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Exclusive breastfeeding – Does it make a difference?

*A longitudinal, prospective study of daily feeding practices,
health and growth in a sample of Swedish infants*

BY

CLARA AARTS



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ABSTRACT

Aarts, C. 2001. Exclusive breastfeeding - Does it make a difference? A longitudinal, prospective study of daily feeding practices, health and growth in a sample of Swedish infants.

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The concept of exclusive breastfeeding in relation to daily feeding practices and to health and growth of infants in an affluent society was examined. In a descriptive longitudinal prospective study 506 mother-infant pairs were followed from birth through the greater part of the first year. Feeding was recorded daily, and health and growth were recorded fortnightly.

Large individual variations were seen in breastfeeding patterns. A wide discrepancy between the exclusive breastfeeding rates obtained from "current status" data and data "since birth" was found.

Using a strict definition of exclusive breastfeeding from birth and taking into account the reasons for giving complementary feeding, the study showed that many exclusively breastfed infants had infections early in life, the incidence of which increased with age, despite continuation of exclusive breastfeeding. However, truly exclusively breastfed infants seem less likely to suffer infections than infants who receive formula in addition to breast milk. Increasing formula use was associated with an increasing likelihood of suffering respiratory illnesses. The growth of exclusively breastfed infants was similar to that of infants who were not exclusively breastfed.

The health of newborn infants during the first year of life was associated with factors other than feeding practices alone. Some of these factors may be prenatal, since increasing birth weight was associated with an increasing likelihood of having respiratory symptoms, even in exclusively breastfed infants. However, exclusive breastfeeding was shown to be beneficial for the health of the infant even in an affluent society.

Key words: Exclusive breastfeeding, infant feeding pattern, infant growth, infant morbidity.

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**A Sudanese doctor told me that he learned in medical training
that breastfeeding had 21 advantages: 7 for the mother
and 14 for the infant**

**If we consider how many mothers and infants there are
and will be in the future,
there will be an incredible number of advantages**

To all families

Original publications

This doctoral thesis is based on the following papers, which will be referred to in the text by their Roman numerals:

I. Clara Aarts, Elisabeth Kylberg, Agneta Hörnell; Yngve Hofvander, Mehari Gebre-Medhin, Ted Greiner. How Exclusive is Exclusive Breastfeeding? A Comparison of Data since Birth with Current Status Data.

International Journal of Epidemiology 2000;29:1040-1046.

II. A. Hörnell, C. Aarts, E. Kylberg, Y. Hofvander and M. Gebre-Medhin. Breastfeeding patterns in exclusively breastfed children - a longitudinal prospective study in Uppsala, Sweden

Acta Paediatrica 1999;88:203-11

III. C. Aarts, A. Hörnell, E. Kylberg, Y. Hofvander, M. Gebre-Medhin. Breastfeeding patterns and duration in relation to thumb sucking and the use of pacifiers.

Pediatrics 1999; 104 (4) URL:<http://www.pediatrics.org/cgi/content/full/104/4/e50>

IV. Clara Aarts, Mehari Gebre-Medhin. Morbidity during the first year of life in relation to size at birth and infant feeding in a Swedish sample. An area-based prospective longitudinal study.

Submitted.

V. Clara Aarts, Elisabeth Kylberg, Yngve Hofvander, Mehari Gebre-Medhin.

Growth under privileged conditions of healthy infants exclusively breastfed from birth to 4 to 6 months. A longitudinal prospective study based on daily records of feeding.

In manuscript.

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ERRATA

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Page 11, Fourth paragraph should read "(the National Board of Health and Welfare 1952)"

."and 1984" should be deleted.

Page 16, Line 8, (Goldman et al. 1997) should read (Goldman & Ogra 1999).

Page 21, Swedish growth references, last sentence, missing references:

"(Albertsson-Wikland & Karlberg 1994, the National Board of Health and Welfare 2000)".

Page 29, line 4 -5 should be a heading.

Page 30, Under heading "Growth in the first year of life....", third line "received supplements since birth" should read

"received supplements before the age of 16 weeks".

Page 31, First line (n=293,...), infants.." should read "(n=293...), and infants..".

Third line "and infants who had stopped breastfeeding" should be deleted.

Page 44, Fourth line, last word "where" should read "while".

Page 45; Fourth line "(Buhrer et al. 1999)" should read "(Buhrer et al. 1999, Braae Olesen et al. 1997, Leadbitter et al. 1999)".

Second paragraph, last sentence "(Stinzing & Zetterström 1979)" should read "(Stinzing & Zetterström 1979, Catassi et al. 1995).

Page 49, The definition Frequent pacifier use is missing, Frequently ≥ 3 times/24 hours
References:

Page 54, "ILO. (2000).... " missing: "<http://www.ilo.org>
"Karlberg, J. (1989b)" should read "(1989)".

Page 56, "Palmer, G. (1988b)" should read "(1988)"

"Piwoz, E.G.(1995)" should read "(1995)"

Page 57, "the National Board of Health and welfare. (2001)". Should read "(2000)".

Page 58, "WHO & UNICEF. (1990)second line" should read "Paper presented at the Breastfeeding Meeting in the 1990's".

"WHO Global Data Bank on Breastfeeding" missing address
http://www.who.int/nut/db_bfd.htm

Missing references:

Albertsson-Wikland, K. & Karlberg, J. (1994). Natural growth in children born small for gestational age with and without catch-up growth. *Acta Paediatr Suppl*, 399, 64-70.

Braae Olesen, A., Ringer Ellingsson, A., Olesen, H., Jull, S., Thestrup-Pedersen, K. Atopic dermatitis and birth factors: historical follow up by record linkage. *BMJ* 1997;314:1003-8.

Leadbitter, P., Pearce, N., Cheng, S., et al. relation between fetal growth and the development of asthma and atopy in childhood. *Thorax* 1999;54:905-10.

Preface

My professional background is in nursing and in the training of student nurses. I have worked as a child health worker at Child Health Centres. During that time I met many parents with their children, especially mothers with newborn infants. Weighing and feeding counselling was an important part of the work. As a routine question I used to ask the mothers how the breastfeeding was getting on and whether the child slept through the night. I have seen crying mothers together with their crying and hungry children waiting early in the morning at the front door for test weighing. I have talked about growth spurts, although I could never remember at what age these spurts ought to occur. Routinely I recommended that mothers should start the infants on solids or semi-solids at the age of between 4 and 6 months. If mothers asked me how to start weaning, meaning diminishing breastfeeding, I used to advise that they just skipped one meal, although I myself wondered when a breastfeeding episode was supposed to be a meal. Undoubtedly I have also experienced the joy of happy parents coming with their healthy thriving boisterous infants. The work on this thesis has taught me that infant health and growth are part of the interplay of a large number of factors, of which breastfeeding is only one, but seemingly an important one.

This present thesis emanates from the Swedish research participation in “The WHO Multinational Study of Breastfeeding and Lactational Amenorrhoea”, which was conducted during the period May 1989 to January 1994. I worked as a research assistant in the project from September 1989 until January 1993. During that time I had the privilege of following about 80 mother-infant pairs from birth throughout the duration of the study.

Introduction

The health, growth and development of the child is influenced by a range of complex factors, including genetic, immunological, socio-cultural, psychological, nutritional, environmental, economic and political influences.

The present study focuses on the nutritional factor, in particular exclusive breastfeeding, since early infant feeding practice is a major preoccupation of parents and a great deal of the time of professionals at the child health centre is spent in giving nutritional counselling. Further, in the scientific literature, early feeding is often linked to and considered to be a determinant of the health, growth and development of the child. However, nutrition per se cannot in fact be looked upon separately from the other influencing factors.

Infant feeding practice

Breastfeeding has been a common feature of all cultures since the survival of mankind has been dependent upon this behaviour. The use of colostrum, prelacteal feeding, nutritional supplementation and the duration of breastfeeding have varied and still vary between cultures, between urban and rural areas and between the rich and the poor (World Health Organization, 1981a). In many traditional societies breastfeeding is still the principal way of infant feeding, and prelacteal feeds and early supplementation are widely practised (Gunnlaugsson et al. 1992, Shirima et al. 2001).

Changes over time

Globally, breastfeeding practices have fluctuated over the years. Wet nursing, an ancient social custom, was widely accepted for many years (Fildes 1995). In Western Europe, from the early second millennium wealthy families employed wet nurses to feed their children. As an alternative to breastfeeding or as a complement, different types of artificial feeding have probably always been used - cow's milk, goat's milk or milk from other animals, and/or cereal pap.

Not receiving human milk has undoubtedly been associated with problems and has been found in many instances to be fatal, or detrimental to the health of the newborn infant, as mammalian milk is species-specific and there are distinct differences between the milk of different mammals (Lawrence 1994). In the eighteenth and nineteenth centuries high infant mortality rates in certain areas in Sweden could be related to low breastfeeding rates, due to the extremely high work load of the women (Lithell 1988).

Advances in nutritional research, especially biochemistry, have led to the development of different types of nutritionally adequate breast milk substitutes. This has been of great benefit to those infants who could not or in rare cases were unable to receive human milk for medical reasons (WHO 1989, World Health Organization

1989a). However, the access to breast milk substitutes has also led to a decline in breastfeeding rates and duration, concomitantly with changes in the structure of societies, e.g. industrialisation and urbanisation, changes in family structure and the changing role of women (Grummer-Strawn 1996, King & Ashworth 1987, World Health Organization 1981a, Harrison et al. 1993). This decline started in the industrialised countries and then spread to other less developed countries, especially in large cities and urban settlements (Jellife & Jellife 1979, Palmer 1988). In the 1880s, more than 95% of the infants in the United States were breastfed, while the corresponding figure in the 1990s was only about 50% (Fildes 1995). The same trend was seen in Europe, with a decreasing breastfeeding rate after the Second World War. The breastfeeding rate was very low in the beginning of the 1970s in Sweden, but since that time there has been an increasing trend up to the present day (The National Board of Health and Welfare 2000). Decreasing breastfeeding rates have been observed throughout the world (WHO Global Data Bank on Breastfeeding 2000).

Breastfeeding prevalence and duration - a global perspective

There is a lack of uniformity in the collection of data on breastfeeding, and a great deal of the information originates from local or national publications using widely differing methodologies (Cattaneo et al. 2000, Yngve 2000). Further, differences are seen between regions, even within individual countries (The National Board of Health and Welfare 2000). In spite of this lack of uniformity in data collection, the mean percentage of mothers who initiate breastfeeding in Europe varies between 56% in Belgium (Yngve 2000), around 70% in Holland (Burgmeijer 1998), 85% in Italy (Riva et al. 1999) and 98% in Sweden (The National Board of Health and Welfare 2000). Many countries still lack data on breastfeeding rates.

According to the WHO Global Data Bank on Breastfeeding (WHO Global Data Bank on Breastfeeding 2000), which covers 94 countries and 65% of the world's infant population of ages over 12 months, the median duration of breastfeeding in the African region was 22.5 months and in the Americas, South-East Asia, Europe and Eastern Mediterranean and Western Pacific 10, 25, 19 and 14 months, respectively. The figure for Europe, at least, seems to be falsely high compared with the figures for individual countries from the WHO Regional Office for Europe. They conclude that the lack of representative and comparable national data makes any statement about the breastfeeding prevalence extremely difficult (WHO Regional Office for Europe et al. 1999).

Why do breastfeeding practices differ?

Breast feeding practice is the result of a complex interplay between biological, cultural and psychological determinants (Stuart-Macadam & Dettwyler 1995). Great differences regarding the breastfeeding duration, frequency of feeds, suckling time, night feeds and complementary feeding have been found both between individuals and between countries (Butte et al. 1985, De Carvalho et al. 1983, Quandt 1986,

Woolridge 1995, World Health Organization 1981a, World Health Organization Task Force on Methods for the Natural Regulation of Fertility 1998a, Zohoori et al. 1993) (Manz et al. 1999).

Several theories, frameworks and models of feeding practices and breastfeeding behaviour have been proposed, focusing on individual and environmental factors at the family, community, national and global levels (Klepp 1993, Quandt 1995, Sjölin et al. 1979, Wambach 1997, Wright 1989, Allen & Pelto 1985, Young et al. 1991). A model that incorporates these ideas is presented in Figure 1.

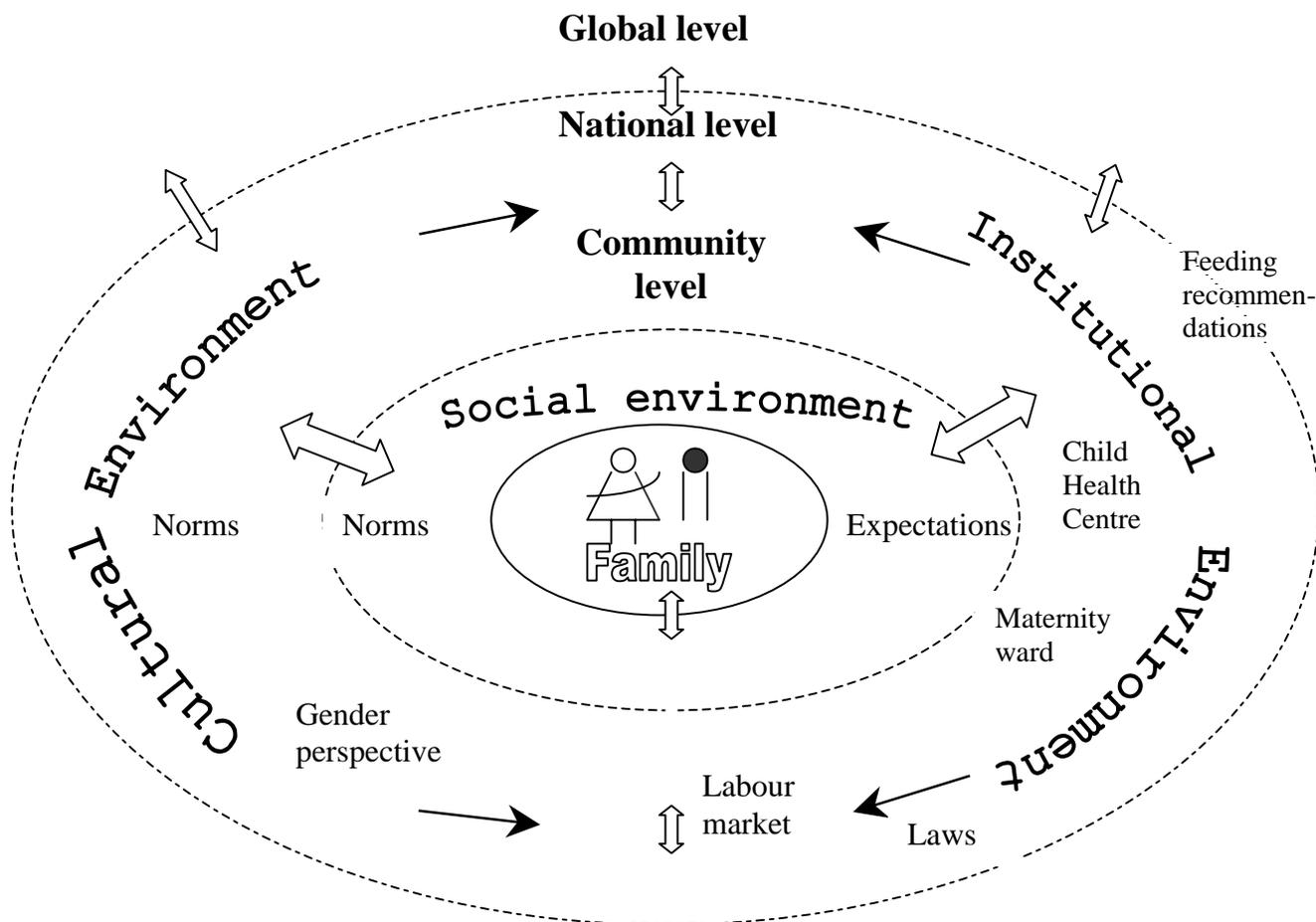


Figure 1. Factors that may influence feeding behaviour

Individual factors determining breastfeeding practice

Human milk output is the result of an interaction between biological and behavioural factors, both in the mother and the infant (Lawrence 1994, Lothian 1995, World Health Organization 1981a). Figure 1 summarises some of these factors. Biologically, virtually all mothers have the ability to lactate. The WHO found that in communities where breastfeeding was universal, no more than 2% of the mothers failed to initiate breastfeeding (World Health Organization 1981a). The milk volume is highly regulated by the infant's demand (Daly et al. 1992, Dewey et al. 1991). The active role of the infant together with the mother's response influences the breast milk volume. It

is assumed that the mother's concept of feeding as shaped by environmental factors, determines the mother's breastfeeding style e.g. the frequency of feeds, interval between feeds, sucking duration and co-sleeping (Quandt 1995). These factors influence the milk volume, which in turn affects the degree to which the infant is satisfied. Infants vary in crying, sleeping and other activity patterns, as well as in their general temperament and response to stimuli, including feeding. From these patterns of behaviour the mother (parents) judges the effect of her breastfeeding behaviour on the infant. When making this judgement the mother compares her infant's behaviour with her perception of what characterises a satisfied infant. If the baby is considered to be satisfied, (exclusive) breastfeeding will be continued (Wright 1989), on the condition that the mother (parents) is also satisfied and feels comfortable (Leff et al. 1994).

The mother's intention to breastfeed is related to her and the father's beliefs and knowledge on infant feeding, their attitudes towards breastfeeding, their experiences, expectations, skills, confidence, and emotions involved and to the predicted consequences, for example the mother's perceived work load. These factors have been found to be indirectly related to the personality and age of the parents, their educational level and socio-economic status, the health of the mother and the infant, and the infant's birth weight (Freed 1992, Giugliani et al. 1994, Kessler et al. 1995, Young et al. 1991, Bottorff 1990, Pande et al. 1997, Pérez-Escamilla et al. 1995).

In the Swedish setting the educational level of the population is generally high and practically all parents have at least eleven years of formal education. The employment rate in Sweden in 1991 was 94% in men aged 25-54 years and 87% in women with children below the age of seven years (Statistiska Centralbyrån 1997). The socio-economic level is considered to be fairly homogeneous.

Environmental factors determining breastfeeding practices

There is a constant dynamic interaction between a person's behaviour, the characteristics of the person, and the environment (Bandura 1978). The *social environment*, including social norms and expectations among family members, friends, neighbours and people at their place of work, is under the constant influence of the outer *cultural environment*, including attitudes towards breastfeeding and infant feeding, gender perspectives and the role of women, at the community and national levels (Baranowski 1989-90), Figure 1. There is a continuous diffusion of ideas and concepts between these different levels that constitute the context of the family.

In Sweden, breastfeeding has become part of the culture today. Sweden has a high breastfeeding rate, although there are differences between geographical parts of the country (*The National Board of Health and Welfare, 2000*). This high breastfeeding rate can be seen as a result of both governmental and non-governmental advocacy, at community, national and global levels, which may be termed the institutional environment.

Both the social and cultural environments are strongly influenced by the surrounding *institutional environment* at community, national and global levels,

including governmental and non-governmental regulations, public information and recommendations, and legislation. The institutional environment, in turn, is shaped by the cultural environment, which in turn is influenced by new knowledge through research and the changing socio-economic situation.

Promotion of breastfeeding at community and national levels

Breastfeeding promotion can be said to be a function of the working principles, guidelines, and attitudes and skills of the health services personnel involved in pre-natal, delivery and post-natal care.

The Swedish health care services function both at the national and the regional level under the guidance of the national authority. The maternity and child health services cover all mothers and children and are all free of charge. Almost all deliveries in Sweden take place in hospital, and home deliveries are very unusual. After the delivery, all fathers get 10 days' paid leave. The official parental leave, which can be shared by the parents, was one and a half years (almost fully paid) during the study period, and fathers were taking an increasing part of it, 4% in 1990 and 11% in 1994 (Statistiska Centralbyrån 1997).

Infant feeding recommendations by the relevant authorities have changed during the last 50 years. Breastfeeding has always been recommended, but the timing of feeding and the suckling duration, as well as the timing of introduction of vitamins/minerals and supplements have varied. In the beginning of the 1950s it was recommended that breastfeeding should follow a rather strict time schedule, with feeding every 4th hour (The National Board of Health and Welfare 1952 and 1984). This practice was replaced in the 1970s and 1980s with more flexible on demand scheduling (The National Board of Health and Welfare 1977). The timing of introduction of semi-solids and solids has varied considerably from between 6 and 9 months in the 1950s to 3 months in the 1970s. The Swedish mother support group for breastfeeding "Amningshjälpen", a non-governmental organisation, was started in 1973. The group still plays an important role in breastfeeding counselling.

Global strategies for breastfeeding during the last 30 years

In the 1970s the World Health Assembly (WHA) drew attention to the general decline in breastfeeding in many parts of the world. This trend coincided with changing socio-economic conditions for mothers and also with the promotion of manufactured breast milk substitutes. The Assembly urged their member countries to give priority to supporting and promoting breastfeeding, and to take legislative and social action to facilitate breastfeeding by working mothers and regulate inappropriate sales promotion of infant foods used to replace breast milk. As a result of international collaboration between WHO, UNICEF, medical experts, government representatives, and representatives of the infant food industry and consumer groups, in May 1981, the WHA adopted the International Code of Marketing of Breast-milk Substitutes, partly on the initiative of the Nordic countries (World Health Organization, 1981b). The

object of the Code is to control unethical marketing of breast milk substitutes to parents and staff in health care facilities. The Code was recommended as a basis for action and had to be adopted and implemented in the individual member states. In Sweden this was done in 1983 as a voluntary measure (The National Board of Health and Welfare, 1983).

In 1975 WHO started a collaborative study on breastfeeding, on the initiative of Sweden, with the overall aim of achieving a better understanding of the various factors that influence breastfeeding patterns in different settings (World Health Organization, 1981a). The study began in nine countries, Chile, Ethiopia, Guatemala, Hungary, India, Nigeria, the Philippines, Sweden and Zaire. The results showed, in brief, differences in the breastfeeding pattern and duration between different socio-economic groups - urban elite, urban poor and traditional rural. Life-style, educational background and cultural differences were found to be some of the important determinants. The results served as a basis for planning and implementation of national programmes of education and public information on breastfeeding.

The Convention on the Rights of the Child was adopted by the United Nations General Assembly in 1989. It contains a comprehensive set of international legal norms for the protection and well-being of children and includes actions for promotion, protection and support of breastfeeding (United Nations Children's Fund (UNICEF) 1990).

WHO/UNICEF made a joint statement in 1989 for health personnel on the protection, promotion and supporting of breast feeding which included Ten Steps to Successful Breastfeeding (World Health Organisation 1989). This was followed in 1990 by the Innocenti Declaration (WHO & UNICEF 1990), the name taken from the place where the meeting was held at Spedale degli Innocenti, in Florence, Italy. The declaration was adopted by over 30 countries which participated in the WHO/UNICEF meeting on "Breastfeeding in the 1990s: A Global Initiative", co-sponsored by the United States Agency for International Development (USAID) and the Swedish International Development Authority (SIDA) (World Health Organisation 1989). The four targets set were: 1. A national breastfeeding co-ordinator and a national breastfeeding promotion committee should be appointed in every country. 2. Maternity facilities should practise the Ten Steps to Successful Breastfeeding. 3. Implementation of the International Code of Marketing of Breast-milk Substitutes. 4. Protection of the breastfeeding rights of working women.

One outcome of the Innocenti Declaration was the Baby Friendly Hospital Initiative, introduced in 1991 by WHO/UNICEF. The goal of the declaration was to promote breastfeeding in hospitals and maternity services through implementation of the Ten Steps to Successful Breastfeeding. When a hospital meets all criteria, it is designated as "baby friendly" and receives a plaque. In Sweden the Initiative was launched in 1992.

Working mothers' rights to take breastfeeding breaks at their work-place were included in the third International Labour Organisation (ILO) convention, as early as in 1919, and this was reinforced in convention 103 in 1952 and in the recently revised Maternity Protection Convention 183 (ILO 2000).

The current WHO infant feeding recommendation is that exclusive breastfeeding should be practised during the first 4 to 6 months, after which breastfeeding should continue, with the addition of complementary foods, for 2 years or beyond (World Health Organization 1995). Since the beginning of the 1990s it has been debated whether the recommendation should state an explicit age range “4 to 6 months”, for the time of introducing complementary feeding, or leave the issue slightly more open - “about six months” (World Health Organization 1998).

There are several non-governmental organisations that promote breastfeeding at the global level. These include the World Alliance for Breastfeeding Action (WABA), the International Baby Food Action Network (IBFAN), the International Lactation Consultant Association (ILCA) and La Leche League International (LLL).

Non-nutritive sucking and pacifier use

Non-nutritive sucking (NNS), especially sucking a pacifier, has been studied extensively. Non-nutritive sucking can be defined as any repetitive mouthing activity, other than biting, without receiving liquid (Hafström 2000), characterised by bursts of approximately 3-12 sucking cycles separated by pauses (Finan & Barlow 1998). Non-nutritive sucking by the newborn is a fundamental behaviour and is one of the first co-ordinated muscular activities in the foetus (de Vries et al. 1984). It is related to infant maturation (Hafström 2000, Lundqvist & Hafström 1999) and includes sucking the thumb, finger or a pacifier (dummy/soother). Pacifiers are used almost world-wide, although there are great differences in their usage between cultures and socio-economic groups (Larsson et al. 1992, Mathur et al. 1990, Victora et al. 1993).

As part of the Baby Friendly Hospital Initiative, WHO/UNICEF recommends that a pacifier should not be used in the early post-partum period when the infant is learning to suck from the breast (World Health Organisation, 1989). Sucking on a pacifier and suckling at the breast have been described as being different techniques, and it has been stated that sucking a pacifier might interfere with learning to suck the breast correctly, leading to so-called nipple confusion, in some cases causing maternal breast problems (Neifert et al. 1995, Newman 1990, Righard & Alade 1992, Righard & Alade 1997). Infants sucking a pacifier may have fewer daily breastfeeds, which may reduce breast stimulation, resulting in decreased milk production and a shorter breastfeeding duration (Barros et al. 1995, Clements et al. 1997, Ford et al. 1994, Howard et al. 1999, Newman 1990, Righard & Alade 1997). Other described negative effects related to pacifier use are increased incidence rates of otitis media, oral Candida infections and dental malocclusion (Niemela et al. 1995, Niemela et al. 2000, North et al. 1999, Paunio et al. 1993).

Reported positive effects of pacifier use, especially in pre-term infants, include enhanced development of sucking behaviour, less behavioural stress (Uvnäs-Moberg 1989, Dipietro et al. 1994, Gill et al. 1992), higher rhythmicity (Kelmanson 1999), elevation of the pain threshold (Blass 1994), and improved digestion of enteral feeds (Dipietro et al. 1994).

On the other hand, in a recent Cochrane review on the effects of NNS in preterm infants, the only statistically significant effect of NNS intervention was found to be a decrease in the length of stay at the hospital, compared with that in control infants (Pinelli & Symington 2000).

Benefits of breastfeeding

Breast milk has an ideal nutrient composition for the newborn and young infant. There is probably no need for supplementation of breast milk with vitamins, minerals or other nutrients before the age of about 6 months, although this may differ between individual infants and is a subject of debate (Butte et al. 1984, Cohen et al. 1994, Dewey et al. 1992, Hijazi et al. 1989, Lutter 2000, Underwood & Hofvander 1982, Whitehead 1995).

All infants in Sweden receive supplementation with vitamins A and D - Vitamin D is provided because of lack of sun during the dark winter period. However, the need for vitamin A supplementation in infants and children has recently been questioned (Axelsson et al. 1999).

The benefits of breastfeeding for both the infant and the mother are well documented in both the developing and industrialised countries. One of the psychological benefits is that breastfeeding helps to create a bond between the mother and infant (Widstrom et al. 1990, Uvnäs-Moberg & Eriksson 1996). Maternal health benefits include an increase in the circulating level of oxytocin, resulting in less post-partum bleeding and more rapid uterine involution, promotion of birth spacing and a reduced risk of ovarian and breast cancer (Newcomb et al. 1994, Nissen et al. 1995, World Health Organization Task Force on Methods for the Natural Regulation of Fertility 1998b).

As far as the infant is concerned, breastfeeding gives protection against gastrointestinal illnesses, otitis media and respiratory tract infections, atopic eczema and allergy (Aniansson et al. 1994, Cushing et al. 1998, Lopez Alarcon et al. 1997, Oddy et al. 1999, Perera et al. 1999). There is evidence that this protective effect is not restricted to the lactation period, but is long-lasting, persisting for years after termination of lactation (Silfverdal et al. 1997, Beaudry et al. 1995, Saarinen & Kajosaari 1995, Wilson et al. 1998). Published data suggest that breastfeeding protects against cardio-vascular disease and reduces the risk for childhood obesity and promotes cognitive and neuro-development (Horwood & Fergusson 1998, von Kries et al. 1999, Ravelli et al. 2000, Vestergaard et al. 1999).

Extensive research on the human milk composition and, in particular, on the immunological qualities of human milk has recently shed light on the enormous immunological role of human milk in the protection against infections. The infant's immune system is not fully developed at birth.

The newborn infant produces very little immunoglobulin, and the main circulating antibody is immunoglobulin G (IgG), derived passively from the mother, transferred mostly through the placenta during late gestation. IgG antibodies are important for tissue defence (Berg & Nilsson 1969, Hanson 1998).

Breast milk and maturation of the immune system

The initial response to all infections in infants takes place in mucosal membranes of the respiratory, gastrointestinal and urinary tract, and the mucosal immune system is the first line of defence that protects the infant from nearly all infectious bacterial and viral disease; this is the so called mucosal defence (Husband et al. 1999). The first 12 months of life appear to be critical for the maturation of this mucosal immune system. Human milk is linked to the mucosal immune system and early infant feeding therefore plays an important role in the maturation of this system. The development of mucosal immunity is profoundly affected by exposure to infections. Oral feeding per se also provides a stimulus for mucosal immune development. Increased antigenic exposure of infants (lower standards of hygiene, hospitalisation, day care) results in a higher level of antibodies in the saliva (Cripps & Gleeson 1999, Mellander et al. 1985).

The mucosae of the gut and respiratory tract have to absorb substances that are essential for life. To be selective, the intestinal mucosa has developed a complex network composed of elements that are extrinsic to the intestine itself, as well as elements defined by the intestinal structure. Antigen entry is prevented by non-specific (gastric acid, mucus, digestive enzymes, peristalsis) and immunological mechanisms in the gastrointestinal tract as well as by the physical structure of the epithelium itself. Mucus acts as the outermost sensory "organ" of the mucosal immune system, since the mucus blanket, like a cell membrane, is a selective permeable barrier. The intestinal permeability decreases with age and is related to the type of feeding. It decreases faster in breastfed infants than in those fed formula (Catassi et al. 1995, Shulman et al. 1998). The introduction of cow's milk protein into the diet of the young infant can cause mucosal injury and has been incriminated as a cause of bleeding from the gut, and it can also cause cow milk allergy (American Academy of Pediatrics 1992, Stinzing & Zetterström 1979, Ziegler et al. 1990).

The most important antibody in human milk is secretory immunoglobulin A (SIgA), which has antiviral, antibacterial and antiparasitic activity. SIgA contains antigens from the mother's intestinal flora and ingested microbes and foods. The secretory antibodies are produced in the mammary glands by lymphocytes which have migrated there primarily from the Peyer's patches in the mother's gut, where they have been exposed to all microbes, foods etc. that pass through the gut. These lymphocytes do not originate solely from recent antigen exposure, but also include memory cells representing previous encounters with microbial and other antigens in the mother's life. The secretory antibodies protect the infant against all of the microbes to which the mother has been exposed by blocking the attachment of microbes to mucosal membranes (Hanson 1998). The approximate time of maturation of SIgA in infants is at the age of 4-12 months, and a full antibody repertoire has developed at 24 months

(Goldman & Ogra 1999). This timing is dependent on the exposure level; for example Pakistani infants, who are more heavily exposed, have been found to have adult levels of saliva SIgA against *Escherichia coli* already by the age of a few weeks (Mellander et al. 1985).

As well as containing SIgA and some IgG and immunoglobulin M (IgM) antibodies, human milk also contains cytokines and growth factors, numerous leucocytes (mostly macrophages but also granulocytes), multiple T and B lymphocytes, lactoferrin and lysozyme (Goldman et al. 1997, Hanson 1998, Hanson 1999). We do not really know the clinical value of lactoferrin and lysozyme, and this is difficult to test, but they are probably important in the defence mechanisms on mucosal surfaces, especially lactoferrin (Cripps & Gleeson 1999). Lactoferrin has bacteriostatic, bactericidal, fungicidal and virucidal activity. Lactoferrin blocks the production of cytokines. Lysozyme is able to bind to bacterial cell surfaces (anti-bacterial effects) and may impair vital membrane functions. The concentration of lysozyme is higher in human milk than in the milk of most other species. For instance it is 3,000 times higher in human milk than in cow's milk, but the concentrations vary during lactation (Pruitt et al. 1999). The concentrations of these components are very high in colostrum and decrease in mature milk. As the decreased concentrations are compensated for by an increasing milk volume, the infant intakes remain more or less at the same level with the progression of breastfeeding (Lawrence 1994, World Health Organization 1989).

Exclusive breastfeeding - a new concept

Definitions and methodology regarding exclusive breastfeeding

It is now believed that the benefits of breastfeeding are enhanced if breastfeeding is practised exclusively, without supplementation, for at least the first 4 to 6 months (World Health Organisation 1989). Exclusive breastfeeding as recommended by WHO/UNICEF allows, besides breast milk, feeding with only vitamins, medicine and herbal-tea and no water is allowed according to the strict definitions (World Health Organisation 1991). This recommendation is based on the knowledge that water was not needed, not even in hot climates, and that the use of dirty water and dirty bottles is harmful to the health of the infant (Brown et al. 1989).

Exclusive breastfeeding is a relatively new concept and it is rarely practised anywhere for the recommended period. Few studies have applied this strict definition of exclusive breastfeeding and there is a lack of clarity regarding the benefits of exclusive breastfeeding, due to differences in methodology and the breastfeeding definitions applied. Exclusive breastfeeding and full breastfeeding are often regarded as equivalent and allow the infant to receive prelacteal feeds, water and water-based drinks, and / or supplementation irregularly. Various authors have pointed out the difficulties in interpreting the results of breastfeeding studies because of the different methods and breastfeeding definitions used (Auerbach et al. 1991, Bauchner et al.

1986, Labbok & Krasovec 1990). WHO has therefore developed a set of definitions and indicators to be applied in assessing breastfeeding practices (World Health Organisation 1991). These definitions and indicators were intended for application in surveys using the 24-hour methodology; that is, all mothers with children less than 24 months of age would be asked the current age of the child and the kinds of food given during the previous 24-hours.

The validity of data on exclusive breastfeeding based on single 24-hour periods has been questioned (Piwoz et al. 1995, Zohoori et al. 1993), as this fails to take into account the possibility that many infants may have received other drinks or foods earlier.

Although breastfeeding definitions were developed in the early 1990s, these recommended definitions are still not used in many studies, and comparisons between breastfeeding rates and health outcomes are therefore difficult (Labbok & Coffin 1997, Cattaneo et al. 2000). In a review (Medline search) of empirical studies on the relation between infant feeding practices and morbidity, published between 1995 and 1999, 18 studies were found with the expression “exclusive” or “exclusively” breastfed mentioned in the abstract. In only five of these studies was the currently recommended WHO definition for exclusive breastfeeding used, while in six of them exclusive breastfeeding was not defined at all. Further, most of the studies had a retrospective design.

Prevalence of exclusive breastfeeding

Notwithstanding these problems of terminology and definitions, according to the WHO Global Data Bank on Breastfeeding (WHO Global Data Bank on Breastfeeding 2000), which covers 94 countries and 65% of the world’s infant population of ages <12 months, 35% of these infants are exclusively breastfed between 0-4 months of age. The data are mainly derived from national and regional surveys, carried out with different methodologies. The rates differ considerably between the different regions, with low rates in a number of countries in the African region, varying from 2% in Nigeria in 1992 to 23% in Zambia in 1996. In the South-East Asia region the rate of exclusive breastfeeding is very low, e.g. 4% in Thailand in 1996. Data for South America have shown a slight decrease over time in the exclusive breastfeeding rate, although this is still high compared to other regions; e.g. Bolivia 53% in 1994 and Colombia 16% in 1995. Some rates for the Eastern Mediterranean region are 68% in Egypt in 1995 and 25% in Pakistan in 1992. In the European region the situation also differs greatly between different countries, with the highest rates in Norway and Sweden; in Sweden the figure in 1998 was 69.1% (The National Board of Health and Welfare 2000).

Why is exclusive breastfeeding so rare?

The practice of giving the infant some fluids “before the milk has come in”, so-called prelacteal feeding, or giving ritual foods or fluids depending on cultural influences, is

very common in most societies (Dimond & Ashworth 1987, Gunnlaugsson et al. 1992, Shirima et al. 2001). This practice is now slowly changing, however, partly as a result of the Baby Friendly Hospital Initiative.

The most common reasons given for not breastfeeding exclusively include: cultural beliefs, that the mother has to work or is temporarily absent, that the mother does not have enough milk or thinks that she does not have enough milk (so-called insufficient milk supply), sore nipples, or that she thinks that the infant should become accustomed to different flavours and other foods (Harrison et al. 1993, Hillervik-Lindquist et al. 1991, Martines et al. 1989, Sjölin et al. 1979).

Infant growth in relation to early feeding

The regulation of growth

Children's health is often evaluated as a function of growth by using anthropometrical measurements, usually weight and length / height. Each individual's pattern of growth and final adult height represent the sum of the effects of a range of factors, including genetics, nutrition, hormonal milieu, social-economic environment, and the seriousness and duration of any illness (Falkner 1986). However, how these factors interact or, for example, exactly how genes regulate the number of cell divisions, individual cell size, and the rate of growth is not fully clear. Optimal growth requires both sufficient energy and specific nutrients. Growth and sex hormones as well as thyroid hormones must be secreted at appropriate times to enable the normal sequence of growth and subsequent sexual maturation. Various diseases and abnormalities of digestion or absorption as well as socio-economic conditions may lead to nutritional deprivation. However, unless the illness is severe or prolonged, a period of accelerated "catch-up" growth occurs following illness, that helps the child regain the growth pattern it should follow.

A number of researchers have described the growth pattern using varying mathematical models (Preece 1981, Karlberg 1987). Recently Karlberg (1989) has proposed a further model, based on a longitudinal growth study which covers the whole postnatal period. This model breaks down growth into three additive and partly superimposed components; Infancy, Childhood and Puberty; so-called ICP model. It is postulated that these different components of the human growth curve from birth to adulthood strongly reflect the different hormonal phases of the growth process. Thus the growth of the young infant is a continuation of the intrauterine growth pattern. This pattern in turn, is under the influence of mainly two sets of factors, namely genetic potentials and maternal influences. Briefly, the mother enters the reproductive process with her genetic condition and her environmental attributes. Further foetal growth then proceeds as a function of the interplay between the characteristics of the foetus (genetic) and placenta, and factors mediated through the maternal characteristics, including parity, anthropometry, nutrition and smoking (McFayden 1985, Nordström & Cnattingius 1996).

Growth references

The growth of their children is a major concern of parents. In Sweden, parents with newborn infants visit the child health centre to weigh their infants many times during the first year of life. A scrutiny of the records at one health centre showed that weighing occurred between 6 and 23 times (median 11) from age 0-6 months and 1-10 times between 6 and 12 months (Personal communication). In view of this the need for valid growth references as tools for growth monitoring, for detection of growth faltering or excessive growth and for breastfeeding counselling and timing of introduction of complementary foods is evident. Many countries use their own growth references, as does Sweden, but internationally used references are also available.

The United States National Center for Health Statistics (NCHS) and the NCHS/WHO reference

A commonly used reference has been the NCHS reference, published in 1977. In 1978 the Centres for Disease Control and Prevention (CDC) modified the NCHS growth curves. These modified charts were adopted by WHO for international use and are referred to as the NCHS/WHO reference (World Health Organization 1983). For children under 2 years of age the data originated from the Fels Longitudinal Study carried out in Yellow Springs, Ohio, and reflect the growth patterns of 476 predominantly Caucasian, middle-class, mostly formula-fed infants, born between 1929 and 1975 (WHO Expert Committee on Physical Status 1995).

The “12-month breastfed pooled data set”

Many studies have shown that the growth of exclusively breastfed infants differs from the references available (Nutrition Unit World Health Organization 1994). The WHO working group on infant growth examined the growth patterns of a subset of 226 infants from seven different longitudinal studies (Dewey 1992, Krebs 1994, Michaelsen 1994, Persson 1985, Salmenpera 1985, Whitehead 1989, Yeung 1983). These infants were exclusively or predominantly breastfed for at least 4 months and then breastfed for the remainder of the first year or possibly longer. This series of infants is referred to as the “12-month breastfed pooled data set” (Nutrition Unit World Health Organization 1994, Garza & de Onis 1999). From this it follows that the infants were not exclusively breastfed.

During the first year of life, beginning after the first 2 months, breastfed infants grow more slowly relative to the NCHS-WHO reference (WHO Working Group on Infant Growth 1995, World Health Organization 1989). The WHO working group on infant growth therefore initiated a multi-country growth study for development of a new growth reference for infants fed according to the WHO feeding recommendations; with exclusive breastfeeding during the first 4-6 months of life (WHO Working Group on Infant Growth 1995, de Onis et al. 1997)

NCHS/CDC reference

The NCHS growth charts have recently been revised and called “The CDC Growth charts: United States” (Kuczmarski et al. 2000). The charts for infants 0-36 months old include data from the National Health and Nutrition Examination Survey (NHANES) I-III. NHANES II, beginning at 6 months, was conducted between 1976 and 1980 and NHANES III, beginning at 2 months, between 1988 and 1994. NHANES III was specifically designed to over-sample infants and children 2 months to 5 years of age. NHANES III, a cross-sectional survey, consisted of 5,594 non-Hispanic white, non-Hispanic black and Mexican American infants and children. Information on infant feeding practices was obtained by current-status and retrospective methods; 21% were exclusively breastfed for 4 months, 10% were partially breastfed, 24% were breastfed for < 4 months and 45% were never breastfed. Data for infants <1,500 g were excluded. The revised weight-for-age curves are generally higher for infants below 24 months than in the 1977 charts and the revised length-for-age curves tend to be lower.

No special charts for breastfed infants were developed. However, infants who were exclusively breastfed for 4 months were compared with infants who were fed in other ways (Hediger et al. 2000). The exclusively breastfed infants weighed less at 8-11 months (200 g), but there were few other significant differences in growth status through age 5 years associated with early infant feeding. At 12-23 months the weight discrepancy had disappeared. Exclusively breastfed infants were defined as those who received no supplements (formula, milk or solids) for at least the first 4 months of life (through 15 weeks). Current or retrospective information on infant feeding practices was obtained at the time of the interview (cross-sectional survey). Questions included whether or not the infant was ever breastfed, and the age at which the infant was first fed formula regularly (i.e. daily), was first fed milk daily, and started eating solid foods daily. Here again, the infants may have received irregular formula, milk and solids.

The Euro-Growth reference

As specific Euro-growth references were not previously available, a Euro-Growth Study for infants and children from birth to 3 years of age has been performed (Haschke & van't Hof 2000), in which 2,245 infants were enrolled at 22 study sites in 11 countries. The study was carried out between 1990 and 1996 and comprised 1,746 infants participated until 12 months of age, 1,205 infants up to 24 months of age and 1,071 infants up to 36 months of age. Anthropometric measurements were made at the target ages 1, 2, 3, 4, 5, 6, 9, 12, 18, 24, 30 and 36 months. Data were collected on growth of a subset of 319 infants exclusively breastfed for at least 4 to 5 months according to the WHO recommendations (Haschke et al. 2000). The infants were followed up longitudinally and during each visit their diet was assessed by a semi-quantitative dietary recall method. However, the exact way in which the questions regarding exclusive breastfeeding were asked is not described, but seemingly these infants were truly exclusively breastfed. This is the closest that the infants come being exclusively breastfed. Further, 185 infants were breastfed but had received solids from

an early age and 1,509 infants (control group) were fed in a variety of ways, which included breastfeeding during the early months of life in the majority (65%) of the infants.

The pattern of growth of children who were fed according to the WHO recommendations showed higher z-scores for weight during the first 2 to 3 months of life and lower z-scores for weight from 4 to 12 months compared with the control group from the same cohort. Similarly, z-scores for length were lower after 3 months of age. Between 12 and 36 months of age, differences between groups were small. As the mean z-scores and standard deviations for length and weight of breastfed children were close to the Euro-growth references, the investigators conclude that the Euro-growth references may be used for children who are fed according to the WHO recommendations. (The differences in mean z-scores for length ranged from -0.26 to +0.14 at all target ages and the differences in mean z-scores for weight at 1 and 2 months of age were 0.30 and 0.28, respectively. After 2 months of age, the differences in the mean z-scores were <0.15.)

Swedish growth references

In 1973 growth references were developed in Sweden on the basis of a longitudinal study of 212 infants, 90 girls and 122 boys, born between 1955 and 1958 in an urban community (Engstrom et al. 1973). The feeding pattern was not reported. Anthropometric measurements were made at the ages of 1, 3, 6, 9, 18 and 24 months. (Karlberg et al. 1968, Karlberg et al. 1976)

In 1999 a new growth reference was introduced in Sweden. The anthropometric values were taken retrospectively from the health records of 5,111 children in the final grade of schools in 1992 in the city of Gothenburg. Of these, 76.8% were born in 1974, 16.8% in 1973, 3.6% in 1995 and 3% before 1973. In the final analysis there were 3,650 healthy full-term children (37-43 weeks). It is clear that the children included in the study were born at the time when the breastfeeding rates in Sweden were at their lowest level.

The rationale of the present study

Clarity regarding the methods of assessment of early infant feeding is crucial, since the type of feeding given and the pattern of feeding adopted are often said to have a bearing on the morbidity, growth and even longevity.

Exclusive breastfeeding is a fairly new concept. A major part of the work at the child health centre consists of counselling parents on infant feeding, and monitoring the growth and the health status of the child. It is therefore of particular importance to define the concept of exclusive breastfeeding, to study exclusive breastfeeding in practice and to study the relation between exclusive breastfeeding and the health of the child in different settings. Such studies are seemingly lacking, and available data are inconsistent on account of differences in the methodology applied. Another important

reason for a clearer definition of exclusive breastfeeding and its application is the fact that the practice of exclusive breastfeeding for 4 to 6 months might be rather demanding for some mothers, even if they have long parental leave.

Sweden is an affluent welfare society with a high proportion of well-educated parents. The majority of the people live under good hygienic conditions, parents have extended leave after childbirth and an exceptionally high proportion of the mothers breastfeed their infants exclusively for a relatively long time. Sweden thus seemed a very appropriate country for an investigation of the relation between exclusive breastfeeding and various outcomes, including health, growth and longevity.

The general aim of the present investigation was therefore to look into the concept of exclusive breastfeeding and how it should be assessed, to make a detailed study of the practices of exclusive breastfeeding and to relate carefully defined exclusive breastfeeding to the health and growth of the infant.

The specific aims of the different studies and the questions addressed were:

1) To elucidate possible differences in the rates of exclusive breastfeeding depending on whether information is obtained from a single 24-hour period, the commonly used “current status“ method or from infant feeding data recorded on a daily basis since birth.

2) To relate morbidity patterns to early infant feeding. Are there any differences in morbidity rates between infants who are exclusively breastfed since birth and those who receive supplements in addition to breast milk or have stopped breastfeeding?

3) To relate growth during the first year of life to patterns of early infant feeding. Is there a difference between the growth pattern of healthy infants who have been exclusively breastfed since birth, as ascertained through daily feeding records, and the growth pattern of the non-exclusively breastfed infants from the same cohort? These results were compared with those of the WHO “pooled breastfed data set“, the exclusively breastfed infants in the Euro-Growth study, and the NCHS/WHO reference.

4) To describe exclusive breastfeeding as it occurs in practice, i.e. the frequency of feeds, the suckling duration and the longest interval between two consecutive feeds, and to analyse factors influencing the duration of exclusive breastfeeding as well as the total duration of breastfeeding.

Methodology

The collaborative WHO project

All the studies included in this thesis consist in analyses of Swedish data obtained in the collaborative WHO project entitled "The WHO Multinational Study of Breastfeeding and Lactational Amenorrhoea" (World Health Organization Task Force on Methods for the Natural Regulation of Fertility, 1998a). The aims of the WHO project were to investigate the duration of lactational amenorrhoea in relation to breastfeeding practices in different populations, to establish whether there were any real differences in the duration of lactational amenorrhoea between these populations, and to gain information on factors that may contribute to any differences observed.

This project was carried out in Sweden between May 1989 and February 1994. The Swedish part of the project was organised by the former International Child Health Unit, Department of Pediatrics, Uppsala University, Uppsala.

Study design

The WHO project had a descriptive longitudinal prospective design. The mother-infant pairs were followed from the first week after delivery until the mother's second menstruation post-partum or a new pregnancy.

Study population

The WHO inclusion criteria were that the mother should be healthy, parity 2-4, vaginal delivery at ≥ 38 weeks of gestation, previously breastfed at least one child for at least 4 months, intended to breastfeed the index child for at least 6 months, no intention to use hormonal contraceptives, had had regular menstruation (interval 21-35 days), speaks Swedish. The infant should be healthy, singleton, with a birth weight above the 10th percentile, which in Sweden was set at 3 kg or more, Figure 2.

All mother-infant pairs included in the WHO project were recruited from the University Hospital, Uppsala, where all deliveries in the county take place. Between May 1989 and December 1992, 15,189 children were born. The maternity wards were visited almost every weekday (a total of 758 days) to recruit the mother-infant pairs. The 1,164 mothers who fulfilled all criteria were invited to participate in the study, and 506 mothers agreed to take part, Figure 2. The main reason for non-participation (n=658) was the perceived high work load that the study might entail.

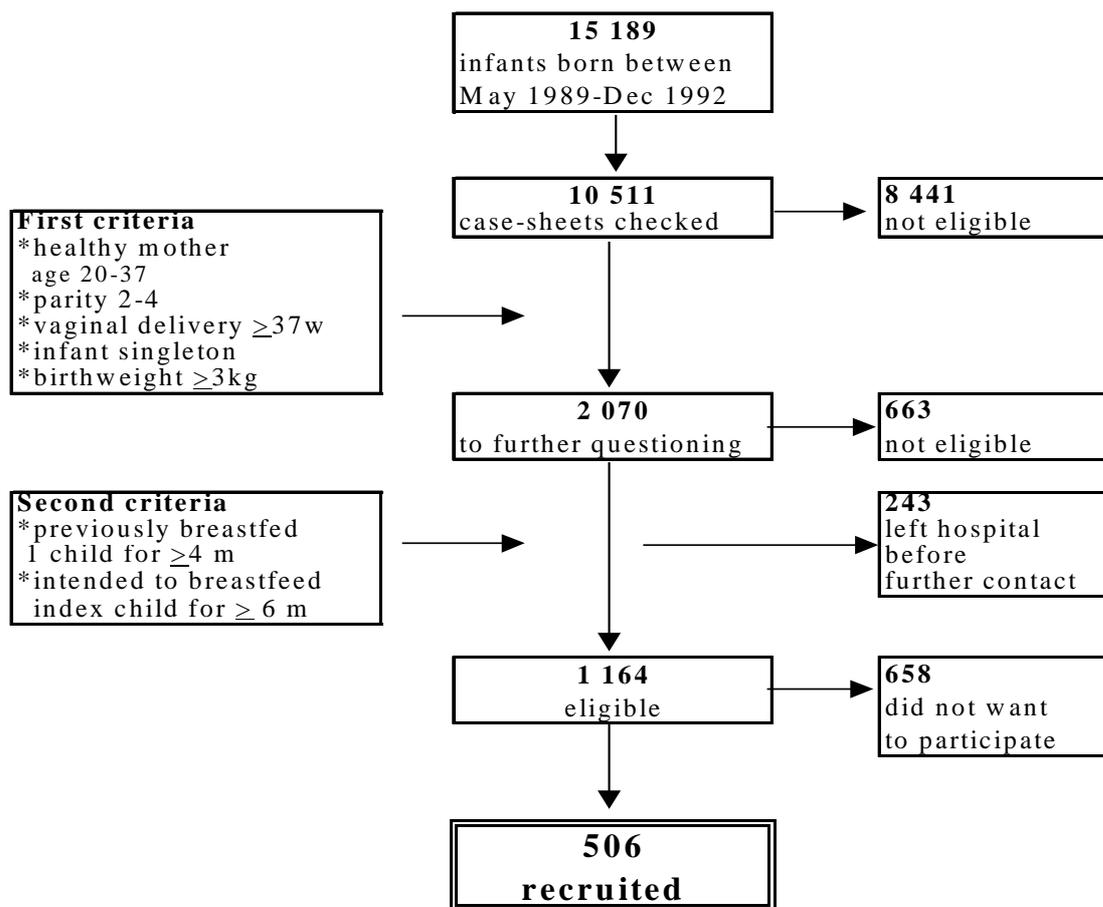


Figure 2. Recruitment details: inclusion criteria, reasons for non-eligibility and reasons for non-participation.

The mean age (\pm standard deviation) of the mothers in the study was 30.7 ± 3.7 years. Of the 506 mothers, 344 had one child prior to the index child, 140 had two previous children, and 22 had three children prior to the index child.

The mean number of years of formal education of the mothers was 14.2 ± 2.9 years; 91.5% had at least 11 years and all mothers had at least 9 years. Seventy-one per cent were married and 29% lived in a common-law marriage. The fathers had a mean age of 33.0 ± 5.0 years. The mean educational level of the fathers was 14.9 ± 3.8 years; 90.5% had at least 11 years of formal education, and all but six had a minimum of 9 years.

The project comprised 270 male and 236 female infants. The average birth-weight of the girls was 3.7 ± 0.4 kg and length 50.9 ± 1.8 cm, and those of the boys 3.8 ± 0.4 kg and 51.8 ± 1.8 cm, respectively. The birth weight distribution of the study sample was comparable to that of all singleton infants, with a birth weight of ≥ 3 kg, born of multiparous mothers in Sweden in 1990, Figure 3.

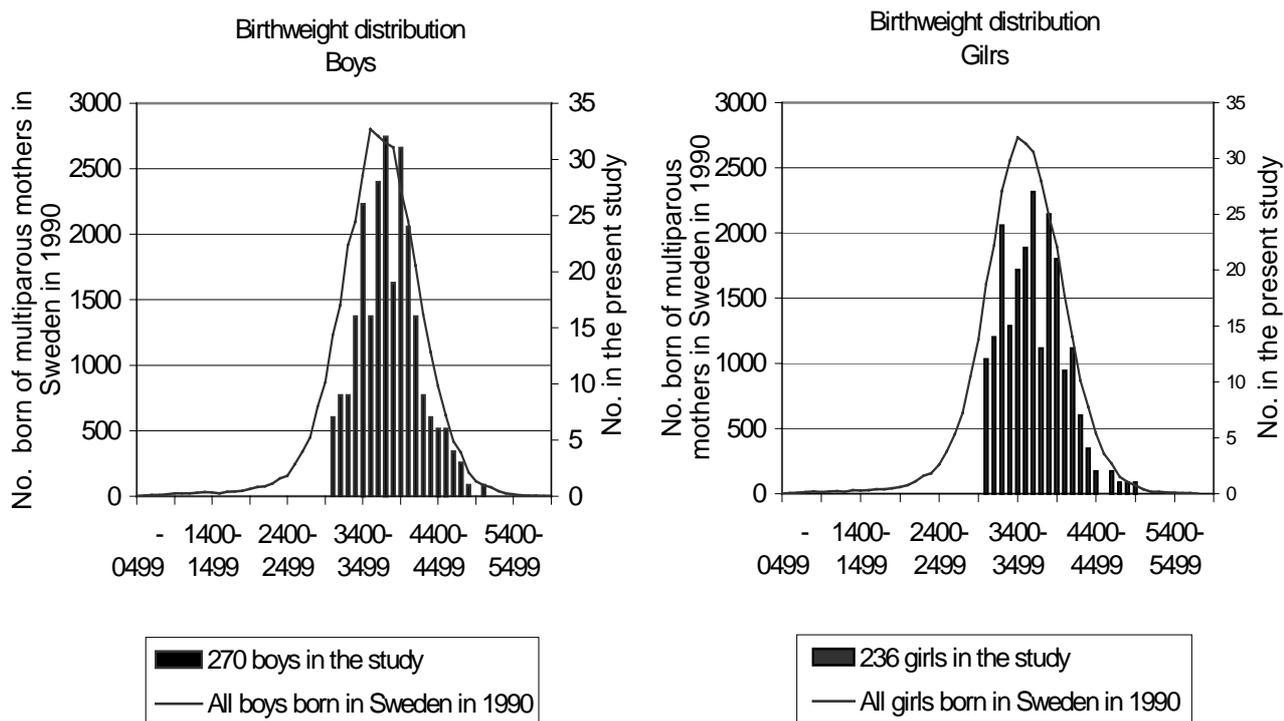


Figure 3. Distribution of birth weight (grams) in the boys and girls included in the study, relative to that of all singleton infants born of multiparous mothers in Sweden in 1990.

Methods and procedures

The mother-infant pairs were followed up from the first week after delivery (within 3-7 days) until the mother's second menstruation post-partum or a new pregnancy. Data were obtained from daily recordings, fortnightly interviews and fortnightly anthropometric measurements.

The daily recordings were completed by the mother on two charts; on one chart the mothers made daily records for 13 days of the number of suckling episodes, the number of episodes of breast milk expression, the number and category of supplementary feeds (including expressed breast milk) and any vitamins/minerals given. The second chart, which the mother completed every 14th day, consisted of a 24-hour detailed record of the timing of every suckling episode and the point in time when other food was given. The first 24-hour record with time-taking was made in the infant's third week of life (two but not yet three weeks of age). Subsequent time-taking was carried out fortnightly after the first 24-hour detailed record. Thus each follow-up period was 14 days long.

Every fortnight structured interviews were conducted by a research assistant in the home. The research assistant checked the record charts and recorded data for the previous two weeks - a validity check on the data. The interviews included information about the health of the infant and mother, the reasons for given something else (>10

ml) besides breast milk, whether the supplement amounted to >10 ml, whether the infant sucked its thumb and/or a pacifier and if so how many times per 24 h. The infant's weight was recorded every fortnight, and its length and head and chest circumferences were recorded monthly by the research assistant in the home. The infants were weighed naked with portable paediatric scales with a precision of 10 g. The length was measured with an infant stadiometer with a precision of 0.1 cm. The birth weight of the infants was recorded at the maternity wards, where all infants are weighed naked on electronic paediatric scales with a precision of 10 g, within 2 hours after birth.

Discontinuation

The mean duration (standard deviation) of participation in the study was 8.7 (3.4) months. The number of drop-outs during the first year and reasons for discontinuation can be seen in Table 1. At 4 months (16 weeks) 34 mothers (7%) had left the project. Of these, 12 had had their second menstruation after delivery, and 22 had dropped out for various reasons.

Table 1. Total study material (n=506), pattern of feeding and reasons for drop-outs during the first year.

Age (w)	Total	Excl ¹ breastfed 14-day period	Exclusively breastfed since birth			Not exclusively breastfed			Stopped breastfeeding			Drop-outs	Reasons for discontinuation (n)
	n	Total	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total	n	
1	506				340								
2	506	430	170	135	305	100	104	201					
4	499	395	162	129	291	104	104	208				7	2 nd mens ² (12)
6	495		143	126	269							4	mother's wish (11)
8	493	337	132	120	252	128	110	238	1	2	3	2	horm contr ³ (6)
10	490		121	113	234							3	family reasons (2)
12	486	290	111	107	218	145	116	261	4	3	7	4	moved (2)
14	481		94	88	182							4	died (1)
16	472	189	79	68	147	170	148	318	4	3	7	5	Σn=34
18	466		54	47	101							6	
20	454	79	33	33	66	198	175	373	8	7	15	12	2 nd mens (64)
22	443		15	18	33							11	mother's wish (3)
24	423	20	6	12	18	202	187	389	10	6	16	20	horm contr (3)
26	401	7	3	4	7	189	183	372	14	7	21	22	pregnant (1)
28	381		1	2	3	166	150	316	34	28	62	20	Σn=71
32	336		0	1	1	142	123	265	38	32	70	45	
36	285					104	97	174	55	29	84	51	2 nd mens (322)
40	230					77	73	150	53	27	80	55	mother's wish (1)
44	164					53	54	107	42	15	57	66	horm contr (4)
48	106					33	35	68	27	11	38	58	pregnant (5)
52	65					21	22	43	13	9	22	41	lost to follow-up (5)
													other reasons (2)
													Σn=336

¹ Excl = exclusive

² mens = menstruation

³ horm contr = hormonal contraception

Missing data

Recording of type and frequency of feeding Occasionally mothers did not make records every day in a follow-up period. Missing data in the daily records amounted to 0.7% of the possible days, and those in the 24-hour detailed record 4%.

Recording of suckling duration The proportion of missing data for duration of night feeds in infants sleeping in their own bed varied from 0% to 1.2% in different 14-day periods. For infants with unrestricted access at night (co-sleeping), missing data varied between 7% and 37% in different 14-day periods. Between 7.6% and 14.5% of the exclusively breastfed infants co-slept frequently or daily with their mothers in each 14-day period.

Recording of anthropometric measurements The proportion of missing data in the fortnightly anthropometric measurements ranged between 0% and 21% (mean 6.9%). Adjustments were made for missing values for weight and length by linear interpolation.

Recording of morbidity It was considered that there were no missing data in the parents' recordings of illnesses. If illness was not recorded, the infant and mother were considered as healthy.

Ethical considerations

The study was approved by the Research Ethics Committee of the Faculty of Medicine at Uppsala University.

The present investigation

Study design, subjects, methods and procedures

An overview of the design in the different studies is shown in Table 2. In study 1 analyses were performed cross-sectionally at 8, 16 and 26 weeks and longitudinally from birth up to 8, 16 and 26 weeks. In studies II and III the data were again analysed both longitudinally and cross-sectionally. The cross-sectional analyses were performed during the first 26 weeks, based on 13-day recordings and 24-hour recordings. Studies IV and V are based on longitudinal analyses from birth.

Table 2. Design of the included studies.

		Birth	Adm -2 w	3- 4	5- 6	7- 8	9- 10	11- 12	13- 14	15- 16	17- 18	19- 20	21- 22	23- 24	25- 26	52- 54	
Study I	Cross-sectional <i>24-h period</i>					X				X					X		
	Longitudinal▶															
	▶															
Studies II + III	Longitudinal▶															
Studies IV + V	Cross-sectional <i>13-day period</i>		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Cross-sectional <i>24-h period</i>		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Longitudinal▶															

Entry= entry into the study

Comparison of 24-hour data on infant feeding with data since birth (Paper I).

In this study 493 infants were included in the analyses of the 24-hour “current status” data at week 8, 472 infants at week 16, and 401 infants at week 26. The same number of infants were longitudinally followed from birth up to these dates (Table 2).

A descriptive analysis (percentage) of the feeding pattern was used for comparison of the 24-hour data on infant feeding (current status) at 2, 4 and 6 months and the feeding data for the same infants for each day from birth to 2 months, 4 months and 6 months. The infants were allocated to one of the following categories: Exclusive breastfeeding, Predominant breastfeeding, Complementary / Replacement feeding, Not breastfeeding, and Stopped breastfeeding; for definitions see page 49.

An infant whose current status was categorised as “exclusively breastfed” was reported to have received nothing but breast milk during a specific 24-hour period; only vitamins, minerals and medicine were allowed in addition. An infant who was categorised as “exclusively breastfed since birth”, based on longitudinal data since

birth, had never received anything but breast milk (vitamins, minerals and medicine allowed), up to the age of 2, 4, or 6 months. As soon as the infant received anything but breast milk, even a teaspoonful of water, he/she was moved to another category.

Exclusive breastfeeding in practice and factors related to duration of exclusive breastfeeding as well as total breastfeeding duration (Papers II and III)

The breastfeeding pattern was investigated in the infants (n=430) who were exclusively breastfed from admission to the study (within 3-7 days after delivery). In each 14-day period (=one follow-up period), approximately 10-15% of the exclusively breastfed infants were given expressed breast milk. These infants were excluded from the analyses of the breastfeeding patterns during that follow-up period (unless otherwise stated), since the patterns can be affected when breastmilk is given in a different way than directly from the breast. Furthermore, the breastfeeding pattern was analysed in two subgroups, namely in the most extreme cases corresponding to the 3rd (n=12) and 97th (n=12) percentiles, among the infants who were exclusively breastfed at 2 weeks. The total breastfeeding duration was then analysed for all the infants included in the study (n=506).

Information on the type of feeding and the frequency of breastfeeding was obtained from the daily record charts, and that on the suckling duration and timing of night feeds was extracted from the 24-hour detailed record chart. The remaining data and information on background factors and the use of a pacifier and/or thumb sucking, were obtained at the fortnightly interviews.

To analyse the normalcy of the distribution of the breastfeeding variables, the Lilliefors, Shapiro-Wilk, and Kolmogoroff-Smirnoff tests were used. The Kaplan-Meier life-table was used to analyse the breastfeeding duration. Day-to-day variations in breastfeeding patterns were analysed by visual assessment. The association between breastfeeding frequency and breastfeeding duration was analysed by linear regression analysis. This method was also used to study the correlation between breastfeeding duration and socio-economic factors. To analyse differences between groups, the unpaired t-test, Chi-square, and Fisher's exact test were used.

Morbidity in the first year of life related to early infant feeding (Paper IV)

The analysis of the morbidity pattern in infants exclusively breastfed since birth included all infants who had only received breast milk during the first week of life (n=340), Table 1 and Table 2. They were followed up until they were no longer exclusively breastfed. The calculation of morbidity incidence rates and the multivariate analyses included all 506 mother-infant pairs.

The diagnoses of illnesses and symptoms in the infants were based on the fortnightly reports given by the parents. The diagnoses were classified as follows:

Respiratory illnesses and symptoms

a) Common cold

b) Respiratory illnesses and symptoms other than common cold, including otitis media, pneumonia, pertussis, throat catarrh, tonsillitis, laryngitis stridulosa, sinusitis, wheezing and bronchitis.

Gastrointestinal symptoms, including colic, stomach pain, diarrhoea, gastro-enteritis, vomiting.

Candidal infections, including candidiasis in the mouth and in the genitals.

Other viral/bacterial illnesses and symptoms, including conjunctivitis, virus infection, influenza, varicella, exanthema subitum, impetigo, urinary tract infection and general malaise with or without fever.

Allergic symptoms, including those of atopic eczema, urticaria, food allergy.

The following diagnoses were excluded because they could seemingly not be related to the feeding pattern: teething, complications of vaccinations, complications of medication, urgent surgical measures, and congenital illnesses. Physiological jaundice of the newborn was not considered, as there were too few cases (n=10).

The incidence rates of respiratory, gastrointestinal, viral/bacterial and allergic symptoms per 100 days were determined for all the infants in 3-month periods from birth up to 12 months of age: birth to 3 months, 4 to 6 months, 7 to 9 months and 10 to 12 months. For every 3-month period the sum (Σ) of the number of new events in that period was divided by (Σ time in days minus days of illness) x 100.

The multivariate analyses (n=506) involved measurements starting at birth and continuing to the end of the first year of life, with two break-down periods, from birth to 3 months and from birth to 6 months. The outcome variables that were processed were: common cold, respiratory symptoms other than cold, gastrointestinal symptoms, candidiasis, other viral/bacterial symptoms and allergic symptoms. Otitis media, which was included in the respiratory symptoms, was also analysed separately.

The independent variables included in the multivariate analyses were: number of days of exclusive breastfeeding since birth, number of days of breastfeeding, frequency of formula use (≤ 10 ml was not included), amount of time spent in the study, infant sex, birth weight, number of siblings, use of pacifier, reason for start of supplements, mothers' education and maternal smoking.

All analyses were adjusted for the effects of the independent variables listed above and all inferences were made at a 0.05 level of significance. However, in view of the multiplicity of the analyses the results at a <0.01 level of significance were considered to be the most strongly supported by the data.

Growth in the first year of life in relation to early infant feeding (Paper V)

A total of 472 infants at 16 weeks were included in the study (Table 1, p 26). Of these, 147 had been exclusively breastfed since birth and of the remaining infants 318 had received supplements since birth and seven had stopped breastfeeding.

The 147 infants exclusively breastfed since birth (79 boys and 68 girls) were divided into three groups, defined according to their birth weights: a) $<25^{\text{th}}$ percentile, b) between the 25^{th} and the 75^{th} percentiles and c) $>75^{\text{th}}$ percentile. Comparisons were made between these groups. All the 147 exclusively breastfed infants were then compared with the 325 infants (318 + 7). This latter group was subdivided into infants

who had received supplements irregularly (n=293, 152 boys and 141 girls), infants who had received formula regularly in addition to breast milk, at least once a day, between the ages of 12 and 16 weeks, and infants who had stopped breastfeeding (n=32, 22 boys and 10 girls).

The exclusively breastfed infants' mean weight and mean height increments as well as increment in per cent of birth weight were compared with the WHO "12-month breast-fed pooled data set" and with the data for the exclusively breastfed infants in the Euro-Growth study (Haschke et al. 2000, Nutrition Unit World Health Organization 1994). Further, the mean weight for age z score (WAZ), height for age Z score (HAZ) and weight for height z score (WHZ) relative to the NCHS/WHO Z score were calculated in EPINUT. The anthropometric data were calculated with the computer program Epi Info.

The infant's birth weight and birth length were taken from the records at the maternity ward. The infant's weight was recorded every fortnight, and its length and head and chest circumferences were recorded monthly. Weight and length adjustments were made for missing values by linear interpolation. Repeated-measures ANOVA was used to analyse differences between the growth pattern of the exclusively breastfed infants and that of the 325 infants who had received supplements before 16 weeks - 293 irregularly and 32 regularly. This latter group was small and the non-parametric Mann-Whitney exact test was therefore used. The computer programme Quest, SPSS 9.0, Epi Info 6.0 and the SAS software, version 6.12 were used for data analyses. All inferences were made at a 0.05 level of significance.

Results

Comparison of 24-hour data on infant feeding with data since birth (Paper I)

The results obtained from the analysis of "current status" data based on a single 24-hour recording of infant feeding and the analysis of data 'since birth' showed differences in the exclusive breastfeeding rate of more than 40 percentage points at both 2 and 4 months of age (92% versus 51% at 2 months and 73% versus 30% at 4 months) and of 9 percentage points at 6 months (11% versus 1.8%).

The single 24-hour data thus clearly overestimates the prevalence of exclusive breastfeeding compared to data since birth.

Exclusive breastfeeding in practice and factors related to duration of exclusive breastfeeding and total breastfeeding duration (Papers II and III)

The feeding pattern per 14-day period in all infants included in the total study material is seen in Figure 4. Wide variations in the breastfeeding frequency and suckling duration were found between different infants.

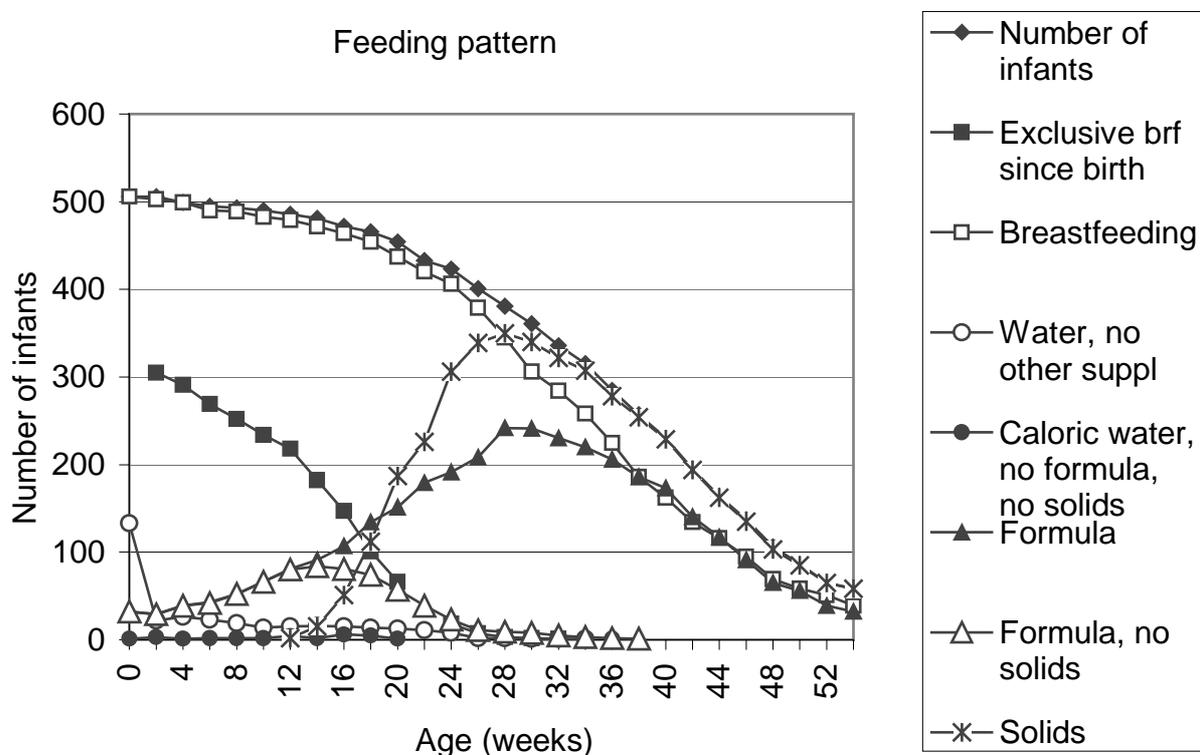


Figure 4. Number of infants and feeding pattern of all infants included in the total study material, per 14-day period. (brf: breastfeeding).

At 2 weeks, the mean frequency of daytime feeds in different infants ranged from 2.9 to 10.8 and that of night-time feeds from 1.0 to 5.1. The daytime suckling duration (based on one 24-hour record) ranged from 20 minutes to 4 hours 35 minutes and the night-time duration from 0 to 2 hours 8 minutes. At any given age, about 98% of the infants were breastfed during the night. Ninety-five per cent of the infants were breastfeeding at 4 months.

A longer breastfeeding duration and a longer duration of exclusive breastfeeding were both associated with a higher frequency of breastfeeds, longer breastfeeding of the previous child, and higher parental education. No gender differences were found. Maternal smoking was associated with a shorter duration of exclusive breastfeeding, but not with a shorter total breastfeeding duration. Frequent pacifier use was associated with fewer feeds and a shorter suckling duration per 24-hours, and a shorter duration of both exclusive breastfeeding and total breastfeeding. Thumb sucking did not influence the feeding pattern.

The main reasons given by the mother for introduction of supplements with the progression of the study were the following: water was given mostly due to warm weather or infant colic, Table 3. Formula was mainly introduced because the mother was temporarily absent or because the infant was not satisfied or was thirsty.

Table 3. Main reasons for introducing supplementation.

Reasons	Water/ caloric water	Formula	Solids
	%	%	%
Infant not satisfied *	55	14	7
Infant "old enough"		6	60
No weight gain		3	7
Infant sick	16	2	
To accustom or infant teaching		12	10
Weaning		6	4
Temporary absence of mother	1	18	
Mother wants the infant to sleep better		7	1
Not enough milk		5	1
Mothers decision		4	2
Mother wants to have more time		3	
Mother back to work		3	2
Mother needs more sleep		3	
Illness in mother		2	
Breast problems		2	

*includes: infant colic, infant thirsty, thirsty due to warm weather

Further, formula was given either to accustom the infant to the taste of formula or to a bottle-feeding as well as to initiate weaning or to stop breastfeeding. In 5% of the cases inadequate milk was mentioned as reason for formula feeding. The main reason for introducing of solids given by the mother was “infant old enough”.

Morbidity in the first year of life related to early infant feeding (Paper IV)

Nearly 30% of the infants who were exclusively breastfed since birth had various symptoms of infections, mainly common cold, during the first 2 weeks of life. The prevalence of these infections increased with age, despite continuation of exclusive breastfeeding. The incidence rates of respiratory, gastrointestinal, viral/bacterial and allergic symptoms increased over time. Common cold was the predominant symptom among all the infants, starting with an incidence rate of 2.02 in the neonatal period and increasing to 3.58 in the later part of the first year.

Increasing birth weight and increasing formula use were associated with an increasing likelihood of having symptoms of common cold and other respiratory illnesses, including otitis media. Exclusive breastfeeding and an increasing number of siblings were associated with a decreasing occurrence of symptoms of common cold in the age period 0-6 months. At ages 0-3 months, increasing pacifier use was associated with a decreasing occurrence of respiratory symptoms (other than common cold). However, at 0-6 months increasing pacifier use was associated with an increasing occurrence of viral/bacterial symptoms (other than respiratory) and with an increasing occurrence of candidiasis, the latter also at 0-12 months (Table 4).

Exclusive breastfeeding was thus shown to be beneficial for the health of the infant even in an affluent society. However, it was concluded that the health of newborn infants during the first year of life was associated with factors other than feeding practices alone. Increasing birth weight was associated with an increasing likelihood of having respiratory symptoms, even in exclusively breastfed infants, pointing to an impact of prenatal factors.

Table 4. Statistically significant relationships (+, -) between increases in the listed independent variables and infant morbidity, in the total study material, analysed in the periods 0-3 months, 0-6 months and 0-12 months. (+ increase in odds of having symptoms, - decrease in odds of having symptoms)

Independent variables	Respiratory symptoms						Other viral/bacterial symptoms						Candidiasis		
	Common cold			Respiratory symptoms other than cold			Otitis media								
	0-3	0-6	0-12	0-3	0-6	0-12	0-3	0-6	0-12	0-3	0-6	0-12	0-3	0-6	0-12
Birth weight	+	+		+	+	+		+	+						
Exclusive breastfeeding		-													
Formula		+	+						+						
Pacifier use				-							+			+	+
Maternal education															+
↑Siblings		-													

Growth in the first year of life related to early infant feeding (Paper V)

There were no statistically significant differences in the monthly weight increments in absolute figures between the three groups of infants, defined according to their birth weights, i.e. either among boys or girls. Only a statistically significant difference in length increment was noted in girls ($p=0.04$), with a smaller increment in those in the heaviest birth weight group. However, the monthly weight and length increments in the three groups in per cent of their birth weight and birth length showed statistically significant differences. The girls in the heaviest group had a smaller weight ($p=0.001$) and length ($p=0.003$) increase in per cent of their birth weight and birth length, respectively, compared to the girls in the two groups. The boys in the heaviest birth weight group ($>75^{\text{th}}$ percentile) showed a smaller weight increase in per cent of their birth weight ($p<0.000$) compared to the boys in the $<25^{\text{th}}$ percentile group. The comparisons were adjusted for mother's height.

No statistically significant differences in the development of either weight, length, head circumference or chest circumference were found between the boys and the girls in the exclusively and the non-exclusively breastfed group. Neither was there a

difference between the exclusively breastfed infants and the formula groups.

However, the girls in the formula group (n=10) were statistically significantly lighter (p=0.03) from birth up to 12 weeks and they had a significantly lower ponderal index (p=0.003) than their exclusively breastfed counterparts. No statistically significant differences in growth were found between infants who used a pacifier frequently and those who did not use a pacifier at all. Further, there was no statistically significant difference in birth weight or growth between the infants whose mothers smoked daily when the infant was 16 weeks old (n= 24) and the infants of non-smoking mothers.

Comparisons of the mean monthly growth increments in the exclusively breastfed infants with the WHO “12-month breast-fed pooled data set” and the Euro-growth reference for exclusively breastfed infants showed fairly similar patterns. When the mean increments on the infants were related to their birth weight and birth length, the growth of the Uppsala infants was slightly smaller than that of the infants in the WHO “pooled data set” and the Euro study.

The exclusively breastfed infants, both boys and girls started at a z score of around +1 SD of the NCHS/WHO reference for weight and at a z score of just above 0 SD for length and then showed a gradual and steady decline in both weight and length relative to the standard throughout the follow-up period. This trend seemed to continue all the way up to the 12th month, although the latter part of the curve is based on fewer children on account of drop-outs. The mean weight in the boys dropped below the NCHS/WHO mean at about week 34, while that in the girls remained above the standard mean with increasing age.

Exclusively breastfed infants seemingly have the same growth as non-exclusively breastfed infants with a high breastfeeding rate. The monthly growth increments were fairly similar to those of the WHO “pooled breastfed data set” and the Euro-growth references for exclusively breastfed infants.

Feeding pattern related to growth and morbidity

In an attempt to shed light on the intricate interaction between the different factors and determinants involved in the process of infant feeding, some case studies are presented below.

Case studies

The association of frequency of feeds with growth and morbidity was investigated in infants displaying extreme patterns (Paper II): One male infant with the consistently highest frequency of feeds at 2 weeks of age (infant A) was compared with another male infant with the lowest frequency of feeds (infant B). Likewise, a girl with the consistently lowest frequency of feeds (infant C) was compared with her female counterpart with the highest frequency of feeds at 2 weeks of age (infant D).

Infant A, with an average of 15 feeds per 24-hour period at 2 weeks, had a mean suckling duration of 13 minutes in the daytime and 32 minutes at night time, Figure 5.

He had periods with colds at the same time as his mother, as early as at the age of 3 weeks and thereafter throughout the follow-up period which lasted 11 months. In addition he had pertussis at the age of 10 months. It is reasonable to suggest that this in the Swedish context extremely high frequency of feeds might have been due to the extended periods of infections. For example, he and his mother both had a cold between day 62 and day 104, and on day 119 (at 4 months) his mother had throat catarrh. Thereafter the child had a cold between days 124 and 128. The child was exclusively breastfed on demand from birth up to 5.5 months, when solids were introduced.

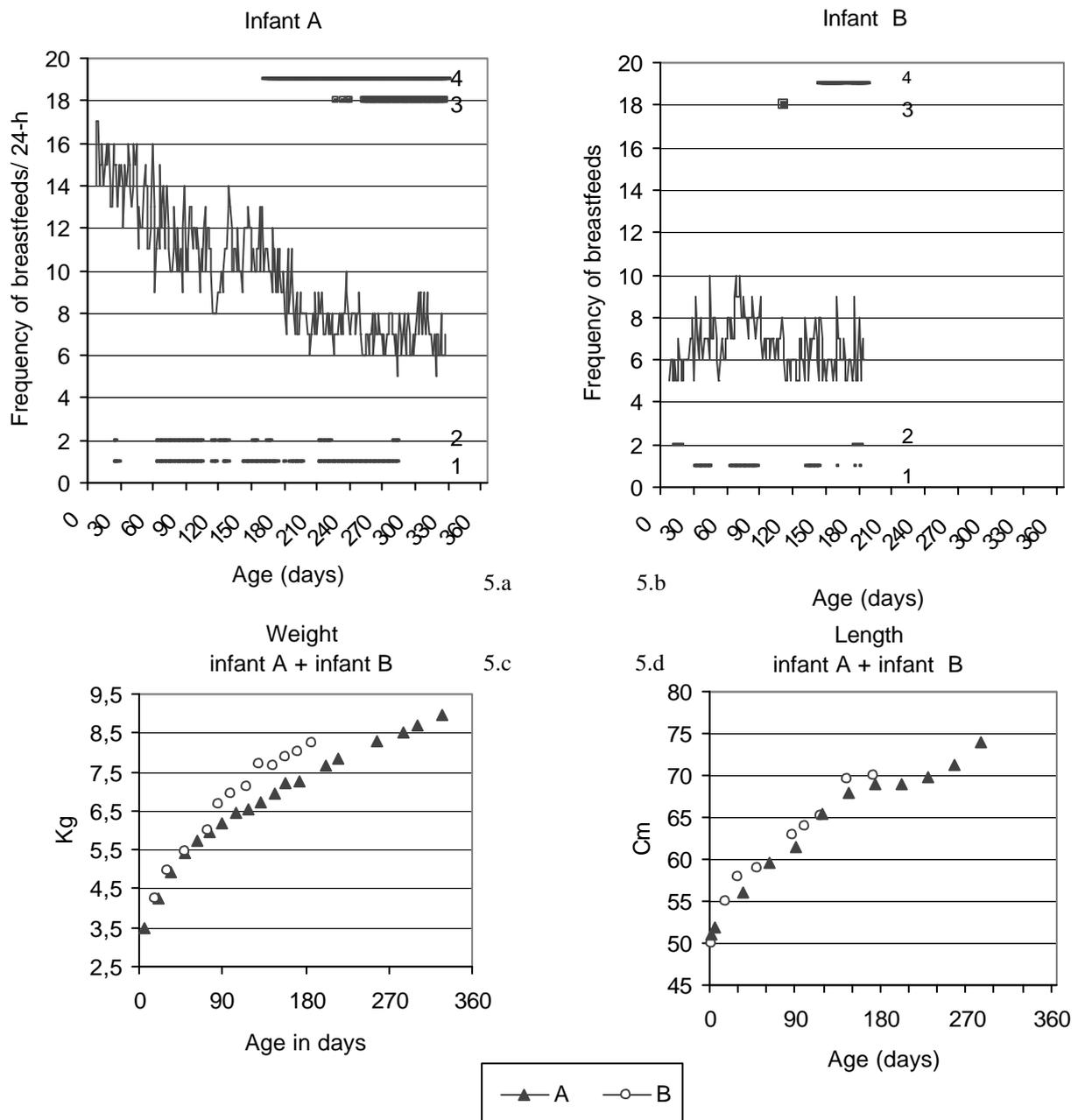


Figure 5. Day-to-day variation in the number of feeds per 24 hours, related to infant and maternal morbidity (5a+5b) and growth (5c and 5d) in one of the exclusively breastfed boys (infant A) with the highest frequency of feeds at 2 weeks and in one of the exclusively breastfed boys (infant B) with the lowest frequency of feeds at 2 weeks of age. Explanation of numbers: 1) infant ill; 2) mother ill; 3) infant formula; 4) solids/semi-solids

The reason given by the mother for introduction of solids was that he was old enough. He often co-slept with his mother and he sucked a pacifier from 5.5 months onwards. He received a follow-on formula once a day from the age of 8.5 months, because his parents wanted him to sleep through the night. His participation in the study was discontinued at 11 months, by which time he was breastfed about 7 times a day.

Infant B had an average of 5.3 feeds at 2 weeks of age and a mean suckling duration of 22 minutes in the daytime, and 11 minutes at night. The mean frequency of feeds per 14-day period slightly increased and remained about 5 to 7 feeds per 24 hours. During the first 60 days the growth pattern of infant B was fairly similar to that of infant A, Figure 5. Infant B also had many periods of colds, as well as having pertussis at 2.5 months, which was reflected in the dip of the weight curve and probably, somewhat later, in the length curve. After that time he seemed to show a catch-up growth, both in weight and length compared to infant A. He was exclusively breastfed on demand during the first 145 days (4.5 months), with one exception when 50 ml of formula on one occasion only, on day 110. The reason for this was that the mother did not have enough milk. He started with tastes of solids because he was considered old enough. He did not suck a pacifier. They discontinued participation in the study at 6 months as they were moving abroad.

Infant C had an average of 5.5 feeds per 24-hour period at 2 weeks, and a mean suckling duration of 23 minutes in the daytime and 13 minutes at night, Figure 6. She and her mother suffered from colds now and then throughout the follow-up period. This is not reflected in the feeding or growth pattern. The girl had received some water during the first days of life and thereafter was exclusively breastfed on demand for 4 months. She was given tastes of semi-solids/solids between 4 and 6 m. These were introduced because she was considered old enough. She never sucked a pacifier. At 7.5 months the mother started to give her follow-on formula irregularly, because the infant woke up early in the morning. At the same time the mother had a cold. At 8 months the child got a cold and she received follow-on formula regularly once a day. The mother stopped breastfeeding at 9 months because the "infant became hungry again soon after a breastfeed".

The growth pattern of infant D was fairly similar to that of infant C. Infant D had an average of 11.2 feeds per 24 hours at 2 weeks of age and a mean suckling duration of 15 minutes in the daytime and 23 minutes at night, Figure 6. The frequency of feeds remained at that level during the first 9 months, 11-12 feeds per 24 hours. The infant was breastfed on demand and did not suck a pacifier. She started with tastes of solids at about 5 months and was breastfed for 15.5 months.

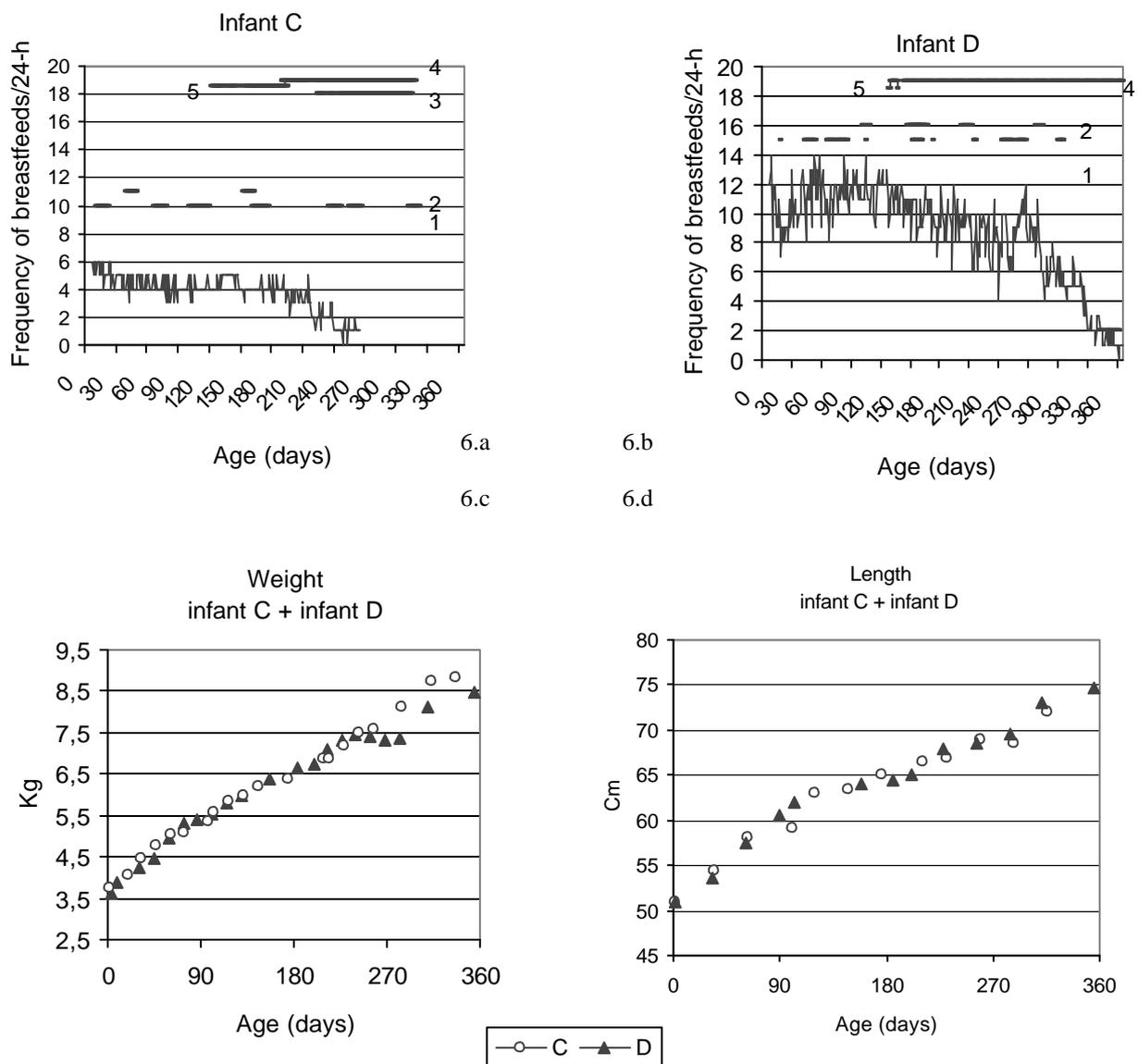


Figure 6. Day-to-day variation in the number of feeds per 24 hours, related to infant and maternal morbidity (6a+6b) and growth (6c and 6d) in one of the exclusively breastfed girls (infant C) with the lowest frequency of feeds at 2 weeks and in one of the exclusively breastfed girls (infant D) with the highest frequency of feeds at 2 weeks of age. Explanation of numbers: 1) infant ill; 2) mother ill; 3) infant formula; 4) solids/semi-solids; 5) tastes of solids/semi-solids

Infant E, a boy, suffered twice from otitis media while being exclusively breastfed from birth, Figure 7. He suffered a cold in the second week of life while his mother had acute sinusitis. He and his mother both had a new cold on day 38, and on day 44 the infant developed otitis media, which was treated with antibiotics. This treatment resulted in 9 days of diarrhoea. He had another cold at 3 months of age, on day 96 (in

the winter, November) and suffered from otitis media 2 days later. He received antibiotic treatment between days 102 and 109, after which the mother had engorgement. The infant received another antibiotic course on days 114-121. The second otitis media would obviously seem to be reflected in the increased number of feeds. The pattern was repeated again between days 219 and 244. During this time the mother had tonsillitis which required antibiotic treatment. The infant was also given antibiotic treatment at the same time. Following this both the mother and the infant got gastroenteritis after which the mother had engorgement again, on days 242 to 244. Once again these events seem to be reflected in the increased number of breast feeds. The breastfeeding was stopped somewhat later on grounds that the infant refused the breast.

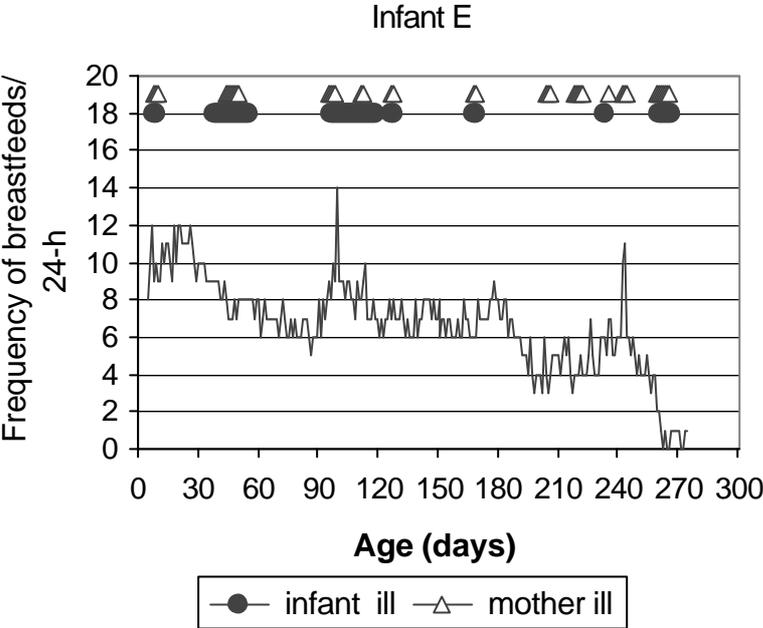


Figure 7. Day-to-day variation in the number of feeds per 24 hours in one of the exclusively breastfed boys, related to infant and maternal morbidity.

These cases clearly illustrate the complexity of the process of infant feeding. The pattern of feeding is closely related to the health and growth of the infant, at the same time as these in turn influence the pattern of feeding. These cases also illustrate the possible impact of the health of the mother (and probably also that of the siblings) on the pattern of feeding of the index child.

Summary of the results

The present thesis has shown the importance of using strict definitions of what constitutes exclusive breastfeeding and how it is measured. Wide variations in the feeding pattern between individual infants were seen. However, feeding patterns, growth and morbidity have a complex interplay.

Infants who are truly exclusively breastfed from birth do suffer infections, but are less likely to do so than infants who receive formula in addition to breast milk, even in a highly affluent society. Increasing use of formula was associated with an increasing likelihood of common cold and other respiratory illnesses, including otitis media. However, the health of newborn infants during the first year of life is associated with factors other than feeding practices alone. These factors may be partly prenatal, since increasing birth weight was associated with an increasing likelihood of suffering respiratory symptoms, even in exclusively breastfed infants. The growth of exclusively breastfed infants was similar to that of infants who were not non-exclusively breastfed.

There was an association between longer duration of exclusive breastfeeding as well as longer total breastfeeding duration and higher frequency of breastfeeds, no use of pacifier, longer breastfeeding of previous child and higher maternal education. Maternal smoking was associated with a shorter duration of exclusive breastfeeding. No gender differences were found to be related to the variables studied.

Discussion

The aim of the present study was to explore the concept of exclusive breastfeeding, to examine the question of how this feeding should be assessed, and to compare daily feeding practices and the health and growth outcome in carefully defined exclusively breastfed and non-exclusively breastfed infants.

An excellent opportunity to elucidate these issues was offered by this cohort of mothers with breastfeeding experience, who were willing to breastfeed the index child for at least 6 months. Careful data were obtained regarding health and growth in infants in whom the exclusiveness of breastfeeding and the occurrence of illness since birth had been ascertained, and at the same time in whom the timing of and the reasons for introduction of supplements had been recorded. Now that such a cohort was available, the following question, among others, was raised: Does it make any difference regarding the health and growth of the infant in an affluent society, whether the infant is breastfed exclusively from birth or breastfed while receiving irregular supplementation? To answer this question reliable methodology is required. Hence, the question arises: How do rates of exclusive breastfeeding obtained by the 24-hour “current status” method compare with exclusive breastfeeding rates obtained from data “since birth”? A further question is: Do possible discrepancies between the two methods have any impact on the interpretation of data on the health and growth of infants?

The validity of data on exclusive breastfeeding based on single 24-hour periods has been questioned previously (Auerbach et al. 1991, Bauchner et al. 1986, Labbok & Krasovec 1990, Cattaneo et al. 2000, Zohoori et al. 1993). The present study showed wide discrepancies between the rates of exclusive breastfeeding obtained in the two different ways - the widely used 24-hour “current status” method and data recorded “since birth”. This underlines the importance of the application of consistent and accurate definitions and methods for assessment of infant feeding. Without such uniform methodology it is difficult to compare the possible effects of different patterns of early feeding on various outcomes. Since the methods and procedures in different studies vary considerably, hitherto published data regarding exclusive breastfeeding and health outcomes are difficult to interpret.

Exclusive breastfeeding since birth - does it make a difference?

No difference was found in the total breastfeeding duration between infants who had received supplementation during the first week of life, those who had received formula irregularly and those who had been exclusively breastfed since birth. This leads us to conclude that irregular supplementation does not seem to influence the breastfeeding duration, at least in our population. This finding is at variance with results from other studies, in which a shorter breastfeeding duration has been found in relation to early supplementation (Blomquist et al. 1994, Riva et al. 1999).

Increasing use of formula was associated with an increasing likelihood of suffering respiratory tract infections, including otitis media. Formula given on an irregular basis would be missed in the 24-hour "current status" analysis, but not in the analysis "since birth". The discrepancies in the rates of formula given at 2 months and at 4 months using two methods were of the order of 12 and 15 percentage points, respectively, in the present study. This would mean that the "current status" data overestimate the relative number of exclusively breastfed infants and underestimates that of infants who have received formula. Consequently, the 24-hour method might overestimate the rate of infections related to formula.

We were unable to analyse the possible association between supplementation only with water or solids and the occurrence of morbidity. This was not included in the multivariate analyses as supplementation with water alone occurred mostly during the first weeks of life. No statistically significant difference in the morbidity pattern was seen between the exclusively and the non-exclusively breastfed infants during the first 2 weeks of life, except for physiological jaundice. Those receiving supplementation were probably given this because they were jaundiced.

The recommendation for the timing of introduction of solids or semi-solids was (and still is) between 4 and 6 months. If solids were introduced before the age of 4 months, in our infants, the introduction occurred just before this period and solids were introduced only in very small amounts, <2 teaspoons over a longer period of time with the progression of the follow-up.

There were no differences in growth pattern in the present study between the infants who were and those who were not exclusively breastfed since birth. This conforms with observations made by others (Martines et al. 1994, WHO Working Group on the Growth Reference Protocol and the WHO Task Force on Methods for the Natural Regulation of Fertility, 2000). Consequently, the discrepancy between the two methods of obtaining data on exclusive breastfeeding seemingly is not reflected in the data regarding the growth of the infant. The absence of a difference in growth pattern probably reflects the high breastfeeding rate in the present study, the availability of safe water and the fact that the parents were well educated.

These analyses lead us to conclude that the discrepancy between the two different ways of analysing the exclusive breastfeeding rate does not seem to influence the interpretation of the breastfeeding duration, nor does it seem to be reflected in the data on the growth of the infant in a population with a high breastfeeding rate. However, the 24-hour method would underestimate formula use and hence may overestimate the link between formula use and morbidity.

Exclusive breastfeeding in practice

Wide differences in the feeding frequencies between individual mother/infant pairs were seen. The case studies, however, clearly demonstrate that infant feeding is the result of a complex interplay of a variety of factors. These individual feeding patterns need to be considered in parallel with the growth and morbidity patterns of the infant. Appropriately, the whole family picture needs to be taken into account. Mother-infant

pairs do have individual breastfeeding styles which vary widely and which are influenced by biological, social and cultural forces (Quandt 1986, Quandt 1995, Woolridge, 1995). In the present study a significant proportion of the reasons for introducing formula were conditions around the mother and her circumstances, where solids were mainly given because the child was thought to be old enough.

The duration of exclusive breastfeeding was negatively associated with pacifier use and maternal smoking. The total breastfeeding duration was positively associated with the frequency of feeds, previous breastfeeding experience, and maternal age and educational level, but negatively with pacifier use. These findings are in accordance with observations by others (Clements et al. 1997, Diaz et al. 1995, Ford et al. 1994, Riva et al. 1999, Sjölin et al. 1977, Victora et al. 1997, Vogel et al. 1999). Although the Swedish population is generally regarded as having a high educational level, and the socio-economic conditions in the country are considered to be fairly homogeneous, we still found an association between educational level and breastfeeding duration, in conformity with other reports.

We observed an increase in the total breastfeeding duration with the progression of the study, as seen in the whole of Sweden during the same period (The National Board of Health and Welfare 2000). This increase occurred in parallel with changes in infant feeding routines at the maternity wards, since a decline in supplementation of infant feeds during the first week of life was noted during the course of the study. There was also a tendency towards diminished or postponed introduction of formula during this period (Hörnell et al. 2001). These changes may have been partly due to the promotion of the Baby Friendly Hospital Initiative, launched in Sweden in 1992, which led to a debate on the benefits of breastfeeding and in connection with which an increase in the breastfeeding education of health personnel took place. However, there was a concomitant debate about the possible causes of the sudden infant death syndrome (SIDS), in which the advantages of breastfeeding in the prevention of SIDS were being highlighted (Haglund & Cnattingius 1990). This phenomenon may have strongly influenced the drive for increased and more intensive breastfeeding. The issue of SIDS subsequently led to the recommendation that the sleeping position of infants be changed, from sleeping on the stomach to sleeping on the back (The National Board of Health and Welfare, 1992 revised 1994).

The association between a shorter breastfeeding duration and frequent pacifier use may reflect the parents' intention to reduce the number of breastfeeds by giving a pacifier frequently. We did not ask the parents why a pacifier was given. To be able to draw further conclusions about pacifier use a more explorative study design is needed, as in one study in Brazil (Victora et al. 1997).

Morbidity in the first year of life

The occurrence of symptoms of infections in exclusively breastfed infants gives us reason to take into consideration factors other than nutrition in the causation of morbidity at this early age. The finding of a positive association between an increasing birth weight and an increasing likelihood of respiratory illnesses was unexpected and

is a further indication of the possible role of non-nutritional factors in the modulation of the immune system in the prenatal period. An association between increasing morbidity and increasing birth weight has been reported in relation to atopic dermatitis, atopic eczema and allergy (Buhrer et al. 1999). The same pattern has been described regarding increased morbidity in relation to obesity, both in infants and adults (Chandra 1980, Figueroa-Munoz et al. 2001, Stallone 1994).

The likelihood of occurrence of common cold decreased with increasing duration of exclusive breastfeeding. Conversely, and in conformity with other studies, increasing formula use was associated with an increasing likelihood of respiratory symptoms. This is in conformity with other studies (Aniansson et al. 1994, Raisler et al. 1999, Scariati et al. 1997). These associations were maintained even when consideration was paid to the reasons for introducing formula, which strengthens the contention that breastfeeding protects the infant from infections in a pattern suggestive of a dose-response effect, as described by others (Raisler et al. 1999, Scariati et al. 1997). Possible negative effects of breast milk substitutes on the intestinal flora, the intestinal permeability or the immune system cannot be precluded (Stinzing & Zetterström 1979).

In contrast to some reports (Aniansson et al. 1994, Raisler et al. 1999), we found that an increasing number of siblings was associated with a decreasing occurrence of common cold. An inverse association between number of siblings and occurrence of hay fever and atopic diseases has been reported, and this finding has led to a debate regarding the possible negative effects of excessive protection from agents that may help to enhance the immunological competence of the infant. The increasing prevalence of asthma and atopic diseases in recent decades has been partly linked to the diminished rates of infections, which may have deprived the infant of the promotion of enhanced immunological competence (Bodner et al. 1998, Strachan 1989, von Mutius et al. 1994, Illi et al. 2001). If this hypothesis holds true, the increasing occurrence of asthma and atopic diseases in affluent societies in relation to exclusive breastfeeding will constitute a challenging area for future research.

The association between increasing pacifier use and decreasing occurrence of respiratory symptoms in the age range 0-3 months, and the reversed association between increasing pacifier use and increasing occurrence of viral/bacterial infections in the age range 0-6 months, are difficult to explain on the basis of this study, since we did not look at the reasons why parents gave their infants a pacifier.

In contrast to other reports, we did not find an association between pacifier use and increased likelihood of otitis media (Jackson & Mourino 1999, Niemela et al. 1995, Niemelä et al. 2000, North et al. 1999). In a study from the UK, increased earache was found to be related to pacifier use during the first 6 months of life, with the results adjusted for breastfeeding duration. A similar observation has been made in the US (North et al. 1999) in infants 12 months of age or younger, where the data were also adjusted for bottle feeding. The findings in two Finnish studies confirm these relations, although their infants were older than ours (Niemela et al. 1995, Niemelä et al. 2000).

Growth related to early feeding

The fact that exclusively breastfed infants showed the same growth as infants that were not exclusively breastfed may partly be due to the high breastfeeding rates in the latter breastfed group. This similarity between the groups conforms with the results of a study by the WHO Working Group on the Growth Reference Protocol, in which the growth patterns of the infants in the seven countries included in the collaborative WHO project (of which the present study was part) were compared. Adjustments for infant feeding pattern and maternal height led to only a very slight reduction in the inter-site differences in weight and height (WHO Working Group on the Growth Reference Protocol and the WHO Task Force on Methods for the Natural Regulation of Fertility, 2000).

Unfortunately, in the present study the drop-out rate was high during the second half of the first year, as a result of the study design, and a comparison between the formula group and the other groups was not considered reliable after 26 weeks. Many studies have shown a more rapid growth in formula-fed infants, especially in the second half year of life, than in breastfed infants (Waterlow & Thomson 1979, Ahn & Maclean 1980, Dewey et al. 1995). Out of the ten girls in our study who regularly received formula in addition to breast milk, seven had a lower birth weight and a lower ponderal index at birth than the other girls. In the ten girls formula was introduced early and the following reasons were given by the mothers for introducing formula: 2 infants did not gain enough weight, in 7 cases the mother was sick (cold, gastritis, engorgement, sinusitis, cholecystectomy) and did not have enough milk, and one infant "did not want to have the breast". However, the weight and height increments of these ten girls did not differ from those of the others, probably as a result of the supplementation they received.

A so-called "growth spurt" during the second half year of life that we document in the present infants is in conformity with the WHO "12 months breast-fed pooled set", although in the present study the growth spurt was seen earlier. This might be due to methodological differences between the different studies. In the literature several growth spurts were said to occur during the first year (Neville & Neifert 1983, Kitzinger 1990). We observed one such spurt. This growth spurt in the second half of the first year of life might be explained by changes in the feeding pattern or may simply reflect the pattern of normal growth (Karlberg 1989, Liu et al. 1989)

Methodological considerations

Several methodological issues need to be considered in the interpretation of the present data, as the main collaborative WHO project of which this study is part was primarily not designed for the aims of this study. The infant-mother pairs included in the study may not be fully representative of the Swedish population, partly for the reason that newborns with a birth weight below 3,000 grams were excluded; further, all mothers had at least one child before the index child which was breastfed for at least 4 months, and the mothers were willing to breastfeed the index child for at least 6 months. These special characteristics of the study caution against unqualified generalisation to the

entire population. Nevertheless, it may be said that by virtue of the fact that this was a population-based study we obtained optimal data from a group of mothers who were highly motivated to breastfeed.

A limitation of the design was that the mothers left the study after their second menstruation after the current delivery. The onset of the return of menstruation varied greatly, which limited the possibility of following the mother-infant pairs beyond that study endpoint.

Perhaps one of the greatest strengths of the study is the fact that the data were obtained on a longitudinal prospective basis, through daily recordings. The fortnightly home visits with interviews by the same research assistant made it possible to get to know the parents and through questioning and observations we could assess whether the information was likely to be accurate. All assistants judged the mothers to be trustworthy and the reliability of the records was considered good. Missing data were few. A team leader and supervisor checked to see that the anthropometric measurements were performed accurately and the equipment was calibrated regularly.

Further research

Understanding the parents' perspectives and concerns regarding exclusive breastfeeding, and their attitudes in respect to a range of related issues, such as pacifier use, constitute future challenges for research. Similarly, the importance of prenatal factors, including birth weight, for subsequent health and growth, and of factors that may be linked to the prevalence of allergy in relation to early feeding patterns, remain to be investigated.

Conclusions

Our study clearly underlines the complexity of the process of infant feeding (Fig. 8). The pattern of feeding, reflecting the mother-infant interaction, is closely related to the health and growth of the individual infant, as well as to the health of the mother, at the same time as these in turn influence the pattern of feeding. Behind all this looms the society and the cultural as well as institutional context in which the mother-infant dyad finds itself. Using a strict definition of exclusive breastfeeding from birth and taking into account the reasons for giving complementary feeding, the study shows that even exclusively breastfed infants sustain infections early in life. At the same time, truly exclusively breastfed infants seem less likely to suffer infections than infants who receive formula in addition to breast milk, even in a highly affluent society. The health of newborn infants during the first year of life is associated with factors other than feeding practices alone. Some of these factors may be prenatal, since increasing birth weight was related to an increasing likelihood of having respiratory symptoms even in exclusively breastfed infants. Despite this, the study provides a basis for continued promotion of exclusive breastfeeding even in affluent societies.

Cultural and institutional environment

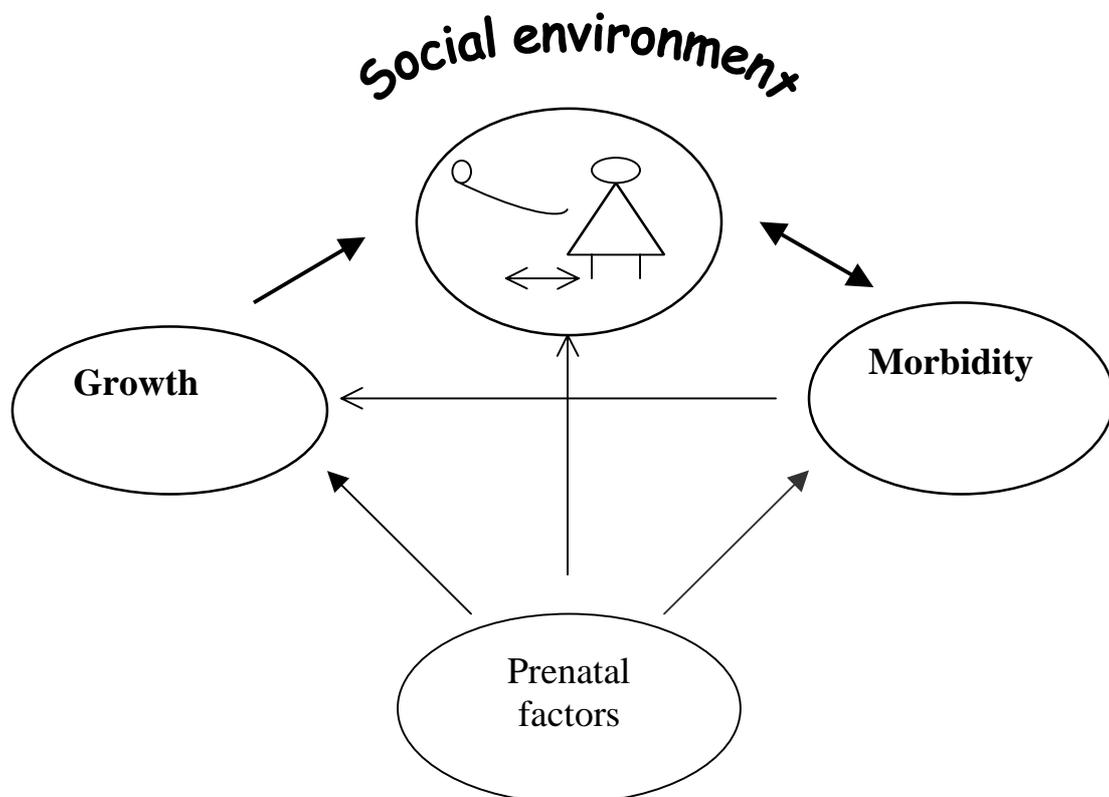


Figure 8. Factors found to influence breastfeeding behaviour

Definitions

One breastfeeding episode. Duration of suckling 2 minutes or longer and separated from previous breastfeed by at least 30 minutes. Suckling for less than 2 minutes was not recorded.

Expression of breast milk. Duration of expression 2 minutes or longer and separated from a breastfeed by at least 30 minutes. Expression for less than 2 minutes was not recorded.

Expressed breast milk (EBM). Mother's own breast milk given to the infant by other means than suckling (i.e. with spoon, bottle, cup, or other).

Taste. ≤ 10 ml of any liquid or food

Meal. >10 ml of any liquid or food

Daytime. 06.00 - 21.59.

Night-time. 22.00 - 05.59.

Feeding on demand. The mother feeds her baby whenever it cries or indicates by some other means that it is hungry.

Infant feeding categories. The criteria of the World Health Organisation (WHO) for allocation to infant feeding categories were used **Fel! Bokmärket är inte definierat.** The criteria were originally intended for cross-sectional surveys using 24-hour recall.

Exclusive breastfeeding. The infant receives breast milk (including expressed milk or milk from wet nurse) and is allowed to receive drops and syrups (vitamins, minerals, medicines). The infant may not receive anything else.

Predominant breastfeeding. The infant receives breastmilk and is allowed liquids (water and water-based drinks, fruit-juice, oral rehydration salt [ORS], ritual fluids, and drops or syrups (vitamins, minerals, medicines). Is not allowed anything else (in particular, non-human milk- or food- based fluids).

Complementary feeding. The infant receives breast milk and solid or semi-solid foods. Is allowed any food or liquid, including non-human milk.

Breastfeeding plus formula. The infant receives breast milk, formula and/or gruel, but no solid or semi-solid foods.

Abbreviations

<i>CDC</i>	<i>Centres for Disease Control and Prevention</i>		
<i>EBM</i>	<i>Expressed Breast Milk</i>	<i>WHA</i>	<i>World Health Assembly</i>
<i>IBFAN</i>	<i>International Baby Food Action Network</i>	<i>WHO</i>	<i>World Health Organisation</i>
<i>ILO</i>	<i>International Labour Organisation</i>	<i>WAZ</i>	<i>Weight for Age Z-score</i>
<i>LLLI</i>	<i>La Leche League International</i>	<i>HAZ</i>	<i>Height for Age Z-score</i>
<i>ILCA</i>	<i>International Lactation Consultant Association</i>	<i>WHZ</i>	<i>Weight for Height Z-score</i>
<i>NHANES</i>	<i>National Health and Nutrition Examination Survey</i>		
<i>NCHS</i>	<i>(United States) National Centre for Health Statistics</i>		
<i>ORS</i>	<i>Oral Rehydration Salt</i>		
<i>SigA</i>	<i>Secretory Immunoglobulin A</i>		
<i>SIDA</i>	<i>Swedish International Development Authority</i>		
<i>SIDS</i>	<i>Sudden Infant Death Syndrome</i>		
<i>USAID</i>	<i>United States Agency for International Development</i>		
<i>WABA</i>	<i>World Alliance for Breastfeeding</i>		

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