation of "users" are critical for sustaining the initial scale-up phase. For this to happen, six conditions need to be met:

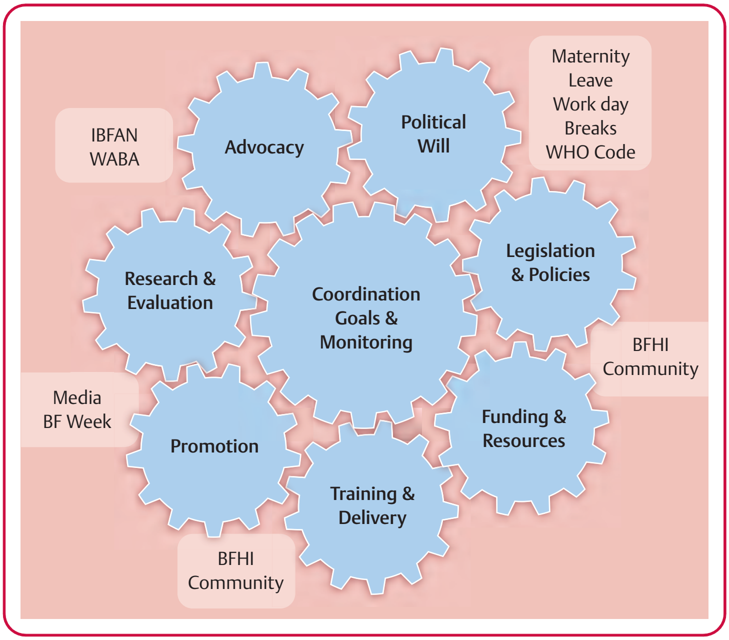
1. Effective sustainable lactation management and communication/counselling through train-the-trainer programmes need to be in place
2. A sustainable workforce development pipeline, including medical, nursing, and technical schools, needs to be developed
3. National intersectoral breastfeeding coordination with adequate budget allocation should not rely heavily on foreign aid and it should be highly decentralised, as in the case of Brazil. Key sectors or stakeholders involved should be target women and communities, government, civil society (e.g., Non-Governmental Organisations [NGOs], women's organisations, unions, and philanthropists), international agencies, medical societies, academic researchers, and mass media
4. Systems to avoid redundancies by incorporating breastfeeding promotion through existing programmes, such as diarrhoea, immunisations, family planning, and growth monitoring, must be in place
5. Facility and community based infrastructure needed for effective breastfeeding promotion must also be available
6. There must be monitoring and evaluation systems that include low-cost rapid-response management information systems to facilitate local decentralised management of breastfeeding promotion efforts

Scaling-up experiences have also identified specific barriers for devolving, including lack of proper staff incentives, "programme fatigue", draining of trained workforce members from the initial user groups, and attempting to devolve through staff who are already overburdened with other duties [40]. Programme fatigue has been identified to be one of the reasons for the decline in BFHI quality in several countries where BFHI was launched over a decade ago. It is apparent that fidelity to the "package" of steps has declined with time, especially once initial certification and recognition is obtained.

22.3.6 A Model for Scaling-up of Breastfeeding Programmes

Using the above classification of mapping of facilitators and barriers, the AIDED mapping was then translated into the pragmatic Breastfeeding Gear Model (BFGM) targeting decision makers (► **Fig. 22.4**).

Analogous to a well-oiled engine, the BFGM indicates the need for several key "gears" to be working in synchrony and coordination for delivering effective breastfeeding protection, promotion, and support at scale. Evidence-based advocacy is needed to generate the necessary political will to enact legislation and policies to protect, promote, and support breastfeeding at the hospital and community level. This political-policy axis in turn drives the resources needed to support workforce development, programme delivery, and promotion. Research and evaluation are needed to sustain the decentralised programme's coordination "gear" required for goal setting and system feedback. The BFGM has strong construct validity and has helped explain the different levels of performance in national breastfeeding outcomes in Mexico and Brazil (► **Fig. 22.5**) [13].



▶ **Fig. 22.4** Breastfeeding Gear Model. (Reproduced from Pérez-Escamilla, et al. [13] with permission)

The BFGM is indeed a specific CAS scaling-up model. The non-linear BFGM provides a good illustration of the CAS "perfect storm" that is needed for national breastfeeding programmes to successfully emerge. According to the BFGM, national breastfeeding programmes behave like an engine, requiring different intersectoral and interlocked gears coordinated by a master gear that utilises feedback loops to ensure the engine is properly functioning. The BFGM fully recognises the need to include influential champions and leaders to create strong demand and acceptance of the programme services (scale-free networks). It also includes an evidence-based advocacy gear, which is often the first to be organised, to create the conditions for the whole machine to be assembled and before substantial impacts in breastfeeding behaviours are actually observed (phase transitions). Finally, while the BFGM posits that the gears are likely to be the same across countries, it fully recognises that the nuts and bolts needed to make each gear function are context specific (path dependent) [41].

The construct validity of the BFGM has been assessed through extensive peer review, confirming that it was able to identify key breastfeeding protection, promotion, and support components as well as the key elements of the policy heuristic model, which calls for agenda setting (i.e., generate attention to problem), policy formulation and adoption, effective policy implementation through diverse programmes or interventions, and programme monitoring and evaluation [42]. It also strongly emphasises the need for champions and visionary leaders to carry the policy process forward [42].

22.3.7 Indicators for Scaling-up of Breastfeeding Programmes

Although currently there are no policy tool boxes to assist policy makers with the scaling-up process of breastfeeding programmes following CAS action-oriented conceptual frameworks such as the BFGM, there are two important initiatives that have sought to develop indicators that can help inform the scaling-up process. These initiatives are the WHO's Infant and Young Child Feeding: A Tool for Assessing National Practices, Policies and Pro-

▸ **Fig. 22.5** Application of the Breastfeeding Gear Model for understanding differences in breastfeeding performance between Brazil and Mexico. (Reproduced from Pérez-Escamilla, et al. [13] with permission)

grammes launched in 2003 [43], and IBFANs World Breastfeeding Trends Initiative (WBT*i*) launched in 2004 [44] heavily building upon the WHO tool. Both initiatives seek to involve stakeholders in assessing IYCF outcomes, activities, and processes with the goal of empowering countries to identify IYCF gaps that need to be addressed.

22.4 WHO Tool

The specific goal of the WHO tool is to help countries 'assess the strengths and weaknesses of policies and programmes for protecting, promoting and supporting optimal feeding practices, and determine where improvements may be needed to meet the aim and objectives of the Global Strategy for Infant and Young Child Feeding' [43]. The tool is recommended to be used every several years to document indicators trends, identify gaps, and assist countries with the planning process. The tool specifically targets teams formed by key national policymakers, programme managers/staff, and NGO leaders.

The tool which is strongly driven by the Innocenti Declaration (1990) and related IYCF global strategy (WHO/UNICEF 2003) is divided into three major areas:

- IYCF practices
- National IYCF policies and targets
- National IYCF programme

At the heart of the tool are the criteria that are needed to score and/or rank each indicator within each of the three areas. The manual contains specific instructions on how to assess each indicator including:

- Key question to be answered
- Background on why the practice, policy or programme is important
- Possible sources of information
- Interpretation criteria to identify successes and challenges that need to be addressed

For assessing the prevalence of IYCF practices, the tool recommends using random household surveys representative of the level at which assessment is being conducted (from national to local) (► **Table 22.4**). Each IYCF behaviour indicator is finally rated as "poor", "fair", "good", or "very good" based on prevalence and evidence-based cut-off points.

For assessing IYCF policies and targets, each of the six indicators is scored through weighted scores for each criterion, percentage coverage (i.e., percentage facilities with BFHI accreditation), or compliance with implementation, monitoring and enforcement of policy components (i.e., WHO Code). For each indicator the scores can range from 0 to 10 (► **Table 22.5**) (except for percentage facilities with BFHI accreditation where scores can range from 0 to 100%) and each is finally rated as "poor", "fair", "good", and "very good", based on pre-established cut-off points.

For the IYCF programme, each of the 12 indicators is rated as being "unmet", "partially met", or

► **Tab. 22.4** Infant and young child feeding. A tool for assessing national practices, policies and programmes: Infant feeding behaviours and corresponding indicators.

Infant feeding behaviour	Indicator
Initiation of breastfeeding	% of babies breastfed within one hour of birth
Exclusive breastfeeding	% of babies 0 to < 6 months of age exclusively breastfed in the last 24 hours
Duration of breastfeeding	Median duration in months of breastfeeding of children under three years of age
Bottle-feeding	% of breastfed babies 0 to < 12 months of age fed from bottles in the last 24 hours
Complementary feeding	% of breastfed babies 6 to < 10 or 7 to < 10 months of age who received complementary foods in the last 24 hours

World Health Organization (WHO). Infant and young child feeding. A tool for assessing national practices, policies and programmes, 2003. Available at: http://www.who.int/nutrition/publications/inf_assess_nnpp_eng.pdf

► **Tab. 22.5** Infant and young child feeding. A tool for assessing national practices, policies and programmes: Policies and targets indicators.

Policies and targets	Indicators N	Emphasis
National infant and young child feeding policies	7	Based on Global Strategy on Infant and Young Child Feeding
National coordinators and committees	5	Multisectoral coordination
Baby-Friendly Hospital Initiative achievements	1	% facilities accredited as Baby-Friendly Hospital Initiative achievements
International Code of Marketing of Breast-milk Substitutes	6	Code implementation and monitoring
Legislation protecting and supporting breastfeeding among working mothers	7	Adoption and implementation of ILO Maternity Protection Conventions
Operational targets of the Global Strategy	5	Action plan implementation

ILO = International Labour Organization
World Health Organization (WHO). Infant and young child feeding. A tool for assessing national practices, policies and programmes, 2003. Available at: http://www.who.int/nutrition/publications/inf_assess_nnpp_eng.pdf

▶ **Tab. 22.6** Infant and young child feeding. A tool for assessing national practices, policies and programmes: Programme indicators.

Programme	Indicators N	Emphasis
National infant and young child feeding programme	5	Multisectoral-funded programme in place
An active and sustainable Baby-Friendly Hospital Initiative	7	Resources, infrastructure, and national coordination
Mother-Friendly childbirth strategies	5	Mother-friendly child birth procedures
Health care provider (pre-service) education	5	Medical, nursing, and midwifery schools, nutrition and public health academic programmes
In-service training for health care providers	7	Curriculum content, knowledge, and skills among professionals and paraprofessionals
Community outreach and support	6	Includes non-health organisations
Information, education and communication	7	Comprehensive evidence-based internal communication (IC) strategy
Contraceptive support for breastfeeding women	5	Lactational Amenorrhoea Method (LAM)
HIV and infant feeding	7	Voluntary counselling and testing (VCT) and follow-up support
Infant and young child feeding in emergencies	4	Coordination among government, international agencies, and other and non-government actors; adequate training
Research for decision making	7	Translational research and evaluation for decision making
Monitoring and evaluation	5	Adequate management information systems (MIS) useful to decision makers

World Health Organization (WHO). Infant and young child feeding. A tool for assessing national practices, policies and programmes, 2003. Available at: http://www.who.int/nutrition/publications/inf_assess_nnpp_eng.pdf

“fully met“, with a weighted score corresponding to each response option (▶ **Table 22.6**). The score for each indicator can range from 0 to 10 and each indicator is then ranked as “poor”, “fair”, “good”, or “very good”, based on pre-established cut-offs. Because the programme indicators are often difficult to score quantitatively, an alternative qualitative scoring system is allowed to rank the criteria as either “low-”, “medium-”, or “high-” level of achievement [43].

Based on pre-testing in nine countries, the following recommendations emerged for optimal tool implementation: (1) identification of a key coordinator and the key support needed; (2) identification of an assessment team; and (3) plan and implement assessment based on operating rules established a priori [43].

22.5 The World Breastfeeding Trends Initiative (WBTi)

Building heavily upon the WHO tool and the World Alliance for Breastfeeding Action (WABA) Global Participatory Action Research (GLOPAR), WBT*i* was launched by IBFAN Asia as a tool for tracking, assessing, and monitoring the IYCF Global Strategy worldwide using a web-based tool kit [44]. The WBT*i* methodology involves scoring 15 indicators, 10 of which deal with policies and programmes, and five of which deal with infant feeding practices (▶ **Table 22.7**).

Specific criteria are outlined for scoring each indicator [45]. Each criterion for each of the 10 policies and programme indicators is assigned a score

▶ **Tab. 22.7** World Breastfeeding Trends Initiative (WBTi) indicators.

Policies and programmes	Infant feeding practices
National Policy, Programme and Coordination	Percentage of babies breastfed within one hour of birth
Baby-Friendly Hospital Initiative	Percentage of babies < 6 months of age exclusively breastfed in the last 24 hours
Implementation of the International Code of Marketing of Breastmilk Substitutes	Babies are breastfed for a median duration of how many months
Maternity Protection	Percentage of breastfed babies less than 6 months old receiving other foods or drink from bottles
Health and Nutrition Care System (in support of breastfeeding and IYCF)	Percentage of breast-fed babies receiving complementary foods at 6–9 months of age
Mother Support and Community Outreach (community-based support for the pregnant and breastfeeding woman)	
Information Support	
Infant Feeding and HIV	
Infant Feeding During Emergencies	
Mechanism of Monitoring and Evaluation Systems	

Note: Background information on Millennium Development Goals (MDG) 1 (extreme poverty and hunger), 4 (child mortality) and 5 (maternal health) is collected but is not scored, colour-rated or graded. It can be used to provide a better understanding of the health, nutritional and socioeconomic context which influences infant and young child feeding (IYCF) practices and programmes.
World Breastfeeding Trends Initiative (WBTi). WBTi Guide Book. Available at: https://www.worldbreastfeedingtrends.org/uploads/resources/document/wbti-guide-book-may-2019.pdf

that can range from 0 to 3 with each indicator having a possible score ranging from 0 to 10; thus, each country can attain a maximum score of 150 points. Each indicator is then colour coded as red (score: 0 to 3.5), yellow (4 to 6.5), blue (7 to 9), or green (> 9) for easy visualisation. As in the WHO tool, the ranking of the five infant feeding indicators is based on their actual prevalence in relationship to international recommendations and are colour coded as red, yellow, blue and green. Consistent with the WHO tool, WBT*i* recommends for each country to form its own multi-stakeholder group to conduct the WBT*i* indicators assessment, using existing data and/or by conducting interviews with key informants. All data are entered into the user-friendly WBT*i* webpage, which allows for graphical representation of findings that can be used for evidence-informed advocacy purposes. The expectation is for this participatory process not only to lead to the identification of gaps but also to actual implementation of the changes needed to fill those gaps. The WBT*i* process is recommended to be repeated every 3 to 5 years. There is limited published evidence to support changes in national breastfeeding programmes as a result of the WBT*i* process. However, a study by Lutter & Morrow did document a positive association between the WBT*i* score and EBF [46]. They specifically found that among 22 countries in Africa, Asia, the Middle East, and Latin America with at least two assessments between 1986 and 2010, the median annual increase in EBF was 1.0% in countries in the upper 50^{th} percentile of WBTi scores, in comparison to only 0.2% in countries with the lowest WBT*i* scores (p=0.01).

22.6 Conclusions and Vision for the Future

The individual and societal benefits that can be derived from improved protection, promoting, and support of optimal breastfeeding practices has been well established [19]. Likewise, the key ingredients for effectively scaling-up of national breastfeeding programmes have been identified to a large extent [13]. In spite of this vast amount of knowledge, relatively little progress has been made over the past decade at improving key breastfeeding outcomes such as early initiation of breastfeeding and EBF for six months. The global cost of this inaction or of a lack of adequate translation of knowledge into practice is in the order of hundreds of millions of dollars annually and is a matter that must be addressed [47].

An important step in changing the status quo has been development of indicators to capture the enabling environment and progress with key elements needed for scaling-up breastfeeding programmes to the national level. However, these efforts need to be improved by basing this approach in conceptual frameworks and models that capture the complex non-linear relationships among all key elements that need to be in place for the scale-up of effective breastfeeding protection, promotion, and support programmes [16]. This chapter offers the AIDED framework and related BFGM as powerful conceptual models to take the enabling environment assessments and subsequent monitoring of scaling-up to the next level. For this to happen, however, it is crucial that prospective scaling-up CAS research is embedded in existing assessment tools as well as in CAS-based policy-maker friendly tools currently under development. The goal of these tools should continue not only to be the collection of data per se but to ensure that the assessment process generates the required evidence for decision makers to call for the necessary investments and actions to address poor breastfeeding performance worldwide. Regarding decision making, one of the key pieces of missing evidence is the costing of key elements needed for successful scaling-up of breastfeeding programmes. For example, it is important to empower countries to find out how much it costs their country to have all the gears of the BFGM solidly in place and working as a harmonious system. Without this information it becomes practically impossible for the Ministry of Finance to be able to allocate an itemised budget for the Ministry of Health to run an effective national breastfeeding programme. Although there are ongoing efforts to cost the activities needed to protect, support, and promote breastfeeding at scale [47], [48], there is much work that lies ahead to be able to empower decision makers to make sound evidence-based investment decisions for their programmes. How decisions are made as part of a successful scaling-up process of national breastfeeding programmes is indeed a very high priority area of implementation science research that can benefit many other maternal-child health and nutrition domains.

In conclusion, improving the uptake and scaling-up of effective national breastfeeding programmes should be a top priority for all countries. CAS research is needed to empower decision makers to achieve this goal through well-validated participatory decision making tools to help their countries assess baseline needs (including costs) as well as progress with their scaling-up efforts [13], [16]. Robust systems thinking frameworks and scaling-up models are now available to guide fruitful efforts, enabling their replication with appropriate adaptations across countries [16]. It is expected that this process can help reverse the declines in investments in breastfeeding protection, promotion, and support in diverse world regions [49], [50]. This is likely to increase health equity [51] that is a key principle behind the Sustainable Development Goals.

Key Points

- Scaling-up refers to the expansion of access to quality programmes that result from new technologies and interventions aimed at having a major and rapid impact on improving health in large sections of the target population. Breastfeeding is one such intervention that can have substantial positive short- and long-term impact on mothers, infants and society
- Successful scaling-up of breastfeeding programmes requires to have strong coordination between breastfeeding protection, promotion and

support activities and at the same time requires multi-level, multidisciplinary teams and stable financial commitment

- Implementation research is necessary to develop effective large scale programmes and how to best monitor them. This needs to include an understanding of all stakeholders as well as the complex interrelations necessary for successful programmes
- There are several existing tools to assist in the development of successful breastfeeding scale-up programmes with "Becoming Breastfeeding Friendly" being the newest most comprehensive framework launched in 2017 (http://bbf.yale.edu/) [52]

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23 Towards a Common Understanding of Human Lactation

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23.1 Preface

Throughout this book you may have noticed that different terminologies have been used. Conflicting advice is one of the most common factors that impact on a mother's confidence in her ability to breastfeed and sustain lactation. Consistent terminology is the most basic requirement for the prevention of conflicting advice. Even such basic terms as lactation and breastfeed have either varying or no definition in the scientific literature. For example, does lactation encompass both the mother and the child? Does a breastfeed refer to the infant removing milk from one breast or does it refer to the infant removing milk during a session, which may include more than one breast? These questions can be answered by a glossary that defines a common language. This glossary was developed in parallel with the content of this book and was not available to authors at the time of writing. The use of varying terminologies in preceding chapters serves to further highlight the need for such standardisation. This is an essential starting point towards a common medical and scientific understanding of human lactation.

Terms are included if they have a clear link to the medical or scientific understanding of human lactation.

- Preference is given to objective terms that are quantifiable (e.g. "slow weight gain", rather than "failure to thrive").

Terms that are NOT included:

- Medical diagnoses that are well defined elsewhere and require no additional modification of definition when occurring concomitantly with human lactation
- Organisations, groups, associations
- Acronyms (e.g. L.A.T.C.H.)
- Medications
- Qualifications, e.g., degrees, credentialing, certifications, etc.
- Layman's terms are avoided where possible.

23.2 Alphabetical List of Terms

24-h milk intake The volume of breastmilk, expressed breastmilk and infant formula consumed by the infant over a period of 24 hours. The volume of breastmilk consumed at the breast is calculated by recording a breastmilk transfer measurement after each feed from each breast for at least 24 hours. The volume of breastmilk consumed by the infant is calculated as the sum of all feeds over a 24-hour period. This ensures that a breastfeeding session (sometimes referred to as a "meal") is not counted twice in a 24-hour period. For example, if the first feed occurred at 7 am on the first day with the next feed at 9 am, and the first feed on the second day occurred at 6.30 am with the next feed at 8.30 am, the 6.30 am feed would not be included in the 24-hour calculation.
See also 24-h milk production (p. 366), 24-h milk profile (p. 366), Breastmilk transfer measurement (p. 369)

24-h milk production The volume of milk produced by the mother over a period of 24 hours. This can be calculated in several ways:
1) A breastmilk transfer measurement is recorded after each feed from each breast for at least 24 hours. The total milk production normalised to 24 hours is calculated using:
MP = SUM * (24/TIME) * [(n-1)/n]
Where MP is the 24-h milk production, SUM is the total of all breastmilk transfer measurements, TIME is elapsed time from beginning of the first feed to beginning of the last feed and n is the total number of feeds. This ensures that milk produced beyond the 24-hour period is not included, but milk produced by the mother after the last feed before 24 hours, but within the 24-hour period, is included. Breastmilk expressed over the same 24-hour period is also weighed, summed and added to this total.
2) Maternal milk is expressed from both breasts simultaneously in a relaxed, monitored environment for 10 minutes each hour. This is repeated every hour for 3 consecutive hours. The volume of milk expressed at the fourth expression multiplied by 24 provides an estimate of 24-h milk production.
3) Deuterium oxide-to-the-mother technique measures milk intake over a period of 5–14 days by measuring the changes in deuterium in mother and infant after a maternal dose. Deuterium oxide is uniformly distributed in total body water. Milk intake can be calculated from measuring the decrease in concentration of deuterium in maternal saliva together with the change in deuterium concentration in the infant's urine over 5–14 days. This method only works when milk production is stable. It cannot be used to study changing production, such as that which occurs during secretory activation.
See also 24-h milk profile (p. 366), 24-h milk intake (p. 366), Breastmilk transfer measurement (p. 369).

24-h milk profile A summary of individual infant milk intake (at the breast, expressed breastmilk and/or infant formula) and maternal milk production. A 24-h milk profile is carried out over a continuous 24-hour period and includes consecutive breastmilk transfer measurements, number of breastfeeds, amount and duration of breastfeeds, breastmilk expressions and infant intake of previously expressed breastmilk and/or infant formula.
See also 24-h milk intake (p. 366), 24-h milk production (p. 366), Breastmilk transfer measurement (p. 369)

α-lactalbumin A major nutritional protein present in the whey fraction of human milk. It constitutes about 10–20% of the total protein content of human milk. Metabolically it forms part of the lactose synthase complex.

Abscess (Breast) See Breast abscess (p. 368)

Accessory nipple See Polythelia (p. 382)

Accessory breast tissue See Polymastia (p. 382)

Acini See Alveoli (p. 366)

Acquired immune system (also adaptive immune system) Refers to cells of the immune system which are characterised by their high antigen specificity and their capacity to differentiate into memory cells upon subsequent encounters with the same antigen. The presence of memory cells allows accelerated and enhanced immune response.
See also Entero-mammary pathway (p. 372)

Acute weaning The abrupt termination of breastfeeding. See also Weaning (p. 386)

Adaptive immune system See Acquired immune system (p. 368)

Adenohypophysis pituitary gland (also Anterior pituitary gland) See Pituitary gland (p. 382)

Adenoma, lactational or lactating See Lactating adenoma (p. 375)

After Pains (also after birth pains) Breastfeeding in the immediate postpartum period lowers the risk of blood loss by inducing uterine contractions. These contractions can be associated with deep lower back and abdominal cramping pain in some women. The intensity of the pain varies, increases with parity and usually spontaneously resolves within the first two weeks postpartum.

Allergy An inappropriate inflammatory response of the immune system towards innocuous molecules present in the air such as pollens, house dust mite or in food such as milk, egg, fish, peanut. Symptoms include red eyes, itchiness, runny nose, eczema, hives or asthma attack.
See also Cow's milk protein allergy (p. 371), Hen's egg allergy (p. 373), Food allergy (p. 373)

Alveoli (also acini) The terminal ends of the milk ducts. Formed by a single spheroid layer of lactocytes arrayed around a central cavity (lumen), surrounded by blood capillaries and a web of stellate myoepithelial cells. Milk is secreted into the lumens of these structures.

Alveolar development (formerly mammogenesis) Proliferative activity in the mammary gland during pregnancy that leads first to stem cell division from the terminal end buds of the rudimentary ducts and then to active proliferation of the resulting cells to form the alveolar structures responsible for milk production.

Amastia Complete absence of breast tissue, nipple and areola.

Amazia Absence of breast tissue in the presence of the nipple and areola.

Amenorrhoea (Lactational) See Lactational amenorrhoea (p. 376)

Ankyloglossia (also Tongue-tie) Classic ankyloglossia is considered to be an obvious short or inelastic lingual frenulum, or one attached close to the tip of the tongue that may or may not cause a change in shape (heart shape). Other classifications include those that are thicker, fibrous and are located further towards the posterior tongue. Both types may limit tongue function, however there is no reliably validated tool available to assess tongue function for tongue-tie. Ankyloglossia may or may not inhibit effective breastfeeding with symptoms ranging from nipple pain, difficulty attaching to the breast and/or poor milk transfer.

Antenatal Before birth, during or relating to pregnancy.

Anterior pituitary gland See Pituitary gland (p. 382)

Apoptosis A form of cell death without inflammation that occurs as a normal and controlled part of an organism's growth or development. Programmed cell death. See also Mammary involution (p. 377)

Areola The pigmented area surrounding the nipple. Its surface is dotted with small projections due to the presence of Montgomery's glands.

Areolar glands See Montgomery's glands (p. 379)

Artificial feeding Infant is fed only on a breastmilk substitute, that is, any food being either marketed or otherwise represented as a partial or total replacement for breastmilk.

Artificial formula See Infant formula (p. 374)

Artificial nipple See Artificial teat (p. 367)

Artificial teat (also artificial nipple) An artificial device that is often shaped to resemble a maternal nipple. This is attached to a bottle and used to provide the infant with expressed breastmilk or infant formula.

At-breast supplementer (also Supplemental nursing system, Supply line) A feeding tube device consisting of a fine tube leading from a reservoir of breastmilk and positioned just past the tip of the nipple so that as the infant suckles at the breast, milk can be sucked through the tube to nourish the infant.

Attachment See Bonding (p. 368) and Positioning and latch (p. 382)

Attachment Parenting A parenting philosophy based on the dynamic interpersonal relationship between parents and their children.

Aurora kinase A A cell cycle-regulated kinase that may be involved in microtubule formation and/or stabilisation at the spindle pole during chromosome segregation – thought to have a key role in secretory activation by stimulating the formation of bi-nucleated lactocytes.

Available milk The volume of milk available to either the sucking infant or for expression by either hand or a breast pump. It is calculated as the storage capacity of the breast multiplied by the degree of fullness.

Axillary mammary tissue (also axillary mammary tail) Glandular tissue that extends from the breast towards the axilla partly under the lateral border of the pectoralis major muscle.

β-lactoglobulin A whey protein present in cow's milk but not found in human milk.

Baby blues See Postnatal blues (p. 382)

Baby-led attachment A pattern of instinctive movements of the infant occurring when placed on the maternal chest in a prone position. These movements enable the infant to locate the areolar area of the breast and latch on to the nipple largely unassisted.

Bifidobacteria Gram-positive anaerobic bacteria in breastmilk and common in the gut of breastfed infants that ferment sugars (particularly human milk oligosaccharides) and produce short chain fatty acids such as acetate, propionate and butyrate which play an important role in immune homeostasis.

Bile salt-stimulated lipase (BSSL) Present in low concentrations in the whey fraction. Upon activation by bile salts in the duodenum it hydrolyses a range of lipid substrates (short and long chain mono-, di- and triacylglycerides, cholesterol esters, retinol esters and p-nitrophenyl esters).

Bilirubin A yellow compound that occurs in the normal catabolic pathway that breaks down haeme.

Bioactive component Non-nutritive components of food (e.g., human milk) that have an impact on health via a regulatory effect on biological processes.

Birth weight The body weight of an infant at its birth.

Bleb See Blocked nipple pore (p. 368)

Blocked milk duct (also plugged duct, clogged duct, caked breast, caked duct, focal engorgement) A tender lump in the breast ranging from the size of a pea to a large wedge-shaped area. Not associated with either systemic illness or inflammation.
Note: It can be difficult to differentiate between engorgement, blocked milk duct, mastitis and breast abscess because they are a continuum without distinct boundaries. Each includes some element of milk stasis or impaired drainage.
See also Breast abscess (p. 368), Pathological engorgement (p. 381), Mastitis (p. 377)

Blocked nipple pore (also bleb, nipple white spot) A milk-filled blister on the nipple, thought to be caused by either the closure of a fine layer of skin growing over a duct opening or by thickened milk.
Presents on the nipple and/or areola as a white, clear or yellow dot. May sometimes stand out as a large blister.

Blood-milk barrier The barriers to the passage of blood constituents into milk directly from the extracellular space as well as direct passage of milk constituents from the alveolar lumen to the interstitium. In full lactation this passage is closed by tight junctions. This barrier is open in pregnancy, possibly in mastitis and during late involution.

Bonding (also attachment) A strong and affectionate connection between mother and infant, influenced positively by the hormone oxytocin.

Bottle-fed See Bottle-feeding (p. 368)

Bottle-feeding The act of feeding an infant from a bottle.

Bovine serum albumin A species-specific protein that is present in cow's milk, but only in low concentrations in the milk of women who consume cow's milk.

Breast (this term is interchangeable with Mammary gland) A female secretory and secondary sex organ. The breast remains in a quiescent state until conception triggers a process of complete remodelling that results in the synthesis and secretion of breastmilk. Functional maturity is only reached during lactation. The breast then returns to a quiescent state after involution, caused by gradual weaning of the infant.
See also Mammary gland (p. 377)

Breast abscess Characterised by a fluctuant, palpable mass that is usually tender and often associated with a localised, painful inflammation of the breast. Fever and malaise are often, but not always present.

It can be difficult to differentiate between engorgement, blocked milk duct, mastitis and breast abscess because they are a continuum without distinct boundaries. Each includes some element of milk stasis or impaired drainage.
See also Pathological engorgement (p. 381), Blocked milk duct (p. 367) and Mastitis (p. 377)

Breast and nipple herpes See Herpes of the nipple and breast (p. 373)

Breast and nipple thrush See Candidiasis of the nipple and breast (p. 370)

Breast augmentation See Mammary augmentation (p. 377)

Breast cancer (also mammary carcinoma) Malignant neoplasm in the parenchyma of the breast.

Breast compression See Breast massage (p. 368)

Breast cup See Breast shell (p. 368)

Breast cyst A benign fluid-filled lump. The mass is characteristically firm, smooth, lobulated and freely moveable. Differs from a galactocoele in that it is not filled with milk.
See Galactocoele (p. 373) and Breast lumps in lactation (p. 368)

Breast expression See Breastmilk expression (p. 369)

Breast feed See Breastfeed (p. 369)

Breast lumps in lactation A palpable mass detected in the breast during lactation. Most lumps detected during lactation are related to the breastfeeding process, such as blocked milk ducts, mastitis and galactocoeles. Some may result from causes other than pregnancy and lactation, such as prior surgery, breast cysts, benign tumours and breast cancer.
See Blocked milk duct (p. 367), Mastitis (p. 377), Galactocoele (p. 373), Breast cyst (p. 368), Lactating adenoma (p. 375), Fibroadenoma of the mammary gland (p. 372) and Breast cancer (p. 368)

Breast massage Gentle manipulation of the mammary gland by rubbing or kneading. Methods used show intercultural variations. There are also substantial differences in the intricacy and duration of the massage techniques. Uses vary from relieving blocked ducts, assistance with secretory activation, to comfort.

Breast milk See Breastmilk (p. 369)

Breast pad (also nursing pads) A single use or washable absorbent pad worn against the breast to prevent breastmilk leakage onto clothing between breastfeeds.

Breast pump A manual or electric device for withdrawing milk from a woman's breast(s) by suction.
See also Manual breast pump (p. 377), Electric breast pump (p. 372) and Hospital-grade breast pump (p. 374)

Breast pumping See Breastmilk expression (p. 369)

Breast reduction See Mammary reduction (p. 377)

Breast refusal (also breast aversion, breast rejection)
Feeding behaviour where an infant is reluctant to attach after having previously breastfed well. When brought to the breast to feed the infant typically turns its head slowly from side to side, crying desperately, arching its back, pushing its head away from the breast and punching with its fists. This action is extremely distressing to the mother.
See also Neonatal breast refusal (p. 379)

Breast shell (also milk cup, breast cup, Meredith shield)
A hard plastic dome worn inside the bra. Consists of an inner and outer section that snap together. The inner section surrounds the nipple and the outer section separates the nipple from the bra and clothing. Marketed as an aid in the management of inverted and/or damaged nipples.
See also Nipple shield (p. 380)

Breast shield The part of a breast pump that consists of a plastic conical device designed to cover the areolar area and then forms a tunnel that encompasses the nipple and allows the milk to flow into a collection bottle.

Breast storage capacity (also storage capacity) The amount of milk available to the infant when the breast is full. It is calculated from the cream content of milk samples collected before and after each feed from each breast, and the volume of milk consumed during each feed from each breast for a 24-hour period of breastfeeding.
See also Potential storage capacity (p. 382), Degree of fullness of the mammary gland (p. 371)

Breastfed Past tense of breastfeed.
See also Ever breastfed (p. 372)

Breastfeed (also breast feed, breast-feed) Removal of milk from one breast by the infant, usually of 8–15 minutes duration.
See also Paired breastfeed (p. 381), Cluster breastfeed (p. 370) and Breastfeeding session (p. 369)

Breastfeeding (also nursing) The act of the infant removing milk from the mammary gland.
See also Breastfeeding session (p. 369), Nutritive sucking (p. 380) and Non-nutritive sucking (p. 380)

Breastfeeding cues (also feeding cues, hunger cues) Infant behaviours that indicate a readiness to breastfeed. The infant is awake in the quiet, alert stage and may also suckle its hands. These behaviours occur prior to infant crying, which is considered to be a late cue. Usually more pronounced in the early postnatal period.

Breastfeeding indicator A measurable variable used to assess breastfeeding practices and defined by the World Health Organization. Key breastfeeding indicators include exclusive breastfeeding rate, predominant breastfeeding prevalence, timely complementary breastfeeding prevalence, continued breastfeeding prevalence and bottle-feeding prevalence.

Breastfeeding patterns Summary of population data for healthy, term, exclusively breastfeeding dyads between 1 and 6 months of age. Includes breastfeeding frequency, breastfeed duration, average quantity of breastmilk ingested, percentage of available milk removed, 24-hour milk production etc.

Breastfeeding positions (also feeding positions) The positions in which the mother holds her infant while breastfeeding, e.g., cradle, transition, straddle, football hold.
See also Positioning and latch (p. 382)

Breastfeeding session Breastfeeding session can comprise of a breastfeed, a paired breastfeed or a cluster breastfeed. To be included in a breastfeeding session, the beginning of each breastfeed must occur within 30 minutes of cessation of feeding from the previous breast.

Breastfeeding to need (also feeding to need, demand breastfeeding, demand feeding) Maternal response to the infant's hunger cues and breastfeeding accordingly. The frequency and milk intake can vary considerably from feed to feed but 24-h intakes remain relatively stable as the infant's appetite regulates milk intake according to need.

Breastmilk (also human milk) The secretion produced by the lactocytes of the human maternal mammary gland from approximately 5 days after birth. Breastmilk contains a complex array of proteins, carbohydrates, lipids, micronutrients, vitamins and biologically active compounds involved in the growth, development and immune protection of the infant. Includes both transitional and mature breastmilk.
See also Colostrum (p. 370), Transitional breastmilk (p. 386), Mature breastmilk (p. 378)

Breastmilk appearance See Breastmilk colour (p. 369)

Breastmilk colour (also breastmilk appearance) Human milk is low in casein, therefore the colour is determined by the fat content, which varies depending upon the fullness of the maternal breast. If the breast is full of milk, the first milk expressed is usually pale blue in colour because of the low-fat content. If the breast is drained of milk the expressed milk is dense white in colour due the high fat content of the residual milk. In contrast, cow's milk is white in colour due in large part to the high content of casein, which remains relatively constant as the gland is emptied.
See also Milk fat (p. 378)

Breastmilk expression (also breast pumping, milk expression) Removal of breastmilk by either hand, manual breast pump or electric breast pump.

Breastmilk feeding When the infant is fed with expressed human milk.

Breastmilk jaundice A prolongation of physiological jaundice. Breastmilk jaundice occurs more than 24 hours after birth. It is a long-term jaundice in an otherwise healthy, breastfed infant and extends up to 8–12 weeks of life. Breastmilk jaundice tends to run in families, occurs equally often in males and females and affects 0.5% to 2.4% of all newborns.
See also Jaundice (p. 375), Pathological jaundice (p. 381) and Physiological jaundice (p. 381)

Breastmilk substitute Any food being marketed or otherwise presented as a partial or total replacement for breastmilk, whether or not it is suitable for that purpose (as defined by the World Health Organisation).
See also Infant formula (p. 374)

Breastmilk transfer The amount of breastmilk transferred to an infant over the course of a breastfeed.
See also Breastmilk transfer measurement

Breastmilk transfer measurement (also test-weigh) A measurement to determine the amount of milk transferred to the infant during a breastfeed. The fully clothed infant is weighed immediately pre and postbreastfeeding using digital scales (accurate to < 2.0g). The difference in the weights is equivalent to the amount of milk transferred to the infant. For improved accuracy, a correction should be made for insensible water loss from the infant during the feed.

Caesarean Section The use of surgery to deliver one or more infants.

Caked breast See Blocked milk duct (p. 367)

Caked duct See Blocked milk duct (p. 367)

Candida A genus of yeasts that is a common cause of fungal infections.
See also Candidiasis of the nipple and breast (p. 370)

Candidiasis of the nipple and breast (also thrush in lactation, candida mastitis) A condition characterised by nipple pain + /– breast pain throughout and after breastfeeds together with extreme nipple sensitivity. The syndrome is usually diagnosed clinically and whether Candida (usually Candida albicans) is the causative organism is yet to be conclusively supported by laboratory tests. Usually secondary to factors reducing natural immunity and/or skin trauma.

Casein/casein micelle A family of related phospho-proteins that form a micellar structure (casein micelles with α-s1, β and λ caseins subunits). It is a major protein in most mammals but only constitutes 10% of the total protein in human colostrum and 40% in mature human milk. The casein micelles and the phosphorylation of the casein molecules contribute to the high availability of calcium in human milk by enabling calcium to remain soluble at high concentrations. λ Casein is hydrolysed in the infant's stomach and the remaining proteins coagulate to form a soft casein curd.
In contrast, the high concentration of casein in cow's milk forms a very firm curd when ingested.

Cells in human milk See Human milk cells (p. 374)

Cellulitis Inflammation of subcutaneous connective tissue caused by a bacterial infection of the skin and its underlying dermis and subcutaneous fat. Symptoms include a painful area of redness that increases in size over several days. Must be differentiated from mastitis if it occurs on the breast during lactation.

Cephalohaematoma A collection of blood under the scalp of a newborn infant. The blood is located between the bones of the skull and the lining over the bones and is usually due to injury during the birthing process.

Choanal atresia Congenital obstruction of the nasal passage, usually by membranous or bony tissue.

Cleft lip and palate Relatively common birth defect resulting from incomplete merging or fusion of embryonic processes normally uniting in the formation of the face. Clefts range from a slight notch in the upper lip to a full opening of the lip into the floor of the nasal cavity (hard palate and soft palate). May be unilateral or bilateral.

Clogged milk duct See Blocked milk duct (p. 367)

Cluster breastfeed A series of breastfeeds occurring within a period of 30 minutes or less

Colic See Infantile colic (p. 375)

Colostrum The usually yellowish viscous secretion of the breast produced during the first two to four days postpartum. It is synthesised by the lactocytes of the maternal mammary gland in small volumes (about 30 mL in the first 24 h after birth). Compared to mature milk, colostrum has high concentrations of sodium, chloride, protein (particularly sIgA), and low concentrations of lactose and citrate.
See also Pre-colostrum (p. 383)

Coloured breastmilk Breastmilk that varies in appearance from the common breastmilk colour. May be pink, red, pink-orange, green or brown. Known causes include drugs, diet, bacterial infection and haemorrhage. Often benign.
See also Breastmilk colour (p. 369)

Complementary feeding Nutrient-containing first foods given during the transition from exclusive breastfeeding to family foods while breastfeeding is maintained.
Complementary breastfeeding commences during weaning, that is from around six months postpartum.
See also Exclusive breastfeeding (p. 372), Non-exclusive breastfeeding (p. 380), Predominant breastfeeding (p. 383), Supplementary feeding (p. 385), Substitute feeding (p. 385) and Weaning (p. 386)

Conditioned milk ejection reflex The ejection of milk in the absence of stimulation of the nipple to activate the neuro-hormonal reflex, i.e. in response to thinking about the infant, hearing an infant's cry.
See also Milk ejection reflex (p. 378)

Congenital A condition existing at birth which may be either hereditary or due to an influence on gene expression occurring up to the moment of birth.

Congenital lactose intolerance A very rare autosomal recessive disorder that is characterised by the complete absence of the enzyme lactase.
See also Lactose intolerance (p. 376), Developmental lactose intolerance (p. 371), Primary lactose intolerance (p. 383), Secondary lactose intolerance (p. 384)

Constipation A delay or difficulty in passing bowel motions. Rarely occurs in exclusively breastfed infants. Sometimes a breastfed infant may not pass a stool for 7 to 10 days and in the absence of symptoms this is not regarded as problematic.
See also Infant dyschezia (p. 374)

Contralateral Pertaining to the opposite side of the body.

Cooper's ligaments (also ligamenta suspensoria) Fibrous ligaments that provide a framework for breast tissue to maintain its structural integrity. They travel from the underlying pectoral fascia terminating at the skin.

Core biopsy (breast) A procedure involving insertion of a hollow needle into the breast to remove a small sample of tissue from an area of concern for laboratory testing.

Corpus luteum A hormone-secreting structure that develops in an ovary after ovulation. It degenerates after a few days unless conception has occurred.

Costal Relating to the ribs (for example costal cartilage).

Costochondritis Inflammation of the cartilage that connects a rib to the sternum. May be an extra-mammary musculoskeletal cause of breast pain.

Co-sleeping (also rooming in) Mother and infant sleeping in proximity (within arm's reach) of one another. This permits the mutual monitoring and exchange of caregiver–infant sensory signals and cues.

Cow's milk protein allergy (CMPA) A food allergy caused by cow's milk proteins. Intact cow's milk proteins have been identified in human milk. Rarely, cow's milk protein allergy can occur during exclusive breastfeeding.
See also Allergy (p. 366), Hen's egg allergy (p. 373), Food allergy (p. 373)

Cream The milk fat fraction that rises to the top of the container when milk either stands for a time or is centrifuged.
See also Milk fat (p. 378)

Creamatocrit A measure of the proportion of cream in a milk sample, determined by centrifuging the sample and measuring the depth of the cream layer as a proportion of the depth of the milk sample.

Crying See Normal infant crying (p. 380)

Cup feeding Placing breastmilk in a small cup and holding it to the infant's lips so that a small amount of milk can flow into the infant's mouth.
See also Paladai (p. 381)

Daily breastmilk intake The sum of breastmilk consumed by an infant over a 24-hour period.
See also 24h milk production (p. 366)

Dancer hand position A breastfeeding position whereby the mother uses her hand to stabilise her infant's jaw and facilitate breastfeeding when muscular weakness is present.

Degree of fullness of the mammary gland Measured using the computerised breast measurement system, the degree of fullness of the mammary gland is a proportion of the amount of milk present in the mammary gland compared to the breast storage capacity at any particular time during the day. The degree of fullness ranges from 1.0 for a full breast to 0.0 for a drained breast.
See also Breast storage capacity (p. 369), Potential storage capacity (p. 382)

Delayed secretory activation Secretory activation that occurs more than 72hr after birth. The mother still has the ability to achieve full milk synthesis unless primary lactation failure is present.
Also see Primary lactation failure (p. 383), Secretory activation (p. 384)

Demand breastfeeding See Breastfeeding to need (p. 369)

Dermatitis See Nipple and areolar dermatitis (p. 379)

Developmental lactose intolerance Occurs in preterm babies of less than 34 weeks gestation and is a consequence of prematurity. Preterm infants should continue to receive breastmilk in all cases if available.
See also Congenital lactose intolerance (p. 370), Lactose intolerance (p. 376), Primary lactose intolerance (p. 383), Secondary lactose intolerance (p. 384)

Deviated nasal septum Deformity of the nasal septum often caused by pressure on the foetus during pregnancy or parturition.

Diabetes Impaired ability to produce or respond to insulin.
See also Gestational diabetes mellitus (p. 373), Type 1 diabetes mellitus (p. 386), Type 2 diabetes mellitus (p. 386)

Diabetes insipidis Caused by a low or absent secretion of the water-balance hormone vasopressin from the pituitary gland or poor renal response to vasopressin.

Diagnostic ultrasound An ultrasound-based imaging technique used for visualising internal body structures for possible anomalies or pathology.
See also Therapeutic ultrasound (p. 385)

Donor human milk Excess human milk voluntarily contributed to a milk bank by lactating women. Usually the donor mothers are screened (similar to blood donor screening) and the milk is pasteurised before being given to the recipient infant.

Donor human milk bank An organisation that may recruit and screen breastmilk donors, then collects, processes, stores and dispenses the donated milk. There is no payment to the donor or cost to the recipient.
See also Human milk bank (p. 374), Milk sharing (p. 379)

Double pumping See Simultaneous pumping (p. 384)

Doula A companion who provides non-medical support and assistance to the new mother throughout the perinatal period.

Draught See Milk ejection (p. 378)

Duct See Milk duct (p. 378)

Ductal papilloma See Intraductal papilloma (p. 375)

Ductal obstruction Scarring or other trauma that results in complete or partial blockage of milk ducts.

Dummy (also pacifier) A rubber, plastic or silicon nipple designed to be given to an infant to suckle. In its standard appearance it has a teat, mouth shield and handle. The mouth shield and the handle are large enough to avoid the danger of the child either choking or swallowing it.

Duration of lactation See Lactation duration (p. 375)

Dyad (breastfeeding) The interactional relationship between a breastfeeding mother and her infant.

Dysphagia Difficulty swallowing

Dysphoric milk ejection reflex (D-MER) A sudden onset of negative emotions, which occur just prior to stimulation of the milk ejection reflex. Symptoms may continue for up to several minutes. Mother's describe themselves as happy between milk ejection reflex episodes.
See also Milk ejection (p. 378)

Echogenicity The ability to bounce an echo, for example, to return the signal in ultrasound examinations. Echogenicity is higher when the surface bouncing the sound echo reflects increased sound waves.

Eczema (Atopic dermatitis) See Nipple and areolar dermatitis (p. 379)

Egg Allergy See Hen's egg allergy (p. 373)

Electric breast pump A breast pump for personal use that requires a power source, either a power outlet or battery. May be either single or double (able to express milk from both breasts simultaneously).
See also Hospital-grade breast pump (p. 374)

Endocrine Glands that secrete hormones directly into the circulatory system to be carried towards distant target organs

Engorgement See Physiological engorgement (p. 381), Pathological engorgement (p. 381)

Entero-broncho-mammary pathway See Entero-mammary pathway (p. 372)

Entero-mammary link See Entero-mammary pathway (p. 372)

Entero-mammary pathway (also entero-mammary link, entero-broncho-mammary pathway) The pathway towards the end of pregnancy whereby lactogenic hormones influence the migration of lymphocytes from aggregates in the gut to the mammary glands. This results in secretory IgA antibodies in breastmilk that are protective against microbes from the mother's gut and her upper respiratory tract secretions. It follows that breastfeeding should be initiated directly after birth to provide protection from exposure to microbes from birth onwards.

Established lactation Lactation from the time that breastmilk becomes mature until weaning commences. Breastmilk is currently considered to be mature after about 2–3 weeks postpartum, however more research is needed to accurately determine the markers of established lactation.
See also Mature breastmilk (p. 378), Transitional breastmilk (p. 386), Weaning (p. 386)

Estrogen See Oestrogen (p. 380)

Ever breastfed Infants who have been put to the breast, even if only once.

Eutherian A subclass of mammals having a placenta through which the foetus is nourished

Exclusive breastfeeding The infant receives only breastmilk (includes milk received via breastfeeding, expressed mothers own milk, milk from a donor and milk from a wet nurse). Allows the infant to receive drops, syrups (vitamins, minerals, medicine). Does not allow the infant to receive anything else including water (defined by the World Health Organization).
See also Predominant breastfeeding (p. 383), Complementary feeding (p. 370), Supplementary feeding (p. 385), Non-exclusive breastfeeding (p. 380) and Substitute feeding (p. 385)

Expressed breastmilk (EBM) Breastmilk that has been removed by expression.

Expression of breastmilk See Breastmilk expression (p. 369)

Failure to thrive See Slow weight gain (p. 384)

Familial puerperal alactogenesis An isolated prolactin deficiency, which causes primary lactation failure (p. 383)

Feedback inhibitor of lactation (FIL) A local mechanism that down-regulates milk synthesis as milk accumulates in the alveoli. Although there is considerable experimental support for such a mechanism, the exact mechanistic pathway remains elusive.

Feeding cues See Breastfeeding cues (p. 369)

Feeding positions See Breastfeeding positions (p. 369)

Feeding to need See Breastfeeding to need (p. 369)

Fertility and breastfeeding See Lactational amenorrhoea (p. 376)

Fibroadenoma of the mammary gland A benign, solid, mobile tumour of epithelial tissue with a conspicuous proliferation of fibroblasts. Often palpable. Tumour cells can form gland-like structures in the stroma. Most common in women aged 15–35 years.

Fine needle aspiration (FNA) A diagnostic procedure using a fine needle to obtain fluid or cells from breast lesions or cysts.

Flat nipple A nipple that is level with the areola, or only protrudes slightly from the breast.
See also Inverted nipple (p. 375)

Focal engorgement See Blocked milk duct (p. 367)

Follicle stimulating hormone (FSH) A hormone secreted by the anterior pituitary gland that promotes the formation of ova or sperm.

Food allergy An inflammatory immune response to dietary proteins. Can occur during exclusive breastfeeding but usually occurs after the introduction of solids to the infant's diet, e.g., hen's egg allergy.
See also Allergy (p. 366), Cow's milk protein allergy (p. 371), Hen's egg allergy (p. 373)

Forceful milk ejection See Strong milk ejection (p. 385)

Fore milk See Pre-feed breastmilk (p. 383)

Frenulum A fold of mucous membrane, midline on the underside of the tongue that helps to anchor the tongue to the floor of the mouth.

Frenulotomy (also frenectomy, frenotomy, frenulectomy) A surgical procedure for excising a frenulum.

Fresh milk Milk that has been expressed from the breast and not exposed to any processes such as pasteurisation, freezing or thawing.
See also Raw milk (p. 383)

Gagging Involuntary gastric and oesophageal movements of vomiting without expulsion of vomitus.

Galactocoele A benign breast lesion characterised by a milk filled cyst thought to develop from an unrelieved blocked duct or defect in the duct wall during pregnancy, lactation or weaning.
See also Breast cyst (p. 368)

Galactogogue (also lactogogue) Any food or medication that is shown to improve milk synthesis.

Galactopoiesis Maintenance of established milk synthesis by the autocrine system balancing supply to demand.

Galactorrhoea See Neonatal galactorrhoea (p. 379)
N.B. maternal galactorrhoea is outside the scope of this glossary.

Galactosaemia A rare condition resulting in the inability to metabolise galactose due to deficiency of either galactose-1-phosphate uridyl-transferase (most common and most severe form), galactokinase or galactose-6-phosphate epimerase. Breastfeeding is contraindicated for infants with this disorder.

Gastro-oesophageal reflux (GOR) See Infant regurgitation (p. 375)

Gastro-oesophageal reflux disease (GORD) (also gastroesphageal reflux disease (GERD)) A condition associated with complications of infant regurgitation.
See also Infant regurgitation (p. 375)

Gestational age Age of the foetus measured from the first day of a mother's last menstrual cycle to the current date. A normal pregnancy can range from 38 to 42 weeks.

Gestational diabetes mellitus (also gestational diabetes) (GDM) A condition in which a woman without previously diagnosed diabetes exhibits high blood glucose (blood sugar) levels during pregnancy (especially during the third trimester). The cause is usually an improper response to insulin.
See Diabetes (p. 371), Type 1 diabetes mellitus (p. 386), Type 2 diabetes mellitus (p. 386)

Ghrelin A peptide produced by ghrelinergic cells in the gastrointestinal tract, which functions as a neuropeptide in the central nervous system and is involved in the regulation of appetite.

Gigantomastia (also pregnancy related gigantomastia, gravid or gestational gigantomastia) Rapid and massive hypertrophy of the breast during pregnancy with grossly dilated nipples and areola and prominent dilated superficial veins.

Glands of Montgomery See Montgomery's glands (p. 379)

Glandular parenchyma (also glandular tissue) Secretory tissue in the mammary gland that secretes milk.

Gonadotrophin Any of a group of hormones secreted by the pituitary gland that stimulate the activity of the gonads.

Gonadotrophin releasing hormone (GnRH) A hormone produced in the hypothalamus and transported to the pituitary gland through the blood stream. It controls the secretion of follicle stimulating hormone (FSH) and luteinising hormone (LH).

Graves disease See Hyperthyroidism

Haemorrhage Copious discharge of blood from vessels.
See also Postpartum haemorrhage (p. 382)

Hard palate The anterior bony subsection of the palate (roof of the mouth).
See also Palate (p. 381), Soft palate (p. 384)

Hen's egg allergy An exaggerated immune response that may be related to dietary exposure to eggs. May also occur after weaning.
See also Allergy (p. 366), Cow's milk protein allergy (p. 371), Food allergy (p. 373)

Herpes See Herpes of the nipple and breast (p. 373)

Herpes of the nipple and breast (also herpes simplex mastitis) Associated with severe pain combined with a unilateral or bilateral acute erosive dermatosis caused by Herpes simplex virus (HSV) infection. Presents similarly to HSV infections elsewhere on the body.

Herpes simplex mastitis See Herpes of the nipple and breast (p. 373)

Hind milk See Post-feed breastmilk (p. 382)

Hirschsprung's disease Congenital disorder of the colon caused by the failure of ganglion cells to migrate cephalocaudally through the neural crest during the early gestational period. Missing nerve cells in the lower portion of the colon prevent contractions of the affected portion of the intestine. Lack of contractions result in a reduction of the passage of contents, which may result in a blockage of the colon.

Hospital-grade breast pump A robust electric breast pump recommended for prolonged, frequent and regular use. May be used by multiple users.
See also Manual breast pump (p. 377), Electric breast pump (p. 372)

Human chorionic gonadotropin (hCG) A hormone produced by the placenta after implantation. The presence of hCG is used in some tests to detect pregnancy.

Human lactology The study of, or specialty in, the scientific or medical field of human lactation.

Human microbiome The catalogue of symbiotic microbes and their genes that are harboured by a human, primarily in the gut. The human milk microbiome and its effects on the infant microbiome are yet to be fully understood.

Human milk See Breastmilk (p. 369)

Human milk bank A store of human milk for later use when required.
See also Milk sharing (p. 379), Donor human milk bank (p. 371)

Human milk cells May be breast-derived or blood-derived. Breast-derived human milk cells include lactocytes, myoepithelial cells, progenitor cells and stem cells. Blood derived cells include immune cells, haematopoietic stem cells, haematopoietic progenitors and possibly other blood-derived cells.

Human milk fortifier Predominantly protein and mineral supplementation added to human milk so that it meets the nutrients required for the rapid growth rate and bone mineralisation of the preterm infant. May be derived from human breastmilk or bovine milk.

Human milk metabolomics The scientific study of the metabolites involved in the metabolic pathways associated with the synthesis of human milk.

Human milk microbiome See Human microbiome (p. 374)

Hydatiform mole A rare mass that forms from the placenta at the beginning of pregnancy

Hyperbilirubinaemia An abnormally large amount of bilirubin in the circulating blood

Hyperreactio luteinalis See Theca lutein cyst (p. 385)

Hypoplastic breasts (also breast hypoplasia, mammary hypoplasia, insufficient glandular tissue) Underdevelopment of the mammary glands. Clinically this may result in insufficient milk synthesis to exclusively breastfeed the infant. It is difficult to predict the effect of hypoplasia on milk synthesis.

Hypothalamus A portion of the brain that has a wide variety of functions – importantly it links the nervous system to the endocrine system via the pituitary gland.

IgE (Immunoglobulin E) A class of antibody that has been found only in mammals. It has an essential role in type-1 (acute onset) hypersensitivity reactions that manifest in various allergic diseases.

Induced lactation The establishment of lactation for an infant by a non-biological mother.
See also Relactation (p. 383)

Infant A child from birth to 12 months of age.

Infant dyschezia A benign, transient condition that causes constipation-like symptoms. It results from a developmental lack of coordination of the relaxation of the pelvic floor and the intra-abdominal pressure increase preceding defaecation.
See also Constipation (p. 370)

Infant formula (also artificial formula, artificial milk) A food manufactured according to compositional standards prescribed in the European Directive or Codex Alimentarius that is suitable as a complete or partial substitute for breastmilk. It is designed to meet the nutritional needs of an infant under one year of age and is usually derived from modified cow's milk but can also be manufactured from either goat's milk or plant sources such as soy.
See also Breastmilk substitute (p. 369)

Infant growth after 14 days of age World Health Organization growth curves are a normative model for breastfed infants and are used to monitor height and weight for age. Growth is expected to follow a trend, tracking a curve roughly parallel to the median.
Growth curves for breastfed babies are different from those that are formula-fed.

Infant-led weaning A method of introducing complementary foods whereby the infant controls their intake. Foods of a suitable texture are presented in their whole form and the infant is allowed to self-feed by selecting and grasping items. This encourages self-regulation with little parental control over intake. Small, hard foods should be avoided due to increased choking risk.
See also Mother-led weaning (p. 379)

Infant output Number of wet and soiled nappies (diapers) per 24 hours

Infant regurgitation (also reflux, posset, gastro-oesophageal reflux (GOR), gastroesophageal reflux (GER) A normal physiologic process defined as the involuntary passage of gastric contents into the oesophagus. Episodes usually last < 3 minutes and occur after meals. The condition is self limiting and benign.
See also Gastro-oesophageal reflux disease (p. 373)

Infantile colic A benign and self-resolving behavioural syndrome characterised by recurrent or prolonged periods of crying, fussing or irritability that start and stop without obvious cause and cannot be prevented or resolved by caregivers, in an otherwise healthy infant under 5 months of age. Exact aetiology is unknown.

Infective mastitis See Mastitis (p. 377)

Initiation (of lactation) See Lactation initiation (p. 375)

Innate immune system Cells of the immune system that are activated by molecules found in pathogens (pathogen associated molecular pattern, PAMP) or liberated upon tissue lesion (danger associated molecular pattern, DAMP). The innate immune system provides an immediate, non-antigen specific immune response.
See also Acquired immune system (p. 368)

International code of marketing of breastmilk substitutes (also WHO code) A set of resolutions that regulate the marketing and distribution of any fluid intended to replace breastmilk, certain devices used to feed these fluids, and the role of health-care workers who advise on infant feeding. It is intended as a voluntary model that could be incorporated into the legal code of individual nations in order to enhance national efforts to promote breastfeeding and to regulate the composition of foods that can replace breastmilk, when it is not available.

Intraductal papilloma A benign breast tumour that can grow to 1 to 2 cm in size inside the milk ducts of the breast, often near the nipple. Sometimes these bodies can bleed or seep fluid, causing a serous or bloody discharge from the nipple.

Intraglandular fat Fat dispersed within the mammary parenchymal tissue.

Intramammary distance The minimum distance between the right and left sternal lines.

Intraoral vacuum Vacuum generated during a breastfeed when the infant's mouth is attached to the maternal breast. Intraoral vacuum peaks at –145 ± 58 mmHg and coincides with milk flow into the infant's oral cavity.
See also Strong sucking vacuum (infant) (p. 385)

Intrapartum Occurring during labour and delivery or childbirth.

Inverted nipple Failure of the nipple to evert caused by poor proliferation of the mesenchyme underlying the mammary primordium. Can present either bilaterally or unilaterally and may pose mechanical problems with breastfeeding.

Involution See Mammary involution (p. 377)

Jaundice A yellowish pigmentation of the skin, the conjunctival membranes over the sclera (whites of the eyes) and other mucous membranes caused by hyper-bilirubinaemia (too much bilirubin in the blood).
See also Pathological jaundice (p. 381), Physiological jaundice (p. 381) and Breastmilk jaundice (p. 369)

Kangaroo mother care (also Kangaroo care) A method of preterm and low birth weight infant care defined by the World Health Organisation. It involves carrying the infant chest to chest, usually by the mother, with skin-to-skin contact and breastfeeding. Kangaroo mother care has been associated with early discharge.
See also Skin-to-skin care (p. 384)

Lactase The enzyme lactase (EC 3.2.1.108) is a β-galactosidase produced in the small intestine that is essential for the hydrolysis of milk lactose to glucose and galactose. It is present in all normal infants and some adult ethnic groups that depend on cow's milk for nutrition as adults.

Lactating adenoma A solid mass in the breast, which only occurs during pregnancy and lactation, typically arising in the third trimester and involutes after delivery.

Lactation A period of sustained milk synthesis, which requires frequent and effective milk removal as well as appropriate hormonal stimulation.
See also Normal human lactation (p. 380)

Lactation cycle The progressive changes that occur in the mammary gland from conception, through pregnancy, birth, lactation, weaning and the return to the quiescent state (i.e. non-pregnant non-lactating state).

Lactation duration The time of lactation from birth until complete weaning.
See also Lactation duration, recommended (p. 375)

Lactation duration, recommended The World Health Organization recommends exclusive breastfeeding for the first 6 months of life then addition of nutritionally adequate and safe complementary foods while breastfeeding continues for up to 2 years of age or beyond.

Lactation failure The maternal inability to produce adequate milk for her infant's optimal growth, development and immune protection. Lactation failure may be primary or secondary.
See also Primary lactation failure (p. 383), Secondary lactation failure (p. 384)

Lactation initiation A cascade of events resulting in the synthesis and secretion of milk constituents from lactocytes in the mammary gland. Includes alveolar development, secretory differentiation and secretory activation.
See also Alveolar development (p. 366), Secretory differentiation (p. 384), Secretory activation (p. 384)

Lactation risk categories Risk categories defined by Dr Thomas Hale to describe the level of risk a medication poses towards the infant or maternal lactation.

Lactation risk factors Factors that are known to cause some degree of lactation failure. Includes factors that result in delayed secretory activation, primary lactation failure or secondary lactation failure.
See also Delayed secretory activation (p. 371), Lactation failure (p. 378), Primary lactation failure (p. 383) and Secondary lactation failure (p. 384)

Lactation stages (also stages of lactation) Include alveolar development, secretory differentiation, secretory activation, established lactation, weaning.

Lactational amenorrheoa Physiological cessation of menses during lactation. The duration of lactational amenorrhoea varies between individuals within societies and also between societies, being as short as 2–3 months in Western societies and as long as 3 years in some Western women and traditional societies.

Lactational amenorrhoea method (LAM) Method of contraception for exclusively breastfeeding mothers. No more than four hours between breastfeeds during the day and six hours at night. Supplementary foods should comprise no more than 5–10% of the breastfed infant's energy intake.

Lactiferous duct See Milk duct (p. 378)

Lactiferous sinus Expanded ductal structures that have failed to be confirmed by recent studies. Previously it was thought that the milk ducts dilated towards the nipple and formed lactiferous sinuses, somewhat analogous to the milk cisterns in ruminants.

Lactobacilli Bacteria in the gut of breastfed infants that ferment sugars and produce acetic acid.

Lactobiome The collective genomes of the microorganisms found in the mammary secretion at any stage of the lactation cycle.
See also Human (p. 376) Microbiome

Lactocrine Hormones that influence mammary gland function.
See also Lactogenic complex (p. 376)

Lactocyte The mammary secretory epithelial cell that is capable of synthesising and secreting milk constituents such as lactose, casein, α-lactalbumin, lactoferrin etc.
See also Human milk cells (p. 374)

Lactoferrin An iron-binding whey protein with anti-microbial properties and ATPase activity. It is one of the most abundant proteins in human milk, but occurs in much lower concentrations in cow's milk.

Lactogenic complex The reproductive (human placental lactogen, progesterone, oestrogen and prolactin) and metabolic (growth hormone, glucocorticoids, parathyroid hormone related protein and insulin) hormones involved in secretory differentiation, secretory activation and galactopoeisis.
See also Lactocrine (p. 376)

Lactogenesis I See Secretory differentiation (p. 384)

Lactogenesis II See Secretory activation (p. 384)

Lactology See Human lactology (p. 374)

Lactobiome The collective set of genes that contribute to the production of milk.

Lactobiome datasets The genomic data set derived from analysis of multiple inbred mouse strains and many other species. The data includes links to electronic databases that provide detailed annotation for each element. The lactobiomes are available for many other species including cows and goats.

Lactogenome The collective set of genes that contribute to the production of milk.

Lactose The principal disaccharide in human milk. It is hydrolysed to glucose and galactose in the small intestine and by bacteria in the large intestine.

Lactose intolerance A clinical syndrome consisting of one or more of the following: abdominal pain, diarrhoea with bulky, frothy watery stools, nausea, flatulence and bloating after the ingestion of lactose-containing food substances. It is caused by lactase deficiency and can be congenital, developmental, secondary and primary.
See also Congenital lactose intolerance (p. 370), Developmental lactose intolerance (p. 371), Primary lactose intolerance (p. 383), Secondary lactose intolerance (p. 384)

Lactose overload Lactose overload has been described in theory and is yet to be supported by scientific evidence. It has been proposed that the infant rapidly ingests large volumes of milk, resulting in faster gastric emptying that presents large quantities of lactose to the small intestine for digestion. As a result, the efficiency of lactose hydrolysis in the small intestine is decreased and an excessive amount of lactose is presented to the large intestine. Thus, there is excess lactose fermentation by the bacteria in the large intestine, generating an osmotic load that draws fluid and electrolytes into the intestinal lumen leading to loose stools. This process is proposed to result in symptoms that mimic secondary lactose intolerance.

Latch See Positioning and latch (p. 382)

Leptin A peptide secreted by adipose tissue that inhibits neuropeptide Y in the brain. It is thought to be an appetite suppressant.

Let-down (also milk let-down) See Milk ejection (p. 378)

Lipase An enzyme that hydrolyses triacylglycerols, fats and oils.

Lobe A collection of lobules that drain into a single milk duct, allowing milk to exit through a nipple pore. Each lobe is separated by connective tissue septa in the human breast.

Lobule Lobes divide into lobules that consist of clusters of alveoli lined with lactocytes.

Lobulo-alveolar system Secretory elements of the mammary parenchyma (excludes the ductal system).

Low breastfeeding confidence (also perceived insufficient milk supply (PIM), perception of insufficient milk) The perception of the mother that her milk supply is not sufficient to meet her infant's requirement, whereas clinical assessment shows that her milk supply is adequate.

Luteinising hormone (LH) A hormone produced by gonadotropic cell in the anterior pituitary gland that triggers ovulation and the development of the corpus luteum in women.

Lumpectomy A common surgical procedure designed to remove a discrete lump, usually a malignant tumour or breast cancer from an affected woman's breast.

Lysozyme A component of the innate immune system with potent bacteriolytic activity.

Macronutrient An energy-providing nutrient required to be consumed in large amounts by an organism. In humans, the macronutrients required are carbohydrates, lipids and proteins.

Mammaplasty See Mammoplasty (p. 377)

Mammary augmentation (also breast augmentation) Plastic surgery terms for breast implants and fat graft mammoplasty approaches used to increase the size, change shape, alter texture of the breasts of a woman.
See also Mammoplasty (p. 377), Mammary reduction (p. 377), Mammary reconstruction (p. 377)

Mammary axillary tail See Axillary mammary tissue (p. 367)

Mammary buds Ectodermal thickenings on the ventrolateral body wall of the foetus that are precursors to the development of mature mammary glands.
See also Terminal end buds (p. 385)

Mammary carcinoma See Breast cancer (p. 368)

Mammary gland (this term is interchangeable with Breast) A female secretory and secondary sex organ. The mammary gland remains in a quiescent state until conception triggers a process of complete remodelling that results in the synthesis and secretion of breastmilk. Functional maturity is only reached during lactation. The mammary gland then returns to a quiescent state after involution, caused by gradual weaning of the infant.
See also Breast (p. 368)

Mammary gland fibroadenoma See Fibroadenoma of the mammary gland (p. 372)

Mammary gland stroma Functionally supportive framework of the mammary gland. Consists of skin, connective tissue and adipose tissue.

Mammary involution (also regression of the mammary gland) The return of a lactating mammary gland to a less differentiated state at the cessation of lactation. Mammary involution leads to the quiescent non-lactating state.

Mammary reconstruction (also breast reconstruction) Plastic surgery of the mammary gland to recreate the breast with respect to appearance, contour and volume. Often performed after mastectomy. Normal function and sensation are not retained.
See also Mammoplasty (p. 377), Mammary reduction (p. 377), Mammary augmentation (p. 377)

Mammary reduction (also breast reduction) Plastic surgery of the mammary gland to reduce its size and (frequently) to improve its shape and position.
See also Mammoplasty (p. 377), Mammary augmentation (p. 377), Mammary reconstruction (p. 377)

Mammary ridge See Milk line (p. 379)

Mammoplasty (also mammaplasty) Plastic surgery of the mammary gland to alter its size, shape and/or position. There are three general categories: Mammary augmentation, Mammary reduction and Mammary reconstruction.
See also Mammary augmentation (p. 377), Mammary reduction (p. 377), Mammary reconstruction (p. 377)

Mammogenesis See Alveolar development (p. 366)

Mammogram A record of the breast produced by x-rays, ultrasound, nuclear magnetic resonance etc. and used as a diagnostic or screening tool usually for breast cancer.

Mammotrophs Pituitary cells that produce prolactin.

Manual breast pump A mechanical breast pump that does not require an electrical power source.
See also Breast pump (p. 368), Electric breast pump (p. 372), Hospital-grade breast pump (p. 374)

Mastectomy The partial or complete surgical removal of one or both breasts.

Mastitis (also lactational mastitis, puerperal mastitis) A clinical and pathological term that describes a wide range of inflammatory disorders of the breast – here refers to mastitis associated with lactation. May be non-infective (featuring pain, swelling, heat and redness at the site) or infective (additionally including fever > 38 °C, chills and flu-like body aches).
N.B. It can be difficult to differentiate between engorgement, blocked milk duct, mastitis and breast abscess because they are a continuum with indistinct boundaries. Each includes some element of milk stasis or impaired drainage.
See also Blocked milk duct (p. 367), Breast abscess (p. 368), Pathological engorgement (p. 381)

Maternal diet A prescribed course of eating and drinking for pregnant and/or lactating women. Dietary recommendations for lactating women are the same as for any healthy adult woman. The diet should consist of a variety of foods from each food group and should be balanced.

Maternity Blues See Postnatal blues (p. 382)

Maternity Bra (also nursing bra) A specialised, wire-free brassiere that allows comfortable breastfeeding without the need to remove the bra and provides additional support.

Mature breastmilk The secretion produced by the lactocytes of the maternal mammary gland following secretory activation. Breastmilk is currently considered to be mature after about 2–3 weeks postpartum, however more research is needed to accurately determine the true time point and define its chemical composition.
See also Colostrum (p. 370), Transitional breastmilk (p. 386), Breastmilk (p. 369)

Meconium First stools passed by the infant prior to ingestion of substantial quantities of milk after secretory activation. Appears as a sticky mass of mucous, uniformly bile stained and dark green in colour.

Meredith shield See Breast shell (p. 368)

Metabolomics See Human milk metabolomics (p. 374)

Microbiome See Human microbiome (p. 374)

Micrognathia A condition characterised by an undersized jaw. Can cause feeding problems due to airway obstruction, difficulty in coordinating sucking, swallowing and breathing and maternal nipple pain. May correct itself during infant growth.
See also Retrognathia (p. 384)

Micronutrients A nutrient required in small amounts for the proper functioning of an organism including trace elements such as zinc, copper and iron as well as growth factors, oligosaccharides and other minor milk components, which are presently being carefully evaluated in many laboratories. There are significant knowledge gaps in the micronutrient composition of human milk. Micronutrient studies should measure maternal milk production in addition to milk composition in order to accurately assess the intake of micronutrients by the infant.

Milk See Breastmilk (p. 369)

Milk Bank See Human milk bank (p. 374)

Milk blister See Blocked nipple pore (p. 368)

Milk colour See Breastmilk colour (p. 369)

Milk "coming in" See Secretory activation (p. 384)

Milk cup See Breast shell (p. 368)

Milk duct (also lactiferous duct) Components of the ductal system that connect the alveoli to the nipple pores – A milk duct leaving individual alveoli fuses with others to form milk ducts of progressively larger diameter as they progress to the nipple pore. There are no lactiferous storage ducts (lactiferous sinuses) beneath the nipple in women and, in contrast, to farm animals, the larger milk ducts do not empty into milk storage sinuses.

Milk-blood ratio Concentration of a given drug or metabolite in human milk in relation to its concentration in maternal plasma or blood.

Milk ejection (also draught) The period of time during which milk availability from the nipple is increased as a result of stimulation of the milk ejection reflex.
Milk ejection during a breastfeed in women is identified by expansion of the milk ducts, an increase in intra-ductal pressure in the unsuckled mammary gland as well as an acute increase in milk flow during expression of breastmilk. Milk ejection in women lasts for about two minutes. Multiple milk ejections are common during a breastfeed but usually the mother does not sense them.
See also Milk ejection reflex (p. 378)

Milk ejection reflex (also milk let-down) A neuro-hormonal reflex elicited by infant suckling and the release of oxytocin from the posterior pituitary gland. Oxytocin causes the contraction of the myoepithelial cells surrounding the alveoli in the mammary gland, moving milk into the collecting ducts and expanding these ducts as milk flows towards the nipple. Milk ejection is a reflex that can be conditioned (see conditioned milk ejection reflex). The sensation of milk ejection varies significantly between women, from reports of initial strong pain, to no sensation at all.
See also Conditioned milk ejection reflex (p. 370), Strong milk ejection (p. 385), Dysphoric milk ejection reflex (p. 372), Painful milk ejection reflex (p. 381)

Milk ejection, strong See Strong milk ejection (p. 385)

Milk ejection, dysphoric See Dysphoric milk ejection reflex (p. 372)

Milk ejection, painful See Painful milk ejection reflex (p. 381)

Milk expression See Breastmilk expression (p. 369)

Milk fat The lipid component of the milk of which 98% is triacylglycerol (TAG).

Milk lipid secretion pathway A highly conserved pathway in which cytoplasmic lipid droplets are synthesised at the endoplasmic reticulum, pass to the apical membrane, combine into larger droplets and are then secreted into the alveolar lumen as milk fat globules.

Milk fistula An abnormal connection that forms between the skin surface and a milk duct in the breast. Usually associated with surgical intervention for either a breast abscess or mass, resulting in milk drainage to the surface of the breast.

Milk let-down (also let-down) See Milk ejection reflex (p. 378)

Milk line (also mammary ridge) A raised portion of ectoderm on either side of the midline occurring by the time the human embryo has attained a length of 4–6 mm (4th week of gestation).

Milk plasma See Whey (p. 386)

Milk production See 24-h milk production (p. 366)

Milk profile See 24-h milk profile (p. 366)

Milk secretion The secretory process that results in the synthesis of milk components and their transfer from the lactocyte to the alveolar lumen.

Milk sharing The sharing of expressed breastmilk in the community. This is generally a private arrangement between individuals, occurring outside of a clinical setting and supervision.
See also Donor Human Milk Bank (p. 371), Human Milk Bank (p. 374)

Milk synthesis Anabolic processes leading to the accumulation of milk components in the lactocyte.

Mixed breastfeeding See Partial breastfeeding (p. 381)

Mondor's disease A rare condition that involves thrombophlebitis of the superficial veins of the breast and anterior chest wall, often with sudden onset of superficial pain, swelling and redness. Although a lump is usually present the disease is self-limiting and generally benign.

Montgomery's glands (also glands of Montgomery, areolar glands) Large sebaceous glands present in the areola surrounding the nipple that produce oily secretions to protect the nipple. Volatile compounds in these secretions may serve as an olfactory stimulus for the newborn.

Mother-led weaning Weaning food is offered to the infant on a spoon with a gradual transition from purees to coarser textures, finger foods, and finally family foods. The feeding style has a high level of maternal control.
See also Infant-led weaning (p. 374)

Moro reflex An infantile reflex normally present in all infants/newborns up to 3 or 4 months of age as a response to a sudden loss of support, when the infant feels as if it is falling. It involves three distinct components: Spreading out the arms (abduction), unspreading of the arms (adduction) and usually crying.

Motilin A 22-amino acid peptide hormone occurring in the duodenal mucosa that controls normal gastro-intestinal motor activity by increasing motility and stimulating pepsin secretion.

Mucosa The lining between the extracellular and intracellular spaces in internal organs such as the gastrointestinal tract, the bronchial tubes and the breast ducts.

Multiparous A woman who has given birth at least twice.

Multiple breast syndrome See Polymastia (p. 382)

Myoepithelial cells Spindle-shaped contractile cells that surround each alveolus, adjacent to the basal cell membrane of the lactocytes. The myoepithelial cells contract in response to oxytocin, forcing milk into the milk ducts.
See also Human milk cells (p. 374)

Neonatal breast refusal Feeding behaviour where the infant is unable to attach and breastfeed successfully from birth.
See also Breast refusal (p. 368)

Neonatal galactorrhoea (also Witch's Milk, neonatal milk) Colostrum-like secretion formed under the influence of the withdrawal of maternal hormones that can occur in the breasts of both female and male infants.

Neonatal hypoglycaemia Low blood glucose during the neonatal period.

Neonatal intensive care unit (NICU) An intensive care unit specialising in the care of ill or premature newborn infants

Neonatal mastitis Breast inflammation usually associated with neonatal galactorrhoea.

Neonatal milk See Neonatal galactorrhoea (p. 379)

Neuro-hormonal reflex A reflex that is initiated by stimulation of sensory neurons that cause a release of a neurohormone from the neurosecretory cells, e.g., milk ejection reflex.
See Milk ejection reflex (p. 378)

Nipple A cylindrical pigmented protuberance on the mammary gland with an average of 9 milk duct openings. The nipple is surrounded by the areola, a circular pigmented area.

Nipple, artificial See Artificial teat (p. 367)

Nipple and areolar eczema See Nipple and areolar dermatitis (p. 379)

Nipple and areolar dermatitis Inflammation of the nipple and/or areola. Presents as an itchy, weeping, burning, painful nipple and/or areola.

Nipple and breast thrush See Candidiasis of the nipple and breast (p. 370)

Nipple erection Sympathetic mammary stimulation brings about contraction of the smooth muscle of the areola and nipple erection, which causes the nipple to become smaller and firmer.

Nipple piercing Cosmetic surgery that has been practiced throughout history and involves perforation of the nipple to enable the application of jewellery. Can result in partial or complete ductal obstruction.

Nipple pore A milk duct opening on the nipple that serves as a discrete outlet for breastmilk from a lobe.

Nipple protector See Nipple shield (p. 380)

Nipple psoriasis A chronic inflammatory skin condition characterised by defined red, scaly plaques on the skin that may itch, burn or bleed.

Nipple shield (also nipple protector) A soft silicone device designed to cover the areolar area and the nipple. It has central holes to let the milk pass through. The infant attaches and sucks on the shield and milk flows through the holes.
See also Breast shell (p. 368)

Nipple tenderness See Nipple sensitivity (p. 380)

Nipple sensitivity Measured by two-point discrimination test. Sensitivity increases markedly at parturition and peaks at day 3.

Nipple white spot See Blocked nipple pore (p. 368)

Nipple vasospasm (also Raynaud's phenomenon of the nipple) Intermittent ischaemia of the nipple associated with exposure to cold. Features include triphase or biphase nipple colour change (white, purple, red) and intense nipple + /– breast pain throughout, after and between feeds.

Non-exclusive breastfeeding Provision of fluids or foods other than breastmilk (excepting oral rehydration solution and drops or syrups of vitamins, minerals or medicines) to an infant under 6 months of age.
See also Exclusive breastfeeding (p. 372), Partial breastfeeding (p. 381)

Non-infective mastitis See Mastitis (p. 377)

Non-nutritive sucking (NNS) Infant sucking at the breast without removing any breastmilk. Intermittent swallowing can occur due to the accumulation of saliva.

Normal bowel output The range of stool output that might be expected for a healthy, term, exclusively breastfed infant.
Normal bowel output/movement shows wide variation and should not be used as a stand-alone indicator of lactation function.
See also Stools, frequency and appearance (p. 384)

Normal function Biological function that does not require medical support or intervention.

Normal human lactation A period of sustained milk synthesis that satisfies the following criteria:
Is comfortable for mother and infant; Provides adequate milk for the infant's optimal growth and development; Requires coordinated maternal and infant adaptation that is facilitated by good maternal and infant health.
See also Lactation (p. 375)

Normal infant crying Crying is a normal feature of infant development and follows a typical pattern characterised by an increase in crying until about 6 weeks of age, followed by a gradual decrease until 3–4 months when it remains fairly stable. Crying exhibits a circadian rhythm with episodes clustering in the late afternoon and early evening hours. A normal healthy infant is expected to have some period of contentment.
See also Infantile colic (p. 375)

Normal urine output (infant) After secretory activation normal urine output for exclusively breastfed infants is usually expressed as 5 or more heavily wet disposable nappies/diapers (6–8 cloth nappies/diapers) per 24 hours.

Normal weight loss after birth Weight loss up to 7% of their birth weight. Birth weight should be regained by 14 days of age.

Nurse See Breastfeed (p. 369)

Nursing bra See Maternity bra (p. 378)

Nursing pad See Breast pad (p. 368)

Nutritive sucking (NS) Infant sucking at the breast and removing and swallowing breastmilk.
See also Non-nutritive sucking (p. 380)

Oestrogen The primary female sex hormone. It is responsible for the development and regulation of the female reproductive system and secondary sex characteristics.

Oligosaccharide Carbohydrate comprised of a small number of monosaccharides. They are the 3rd most abundant component in human milk and are comprised of 150–200 different molecules. They support the growth of favourable bacteria (e.g., Lactobacillus bifidus) and discourage the growth of intestinal pathogens.

Oogamous Reproduction by the union of mobile male (sperm) and immobile female (ova) gametes.

Osmotic load Un-absorbable, water-soluble solutes in the large intestine that retain water through osmosis (water movement from low to high concentrations of solute).

Output – infant See Infant output (p. 374)

Oversupply Maternal failure to down-regulate milk synthesis to match the infant's appetite. Possibly due to ineffective regulation of milk synthesis by autocrine inhibition. It is distinct from engorgement, which occurs in the early postpartum period.

Ovulation The development and release of the ovum (egg) from a woman's ovaries.

Ovum (ova) The female reproductive cell (gamete) in oogamous organisms.

Oxytocin Oxytocin is a peptide containing 9 amino acids, and is a hormone that is produced mainly in the posterior pituitary gland. It is released either by suckling at the nipple, triggering a neuro-hormonal reflex as a result of nipple stimulation or by a conditioned response associated with

the sight, sound or smell of the infant. Oxytocin stimulates milk ejection as well as uterine contractions.
Overall, oxytocin is a calming and connecting hormone. It ensures that breastfeeding is a pleasurable experience focusing on the infant.

Pacifier See Dummy (p. 371)

Painful milk ejection reflex Pain associated with milk ejection. This pain is relieved as soon as milk flow commences.

Paired breastfeed Two breastfeeds occurring when the infant removes milk from the second breast within 30 minutes after finishing the first.
See also Breastfeed (p. 369), Cluster breastfeed (p. 370), Breastfeeding session (p. 369)

Paget's disease of the nipple A rare type of breast cancer that can manifest as a superficial red scaly lesion on the nipple, resembling dermatitis. More advanced disease may cause tingling, itching, sensitivity and burning pain.

Paladai A small, spouted cup used traditionally in India for feeding milk to an infant.
See also Cup feeding (p. 371)

Palate The roof of the mouth separating the oral cavity from the nasal cavity.
See also Hard palate (p. 373), Soft palate (p. 384)

Parity The number of times a female is or has been pregnant and carried the pregnancy to a viable gestational age (including live and stillbirths) a twin pregnancy carried to viable gestational age is counted as 1.

Pars anterior pituitary gland (also Anterior pituitary gland) See Pituitary gland (p. 382)

Partial breastfeeding (also mixed breastfeeding) Infant receives both breastmilk and any other food or liquid including water, non-human milk and formula before six months of age

Parous A woman that has given birth to one or more children.

Pasteurisation A process that is intended to destroy or inactivate microbes in food or drink. This process may be used by donor human milk banks and is known to change the bioactivity of donor human milk.

Parturition Childbirth. The process of delivering the baby and placenta from the uterus.

Pathological engorgement Characterised by bilateral, uniformly swollen, firm, distended, painful, shiny, warm breasts and may be associated with a low-grade fever. It is caused by vascular dilation associated with secretory activation. Oedema occurs secondary to swelling and obstruction of the lymphatic drainage. Onset is most commonly from day 3–5, but can occur up to 14 days post partum. The condition is mostly preventable by frequent, adequate breast drainage.
N.B. It can be difficult to differentiate between pathological engorgement, blocked milk duct, mastitis and breast abscess because they are a continuum without distinct boundaries. Each includes some element of milk stasis or impaired drainage.
See also Physiological engorgement (p. 381), Blocked milk duct (p. 367), Breast abscess (p. 368), Mastitis (p. 377)

Pathological jaundice Pathological jaundice is due to an underlying cause such as haemolysis, hypothyroidism, infection and/or starvation. Jaundice is always pathological if it occurs within the first 24 hours of life.
See also Jaundice (p. 375), Physiological jaundice (p. 381), Breastmilk jaundice (p. 369)

PCR See Polymerase chain reaction (p. 382)

Peer support Support that is provided by mothers who are currently breastfeeding or who have done so in the past and includes individual counselling and mother-to-mother support groups. Women who provide peer support undergo specific training and may work in an informal group or one-to-one through telephone calls or visits in the home, clinic, or hospital. Peer support includes psycho-emotional support, encouragement, education about breastfeeding, and help with solving problems. Peer support does not include medical advice.

Perceived insufficient milk supply (PIM) See Low breastfeeding confidence (p. 377)

Perception of insufficient milk (PIM) See Low breastfeeding confidence (p. 377)

Periareolar surgery An incision immediately below the lower half of the areola.

Periareola fat Fat around the areola area.

Perinatal The period immediately before and after birth.

Perineum The area between the anus and the vulva.

Preterm Birth Birth occurring before 37 weeks of gestational age.

Pharynx The membrane-lined cavity behind the nose and mouth, connecting them to the oesophagus.

Physiological engorgement A sudden sensation of breast fullness usually associated with secretory activation (milk coming in) 50–60 hours after giving birth. This is considered normal.
See also Pathological engorgement (p. 381)

Physiological jaundice The normal pattern of raised serum unconjugated bilirubin in the neonatal period, which gradually decreases to adult levels. Bilirubin levels usually peak by the 3rd day of life, and slowly return to normal levels by day 10.
See also Jaundice (p. 375), Pathological jaundice (p. 381), Breastmilk jaundice (p. 369), Bilirubin (p. 367).

Pituitary gland This pea-sized gland at the base of the brain is a major endocrine organ. It has an anterior lobe, an intermediate and a posterior lobe. Relevant to lactation prolactin is secreted from the anterior pituitary gland and oxytocin from the posterior pituitary gland.

Placenta A flattened circular organ in the uterus of pregnant eutherian mammals, nourishing and maintaining the foetus through the umbilical cord.

Placental retention See Retained placenta (p. 383)

Placental lactogen (hPL) A polypeptide hormone secreted by the syncytiotrophoblast (the epithelial covering of the highly vascular embryonic placental villi) during pregnancy. Its structure and function are similar to human growth hormone. Placental lactogen can replace prolactin in human in pregnancy.

Plugged milk duct See Blocked milk duct (p. 367)

Poland syndrome A rare form of severe chest wall and breast hypoplasia. The syndrome includes absence of pectoralis major and minor muscles, breast hypoplasia and syndactyly of the ipsilateral hand.

Polycystic ovarian syndrome (PCOS) One of the most common endocrine disorders among women of child-bearing age. Characterised by anovulation, excess androgenic (male) hormones, insulin resistance and ovulation related infertility.

Polymastia (also accessory breasts, supernumerary breasts, multiple breast syndrome) Breast tissue found anywhere along the milk line from the base of the axilla (most common) to the vulva region (second most common). The mass of tissue may be with or without an accessory nipple and is separate from the breasts.

Polymerase chain reaction (PCR) A biochemical technique used to amplify a single or a few copies of a piece of DNA, generating thousands to millions of copies of a particular DNA sequence. Can be used to analyse extremely small quantities of sample.

Polythelia (also accessory nipples, supernumerary nipples) The presence of nipples in addition to those normally existing on the breast.
Usually occur along the embryonic milk line.

Positioning and latch A subjective assessment of the positioning of the infant at the breast and its attachment to the nipple and areolar area during a breastfeed.
Effective positioning and latch to the nipple and areola allows adequate milk transfer during the breastfeeding period, without causing either maternal or infant pain. This requires coordinated maternal and infant adaptation, which is instinctive for the infant and largely learned by the mother. There are few objective assessments for effective and comfortable positioning and latch of the infant to the maternal nipple and areolar area during breastfeeding.

Positioning See Positioning and latch (p. 382), Breastfeeding positions (p. 369)

Posset See Infant regurgitation (p. 375)

Posterior pituitary gland See Pituitary gland (p. 382)

Post-feed breastmilk (also hind milk) Milk removed from the mammary gland at the completion of a breastfeed or breast expression.

Postnatal/Postpartum Occurring after child birth.

Postnatal blues (also postpartum blues, maternity blues, baby blues) Abrupt changes in mood and emotion, which usually peak between days 3 and 6 postpartum. Symptoms are self-resolving.

Postnatal depression (PND) (also Postpartum depression) A more severe depression or prolonged symptoms of depression (clinical depression) that lasts more than a week or two and interferes with normal routines including caring for an infant. PND is different from baby blues that are common during the first week after childbirth.

Postnatal psychosis A mental disorder that causes gross distortion or disorganisation of a mother's mental capacity in the postnatal period.

Postpartum/Postnatal Occurring after child birth.

Postpartum haemorrhage (PPH) A condition generally described as blood loss of > 500 mL after delivery (> 1000 mL if severe). It is classified as primary if occurring within 12 hours of delivery or secondary if between 24 hours and 6 weeks postpartum.

Postpartum thyroiditis (also postpartum thyroid dysfunction (PPTD)) Thyroid dysfunction occurring after pregnancy. May involve hyperthyroidism, hypothyroidism or both sequentially. Hypothyroidism persists in 20% of cases.

Postpartum thyroid dysfunction (PPTD) See Postpartum thyroiditis (p. 382)

Potential storage capacity The amount of milk available when the breast is full, calculated from the cream content of milk samples collected before and after each feed or expression from each breast, and the volume of milk consumed during each feed, or expressed from each breast for a 24-hour period of breastfeeding and expressing. Includes both milk consumed during breastfeeding and milk expressed.
See also Degree of fullness of the mammary gland (p. 371), Breast storage capacity (p. 369)

Prebiotic Substances that induce the growth or activity of microorganisms and contribute to the well-being of their host.

Pre-colostrum A mammary secretion that is produced from as early as 20 weeks gestation in some women and continues up to parturition. It is usually viscous and can range from a light straw to thick yellowish secretion. The composition of pre-colostrum is similar to colostrum.
See also Colostrum (p. 370)

Predominant breastfeeding (also full breastfeeding, fully breastfeeding) Defined by the World Health Organization as the infant receiving breastmilk (including milk expressed by the mother or from a wet nurse) as the predominant source of nourishment.
Allows the infant to receive liquids (water and water-based drinks, fruit juice, oral rehydration solution), ritual fluids and drops or syrups (vitamins, minerals, medicines).
Does not allow the infant to receive anything else (in particular non-human milk, food-based fluids).
See also Exclusive breastfeeding (p. 372), Complementary feeding (p. 370), Supplementary feeding (p. 385), Substitute feeding (p. 385)

Pre-feed breastmilk (also fore milk) Milk removed from the mammary gland just before the commencement of a breastfeed or breast expression.

Primary lactation failure Occurs rarely and may involve complete absence of secretory activation (e.g., Sheehan's syndrome). Those mothers that experience secretory activation still experience profound low supply.
See also Lactation failure (p. 378), Secondary lactation failure (p. 384)

Primary lactose intolerance The normal gradual reduction seen in lactase production during the progression to adulthood for about 70% of the world's population. Its presence depends on ethnicity, and is rare in populations with predominance of dairy foods in the diet (e.g., Northern Europeans). Reduced lactase production usually occurs from 2 years onwards and breastfed children should continue to receive breastmilk in all cases.
See also Congenital lactose intolerance (p. 370), Developmental lactose intolerance (p. 371), Lactose intolerance (p. 376), Secondary lactose intolerance (p. 384)

Primiparous A woman who has given birth to only one child.

Primordium An aggregation of cells in the embryo indicating the first trace of an organ or structure.

Probiotic Beneficial bacteria that colonise the human body.

Progesterone (P4) A major member of the group of hormones called progestogens, progesterone plays a crucial role in regulating the monthly menstrual cycle, preparing the body for conception, maintaining pregnancy and triggering secretory activation.

Prolactin (hPRL) A protein hormone from the anterior pituitary gland that is required for breast growth and the synthesis of milk in women.

Prone Lying flat, with the front (ventral) facing surface downward.
See also Supine (p. 385)

Psoriasis of the nipple See Nipple psoriasis (p. 380)

Puerperium/puerperal The period between childbirth and the return of the mother's uterus to its normal non-pregnant size (about 6 weeks).

Pump shield See Breast shield (p. 368)

Pylorus The opening from the stomach into the duodenum.

Raw milk See Fresh milk (p. 373)

Raynaud's phenomenon of the nipple See Nipple vasospasm (p. 380)

Recommendation for the duration of lactation The World Health Organisation recommends exclusive breastfeeding for the first 6 months of life then addition of nutritionally adequate and safe complementary foods while breastfeeding continues for up to 2 years of age or beyond.
See also Lactation duration (p. 375)

Reduction mammoplasty See Mammary reduction (p. 377)

Reflux See Infant regurgitation (p. 375)

Reference range (reference values) The prediction interval between which 95% of the values of a reference group fall into, in such a way that 2.5% of the time a sample will be less than the lower limit of this interval, and 2.5% of the time it will be larger than the upper limit of this interval, whatever the distribution of these values.
A standard reference range generally denotes the range for healthy individuals.

Regression of the mammary gland See Mammary involution (p. 377)

Relactation Re-establishment of lactation beyond the immediate postpartum period.
See also Induced lactation (p. 374)

Relative Infant Dose A method of estimating the risk to the infant of maternal medication use. Calculated by dividing the infant's dose via breastmilk (mg/kg/day) by the maternal dose (mg/kg/day).

Resting breast A non-lactating, non-pregnant breast post lactation.
See also Mammary involution (p. 378)

Retained placenta Placenta not expelled within 30 minutes of the infant's birth. Partial separation of the placenta leads to continued bleeding and either full or partial suppression of secretory activation.

Retrognathia A condition where either one or both jaws recede with respect to the frontal plane of the forehead. Refers to position of jaw, rather than size.
See also Micrognathia (p. 378)

Retro-mammary fat pad The fat pad positioned between the mammary gland and the pectoralis major muscle on the chest.

Rooming in A hospital arrangement whereby a newborn infant is kept in the mother's hospital room instead of a nursery.

Rooting reflex Reflex that assists with breastfeeding, whereby the infant turns its head towards anything that strokes its cheek or mouth, searching for the object by moving in a decreasing arc until it is found. Present at birth and generally disappears about four months of age.
See also Sucking reflex (p. 385)

Secondary lactation failure The most common cause of inadequate milk supply. It is generally due to ineffective or infrequent milk removal resulting in down-regulation of maternal milk synthesis.
See also Delayed secretory activation (p. 371), Lactation failure (p. 375), Primary lactation failure (p. 383)

Secondary lactose intolerance A condition secondary to any form of gastrointestinal mucosal injury. Breastfed infants should continue to receive breastmilk in all cases.
See also Congenital lactose intolerance (p. 370), Developmental lactose intolerance (p. 371), Lactose intolerance (p. 376), Primary lactose intolerance (p. 383)

Secretory activation (previously lactogenesis II) (also milk coming-in) The process by which milk synthesis increases after parturition. It is triggered by a fall in serum progesterone during the first two days postpartum. It may be sensed by the mother as an increase in fullness of the breast near the end of the process. Secretory activation is facilitated by breastfeeding as soon as possible after birth.

Secretory differentiation (previously lactogenesis I) Secretory differentiation (previously known as lactogenesis I) is the process of differentiation of the mammary epithelial cells to form lactocytes capable of synthesising components unique to breastmilk (lactose, casein, α-lactalbumin, lactoferrin, etc.). In most mammals it occurs in the second half of gestation.

Secretory immunoglobulin A (sIgA) Secretory IgA are found in breastmilk and are specific for microbes present in the environment of the mother. The transfer of sIgA through breastmilk to the upper respiratory and gut mucosa of the infant provides mucosal immunity in the infant period when its own immune system is immature. Transplacental transfer of IgG covers systemic immunity during this period.

Sequential pumping (also single pumping) Mother expresses milk from one breast at a time.

Sexuality and lactation difficulty An association of the breast with beauty and sexuality throughout literature and art cannot be denied and in this sense the aesthetic appreciation of the breast can sometimes negatively influence the mothers desire to breastfeed.

Sheehan's syndrome Sheehan's syndrome describes postpartum ischaemia and necrosis of the anterior pituitary gland resulting in a deficiency of prolactin. The effect on lactation is unpredictable, although most women can be expected to have a profoundly low milk supply.

Shield See Breast shield (p. 368)

Short, frequent breastfeeds Breastfeeds of less than 8 minutes in duration with breastfeeding sessions occurring 11 times or more in 24 hours.
N.B. In traditional societies, short frequent feeds are the norm.

Simultaneous pumping (also double pumping) Mother expresses milk from both breasts at the same time. Removes both a greater volume of milk and a higher percentage of available milk than sequential pumping.

Single pumping See Sequential pumping (p. 384)

Skim breastmilk The milk fraction remaining after removal of the fat layer by centrifugation of breastmilk.

Skin-to-skin care (also STS, SSC) The practice of holding an infant in contact with an adult caregiver, usually its mother, with the ventral surface of both individuals touching. Typically, the skin is uncovered, allowing direct contact.
See also Kangaroo mother care (p. 375)

Sleep patterns Normal breastfeeding sleep patterns show that most infants feed between 1 and 3 times at night until 6 months of age and consume 20% of their daily intake during this time. Thus, it is normal for breastfed infants to wake at night under the influence of the 90-minute sleep cycle.

Slow weight gain (also failure to thrive, weight faltering) A pattern of weight measurements that descend to cross 2 or more major centiles or that is below the 5^{th} percentile on the WHO infant growth charts. Slow weight gain includes infants ranging from those with a normal variant of growth to those with serious problems.

Soft palate The posterior soft, flexible subsection of the palate (roof of the mouth).
See also Hard palate (p. 373), Palate (p. 381)

Sonography See Ultrasonography (p. 386)

Soother See Dummy (p. 371)

Stages of mammary development Include ductile development at puberty, alveolar development and proliferation in early pregnancy, secretory differentiation after mid pregnancy, secretory activation after parturition, established lactation, weaning.

Stools, frequency and appearance Normal bowel output shows wide variation. Prior to secretory activation the infant passes meconium. The stools transition from meconium to loose, yellow curds by day 5 after birth. Only 1.1% of exclusively breastfed infants have discrete, formed stools.

Stool frequency The number of stools, greater than 2.5 cm in diameter, passed over a period of 24 hours.

Storage capacity of the mammary gland See Breastfeeding storage capacity (p. 369), potential storage capacity (p. 382)

Strong sucking vacuum Minimum average peak sucking vacuums of less than −200 mmHg. Can result in maternal nipple pain.
See also Intraoral vacuum (p. 375)

Strong milk ejection (also forceful milk ejection) Forceful milk ejection associated with adverse infant feeding behaviours, e.g., gagging, coughing, clamping down on the nipple, refusing to breastfeed etc.

Subcutaneous fat Fat beneath the skin separating the glandular tissue from the dermis.

Sublingual frenulum See Frenulum (p. 373)

Substitute feeding Where breastfeeding is contraindicated and must be substituted with infant formula.
See also Exclusive breastfeeding (p. 372), Predominant breastfeeding (p. 383), Complementary feeding (p. 370), Supplementary feeding (p. 385), Infant formula (p. 374) and Weaning (p. 386)

Suck cycle Describes milk removal from the breast into the infant's oral cavity followed by removal of milk from the oral cavity into the pharynx.

Suck-swallow-breathe reflex (SSwB) The reflex that coordinates sucking, swallowing and breathing during breastfeeding. Infants are able to suck and swallow, suck and breathe, but are unable to breathe and swallow simultaneously.

Sucking, Nutritive See Nutritive sucking (p. 380)

Sucking, Non-nutritive See Non-nutritive sucking (p. 380)

Sucking reflex The instinctive sucking on anything that touches the hard palate of the infant. It is linked to the rooting reflex.

Supernumerary nipple See Polythelia (p. 382)

Supernumerary breast See Polymastia (p. 382)

Supine Lying with the back (dorsal) surface downward.
See also Prone (p. 383)

Supplementary feeding Nutrient-containing fluid feed (including expressed breastmilk, donor human milk or infant formula) given in addition to breastfeeds.
See also Exclusive breastfeeding (p. 372), Predominant breastfeeding (p. 383), Complementary feeding (p. 370), Substitute feeding (p. 385), Weaning (p. 386)

Supplemental nursing system (SNS) See At-breast supplementer (p. 367)

Supply line See At-breast supplementer (p. 367)

Swaddling An age-old practice of wrapping infants in blankets or similar cloth so that movement of the limbs is tightly restricted.

TAG See Triacylglycerols (p. 386)

Tandem breastfeeding Breastfeeding a child through pregnancy and then, after birth, breastfeeding both the new infant and the older child.

Tail of Spence See Axillary mammary tissue (p. 367)

Teat See Artificial teat (p. 367)

Teething ring A ring for the infant to bite onto.

Terminal end buds Sacculations, containing mammary epithelial and stem cells, found at the growing terminus of mammary ducts prior to functional maturation and after involution of the mammary gland.
See also Mammary buds (p. 377)

Test-weigh See Breastmilk transfer measurement (p. 369)

Theca lutein cyst A rare type of functional ovarian cyst associated with testosterone levels 10–150 times higher than normal. If unresolved at birth, delayed secretory activation occurs until testosterone levels decrease to normal (over 5–31 days). Full milk synthesis is possible if well managed.

Therapeutic ultrasound Application of ultrasound to bring heat or agitation into the body. It requires much higher energies and generally a different range of sound wave frequencies than is used for diagnostic ultrasound.
See also Diagnostic ultrasound (p. 371)

Third day blues See Postnatal blues (p. 382)

Thrush See Candidiasis of the nipple and breast (p. 370)

Thyroid-stimulating hormone (TSH) A pituitary hormone that stimulates the thyroid gland to produce thyroxine and then triiodothyronine that stimulates the metabolism of almost every tissue in the body. Measurement of serum TSH is the most common method of evaluating thyroid function.

Tight junctions The junctions that join the apical borders of adjacent secretory cells in the lactating mammary gland. They are responsible for the lack of exchange of milk and serum components between the interstitial space and the milk space.

Tongue protrusion reflex (also tongue thrust reflex, tongue extrusion reflex) A normal response in infants to force the tongue outward when it is touched or depressed. The reflex begins to disappear by about 3–4 months of age.

Tongue thrust reflex See Tongue protrusion reflex (p. 385)

Tongue extrusion reflex See Tongue protrusion reflex (p. 385)

Tongue-tie See Ankyloglossia (p. 367)

Torticollis (also Wry neck) Shortening of the sternocleidomastoid muscle, resulting in an ipsilateral head tilt and contralateral rotation of the face and chin.

Transitional breastmilk A description of breastmilk as it transitions from colostrum to mature breastmilk after secretory activation. It is yet to be defined objectively, but is generally considered to extend from about 40 hours after birth to 2 to 3 weeks postpartum.
See also Colostrum (p. 370), Mature breastmilk (p. 378), Breastmilk (p. 369)

Triacylglycerides See Triacylglycerols (p. 386)

Triacylglycerols (TAG) (also triacylglycerides, triglycerides) Consist of three long chain fatty acids coupled to glycerol by ester linkages.

Triglycerides See Triacylglycerols (p. 386)

Twenty-four-hour milk production See 24h milk production (p. 366)

Twenty-four-hour milk profile See 24h milk profile (p. 366)

Type 1 diabetes mellitus A chronic condition in which the pancreas produces little or no insulin (the hormone needed to allow glucose to enter cells to produce energy and synthesise fat and lactose).
See also Diabetes (p. 371), Gestational diabetes mellitus (p. 373), Type 2 diabetes mellitus (p. 386)

Type 2 diabetes mellitus A chronic metabolic disorder that is characterised by high blood glucose, insulin resistance and relative lack of insulin.
See Diabetes (p. 371), Gestational diabetes mellitus (p. 373), Type 1 diabetes mellitus (p. 386)

Ultrasonography (sonography) Ultrasound-based imaging technique, which may be either therapeutic or diagnostic.
See also Diagnostic ultrasound (p. 371), Therapeutic ultrasound (p. 385)

Ultrasound, diagnostic See Diagnostic ultrasound (p. 371)

Ultrasound, therapeutic See Therapeutic ultrasound (p. 385)

Urine output (infant) See Normal urine output (infant) (p. 380)

Uterine pains See After pains (p. 366)

Vasospasm See Nipple vasospasm (p. 380)

Vegan A diet that does not contain any animal products. Lactating women following a vegan diet should ensure that they have adequate intakes of Vitamin D, ω-3 fatty acids, Vitamin B12 and high-quality protein.

Vegetarianism Abstaining from the consumption of meat and may include abstention from by-products of animal slaughter. A vegetarian diet that contains some animal-derived food, such as milk, milk derivatives, or eggs, is usually complete for lactating mothers.

White nipple spot See Blocked nipple pore (p. 368)

Weaned The complete cessation of breastfeeding.

Weaning The process of gradually reducing breastfeeding. It begins at the time (about 6 months of age) when foods other than breastmilk are introduced to the infant and ends when breastfeeding has completely ceased.
See also Infant-led weaning (p. 374), Mother-led weaning (p. 379), Acute weaning (p. 366)

Weight faltering See Slow weight gain (p. 384)

Weight gain, slow See Slow weight gain (p. 384)

Weight loss after birth See Normal weight loss after birth (p. 380)

Wet nurse A woman who breastfeeds the infant of another mother, without identifying as that infant's mother.

Whey (also milk plasma) Proteins that remain in solution after the precipitation of casein micelles with either chymosin or acid to form a curd. Whey is an extremely complex protein fraction made up of a large number (hundreds in low abundance) of proteins.

Witch's milk See Neonatal Galactorrhoea (p. 379)

Wry neck See Torticollis (p. 386)

Part 5
Addendum

24 Epilogue

Lactation is a robust, resilient and reliable survival mechanism, one critical to evolutionary success. Breastmilk is the bridge between the womb and the world, directing all postnatal growth. Optimised by evolution, it is necessary for unsurpassed infant development. Yet pressures stemming from the social and cultural status of breastfeeding, and women's varying circumstances, often present barriers to breastfeeding successfully over the duration that is recommended for child and maternal health. Industrialisation, lack of medical knowledge and the changing roles of women within society have resulted in population-wide shifts away from breast milk towards commercial products. These shifts are contributing to epidemics of previously rare diseases, many of which are transmitted between generations.

However, growing awareness of the effects of different feeding modes on baby and mother has shifted the focus back towards breast milk feeding – and specifically exclusive breastfeeding from birth. Feeding modes of infants and young children affect their nutritional status, their survival, and their long-term health. Breastmilk provides a natural, complete food for growth and development during the first six months of life. It also continues to provide a substantial proportion of an infant's nutritional needs into the second year of life [1], [2]. Breastmilk supports sensory and cognitive development, safeguards against infections and chronic diseases, reduces infant morbidity and mortality, and speeds recovery from illness (see chapters 2, 4, 5, 7).

By creating gut dysbiosis and immune dysregulation, even small exposures to infant formula in the first days after birth can have long-lasting adverse effects on individual and population health. Infant formula induces measurable biological differences in growth and development, and increases the risk of many diseases (see chapter 4, 5, 16). Genomic, microbiomic and metabolic damage can result from both the absence of breastfeeding's unique properties and components, and from the presence of formula's very different heat-treated ingredients, metabolites, and contaminants. Further research across all body tissues and organs is needed to fully appreciate formula's impact, past and present. To create the healthiest gut microbiome, breastfeeding needs to be exclusive from birth. Hospital staff can help by adopting and implementing evidence-based protocols that end unnecessary neonatal exposure to any food other than breast milk, and any other products affecting primary colonisation of the gut.

A normal part of the female reproductive cycle, breastfeeding also promotes the health and wellbeing of mothers, increasing their metabolic efficiency, and reducing the risk or severity of anaemia, depression, cardiovascular and other serious diseases. Women who do not breastfeed are at increased risk for lifelong and intergenerational maternal morbidity (see chapters 5, 14) as well as severe suffering, and even premature death, from uterine, ovarian and breast cancers (see chapters 1, 2, 3, 4, 5, 7, 10, 11, 13, 14, 17, 22).

Multi-country research evidence supports exclusive breastfeeding for around six months as optimal for infants, and continued breastfeeding, alongside food, for two years or longer [1], [2]. Infant formula should be reserved for when suitable breast milk is unavailable, and only in the first year of life. The gradual adoption of quality complementary family foods and drinking water is important from around six months of age [1].

Health professionals should not be persuaded by industry marketing that formula is almost as good as breast milk. One is a living tissue, the other an unsterile industrial powder. The educational curricula of all healthcare providers should include up-to-date information about all aspects of infant feeding (including the problems of lactation and the risks and harms of infant formulas). Mothers need skilled ongoing support in establishing and maintaining breastfeeding (see chapter 11). Healthcare providers can help encourage the initiation of exclusive breastfeeding, and the continuation of appropriate breastfeeding, by providing ongoing assistance to families.

Communities at large can share the information about infant feeding to help current and prospective parents make informed choices, and can also provide practical resources to enable them to implement their choices as safely as possible. To reduce potential harms, fact-based information on safer artificial feeding is needed, covering not only infant formula products, but also water sources and equipment. All parents and carers who are formula feeding infants need non-judgmental hands-on education about the process. This applies equally to those who choose to formula feed from birth, and many women who will be partly breastfeeding, or were unable to breastfeed, for whatever reason.

This infant feeding information can be extended to the workplace, so employers can ensure that all working mothers have comfortable safe areas to breastfeed or to pump breast milk for later use. Increased employer understanding of the importance of breast milk can also support paid maternity leave, or leave extensions for breastfeeding families (see chapters 2, 8, 9, 10). At every level, families and society will benefit from universal, timely and practical support that enables breastfeeding and minimises risks of bottle feeding.

Breastfeeding and breast milk need to be re-established as the desirable 'gold standards' for every newborn. As with blood banking, regulated human milk banks could be established (see chapter 17). Such banks would enable access to donor breast milk and help meet shortfalls if mothers are unable to supply their infants with their own breast milk. Factual advice about risks and benefits of wetnursing and informal milk sharing between women should be freely available without judgement of these valid parental choices (see chapter 12). Governments could reduce subsidies to infant formula companies, stop providing free infant formula to families, subsidise infant formula only when medically necessary for low income families, and investigate the pricing of infant formulas.

The economic impact of suboptimal breastfeeding on society is substantial [4]. Compelling evidence suggests that national health services could significantly reduce costs through increased breastfeeding (see chapter 11). Infant formula is also expensive for families, societies and the environment. Under-utilising breast milk, a rich, natural resource, can further disadvantage many families. Consideration should be given to pragmatic strategies to encourage, enable and even reward breastfeeding for low income families, involving such families and those working with them, in consultations on the issue.

There are many challenges facing breastfeeding practices and promotion that affect parents, governments, healthcare providers and advocates. All parents, whether they breast or bottle feed, should have the opportunity to learn how to do so as safely as possible, and have access to ongoing support networks. Parental autonomy and choice need to be respected. However, parents also need to understand that health officials and professionals are legally obliged to inform society of the risks of not breastfeeding. Governmental agencies can also drive change by regulating infant formula production and marketing across all media, including social media, thereby providing some balance to the intensive marketing of infant formulas, feeding products and commercial baby foods.

To reiterate, independently funded research is warranted to further explore the lifelong and inter-generational effects, across all human body organs and tissues, of both the absence of breastfeeding, and the presence of infant formulas. In addition, comparison studies on the outcomes of similar infant formulas would be welcome, so healthcare professionals and parents can, when necessary, assess the most appropriate brands for different ages and purposes. Professional health organisations and associations have a role to play, too. By learning the outcomes of new research on infant feeding, they will be better equipped to address the deficit of knowledge often evident among healthcare providers. Additionally, interdisciplinary expert committees, featuring experienced breastfeeding counsellors and advocates, could be created to identify and propose strategies for addressing this deficit, and thus help maximise breastfeeding practices. As well, public health campaigns (see chapter 9) – similar to those that have proven effective in promoting car restraints – could be additional ways to reduce unnecessary reliance on infant formula and encourage breastfeeding. Such breastfeeding promotion is not intended to distress anyone, but to prevent future needless harms, like other public health campaigns that trigger strong feelings among those already affected.

Promoting WHO-recommended practices, where infants begin exclusive unrestricted breastfeeding immediately or within the first hour after birth, for around six months, is necessary to ensure the very best for maternal and child health [3]. The World Health Organization (WHO) challenge in the 2025 Global Targets is increasing the rate of exclusive breastfeeding for the entire first 6 months up to at least 50% [5].

If this is to be achieved, funding needs to increase across all research disciplines, and sound networks of multidisciplinary researchers and well-supported community-based implementers need to work together. Breastfeeding is one of the health interventions with the highest return on investment, yet it continues to be relatively underfunded [4]. For a century, Western governments have directly and indirectly subsidized the creation and spread of artificial feeding. Governments and decision-makers need to accept this WHO challenge, and move infant feeding higher on the political agenda. Investment needs to focus on capacity-building, systems-strengthening and enabling scale up of breastfeeding protection, support, and promotion programmes. It will take significant resources and structural changes (see chapter 10) to make it possible for all women to experience the joy of successful breastfeeding, and for all infants to have access to one of nature's most valuable resources – breast milk.

Geelong (Australia), July 2018
Maureen Minchin

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