THE QUANTITY AND QUALITY OF BREAST MILK

Report on the WHO Collaborative Study on Breast-feeding

WORLD HEALTH ORGANIZATION
GENEVA

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Participants in the WHO Collaborative Study on Breast-feeding: second phase

Guatemala

Dr O. Pineda, Institute of Nutrition for Central America and Panama (INCAP), Guatemala
Dr J. J. Urrutia, Ms B. Garcia

Hungary

Principal investigator
Dr I. Öry, Head, Department of Mother, Child, and Youth Care, Ministry of Health, Budapest

Chief collaborators
Dr P. Cholnoky, Head Paediatrician, General Hospital, Szombathely
Dr Ö. Gaál, Department of Food Chemistry, National Institute of Food and Nutrition, Budapest

Clinical work
Dr M. Csaszar, Miss J. Ács, Mrs M. Csiza, Mrs V. Markóczy

Philippines

Principal investigator
Dr Virginia B. Guzman, Department of Community Health, Institute of Public Health, University of the Philippines System, Manila

Biochemical studies
Manuel P. Macapinlac, Department of Biochemistry, College of Medicine, University of the Philippines System, Manila

Field directors
Lilia V. del Castillo, Department of Community Health, Institute of Public Health, University of the Philippines System, Manila
Theresita R. Lariosa, Department of Community Health, Institute of Public Health, University of the Philippines System, Manila

Biostatistician
Susie Ignacio Morelos, Chief, Biostatistics Section, Department of Epidemiology and Biostatistics, Research Division, Philippine Heart Center for Asia, Quezon City

Sweden

Principal investigator
Professor Y. Hofvander, Department of Paediatrics, University Hospital, Uppsala

Clinical work
U. Hagman, The Swedish National Food Administration, Stockholm

Laboratory work
G. Fransson,[1] Professor L. Hambraeus,[1] H. Jonsson,[2] B. Larsson,[2] C. E. Linder,[2] R. Ras,[2] S. A. Slarach,[2] L. Wahlberg[1]

Zaire

Principal investigator
Professor H. L. Vis, Institute of Scientific Research, Kinshasa; Department of Paediatrics, Free University of Brussels, Brussels, Belgium

Clinical work
P. Hennart, Field Director, Zaire Institute of Scientific Research, Kinshasa. Ruchababisha-Migabo and Nyampeta Uwaytu

Biochemical studies
I. Mandelbaum, Director, Paediatrics Laboratory, St. Peter's Hospital, Free University of Brussels, Brussels, Belgium
Eugenia Colombara, P. Devroede, Agnès Vuye, and Nadine Herremans, Free University of Brussels, Brussels, Belgium
Mrs J. Delonge-Desnoeck, Laboratory Technician, Unit of Reproductive Endocrinology, Free University of Brussels, Brussels, Belgium
Dr A. Heyndrick, Director, Laboratory of Toxicology, Ghent University, Ghent, Belgium

---

[1] Institute of Nutrition, Uppsala University, Uppsala.
[2] The Swedish National Food Administration, Stockholm

Dr C. Robyn, Head, Unit of Reproductive Endocrinology, Free University of Brussels, Brussels, Belgium
N. Sookvanchsilp, Pharmacist, Laboratory of Toxicology, Ghent University, Ghent, Belgium
M. Warnez, Pharmacist, Laboratory of Toxicology, Ghent University, Ghent, Belgium

Consultants

Mr W. Z. Billewicz, Medical Research Council, Reproduction and Growth Unit, Newcastle-upon-Tyne, England
Dr L. Hambraeus, Institute of Nutrition, Uppsala University, Uppsala, Sweden

International Atomic Energy Agency

Dr R. M. Parr, Department of Research and Isotopes, IAEA, Vienna, Austria

WHO Secretariat

Dr M. Béhar, Nutrition, Division of Family Health, Geneva
Dr M. Carballo, Maternal and Child Health, Division of Family Health, Geneva
Dr E. M. DeMaeyer, Nutrition, Division of Family Health, Geneva, (*Study coordinator*)
Mr P.-C. Kaufmann, Health Statistical Methodology, Division of Health Statistics, Geneva
Dr A. Petros-Barvazian, Division of Family Health, Geneva

Contents

1. Introduction

The desirability of a multinational study on breast-feeding was advanced by the Thirteenth International Paediatric Congress in Vienna in 1971, and in the following year, a colloquium arranged by the International Children's Center in Abidjan recommended, *inter alia*, that WHO should play a leading role in the organization of such a study. It was also recommended that the latter should be carried out in two phases—the first dealing with the prevalence and duration of breast-feeding, and the second with the volume and composition of breast milk. In early 1973, WHO decided to implement these recommendations, the first phase of the study being initiated shortly thereafter. This phase was completed in 1976, and the results were published by WHO in 1981 in a book entitled *Contemporary patterns of breast-feeding* (*21*). Thereafter, plans were made to initiate the second phase to investigate more specifically the volume and composition of breast milk. This second study, the results of which are presented in this book, was timely in view of the questions that have been raised in recent years concerning the adequacy of breast-feeding by mothers living in the developing world, in circumstances that are not always conducive to the best nutritional status and the best physiological performance of the mothers.

It has been known for some time that mothers in developing countries tend to produce less milk than mothers living in developed countries. On the other hand, most of the information collected so far indicates that any differences in the composition of breast milk that may exist between mothers living in developed countries and those living in developing countries, do not modify significantly the nutritive value of the milk, especially its energy value. Most of this information, however, has been collected using different methods and is not strictly comparable; it is therefore of doubtful value. In order to be able to compare data from different parts of the world, it has been stressed repeatedly that the methods used by different investigators should be rigorously standardized. The same applies to the determination of the various components of breast milk, and is particularly important with regard to the determination of trace elements. It is only by such rigorous standardization of methods that it will become possible to compare data on breast-milk quantity and quality from different races living under different ecological and

socioeconomic conditions and, presumably, of different nutritional backgrounds.

This volume reports the results of the study concerning the quantity of breast milk, its composition in protein and non-protein nitrogen, lactose, fat, lactalbumin and lactoferrin, vitamin A, and vitamin C and the levels of pesticides present in the breast milk. The results of mineral and trace element determinations in breast milk will be reported in a subsequent volume.

It is a common observation that children in developing countries have a growth rate similar to that of children in developed countries up to the age of 3–4 months. Thereafter, their growth curves tend to flatten and diverge from those of children in developed countries. This observation has led many people to question the adequacy of breast-feeding after 3 months of age in developing countries—because either the volume of milk might be insufficient or its nutrient composition might be inadequate. The study reported here of lactating mothers living in contrasting socioeconomic conditions and in different geographical areas of the world was intended to answer such questions. If it were found that mothers in developed and developing countries produced equal quantities of milk of similar nutritional value then the reason for the suboptimal growth curve after 3–4 months of age would have to be sought elsewhere.

The present study was designed to provide easily interpretable information on some of the points raised above. The answers should be of great value not only in terms of what the nutrient requirements of an infant are, but also in terms of how and when to start supplementing the diet of a breast-fed infant. Tentative answers to these questions have been provided in the reports of several joint FAO/WHO scientific groups dealing with nutrient requirements, young child feeding, or both, but an answer supported by reasonably accurate facts collected in various environmental conditions is still required. It is hoped that this collaborative study will lead to recommendations on when and how to supplement the diets of breast-fed children, and that the results will form a basis for nutrition education and supplementation feeding programmes.

2. Breast-milk quantity and composition: a review

2.1 Quantity or Volume of Breast Milk

2.1.1 *Methodology for the measurement of breast-milk quantity or volume*

The methods generally used for the measurement of breast-milk quantity or volume can be divided into two categories: those that measure breast secretory capacity—i.e., the ability of the mother to secrete milk, and those that measure the infant's intake of milk. Since the infant's intake of breast milk is influenced by both the maternal secretory capacity and the baby's sucking ability and appetite, one expects the estimates of the infant's intake to be lower than those of the mother's ability to secrete milk. Furthermore, the determination of breast-milk quantity generally interferes with the normal interaction between the mother and the child and with the family life-style. This may have a negative effect on the let-down reflex, causing lower values for breast-milk volume. The degree of effect on the volume depends on the method used, and, in many cases, on the skill of the person making the measurements. For the purposes of this study, breast-milk quantity, volume, output, or yield will refer to infant intake or maternal secretory capacity, or both.

Measurement of maternal ability to secrete milk. The most common method of measuring maternal secretion is by collecting milk by manual or mechanical expression, and measuring the volume over a 24-hour period. Hytten (*51*) has observed that manual expression does not yield as high a quantity of milk as does the "test-feeding" method discussed below. On the other hand, he found that the expression of milk using the breast-pump yields higher values than the test-feeding method. Macy et al. (*79*) found manual expression to yield milk volumes similar to those obtained by Hytten with a breast-pump. The conflicting results among studies illustrate that results obtained by different methods are difficult to compare because of the many factors that may influence the outcome.

Another method for measuring maternal secretory capacity is first to make a test-feeding (see below) and then collect the remainder of the milk by expression either mechanically or manually; the two values are then added together.

Measurement of infant breast-milk intake. The "test-feeding" or "test-weighing" method of measuring the infant breast-milk intake is the method most often used. The quantity of breast milk that the infant ingests is calculated by subtracting the weight of the baby before feeding from its weight after feeding. If the infant is breast-fed during the night, care must be taken to carry out weighings during the night also; it is not sufficiently accurate to calculate the daily quantities on the basis of weighings over part of the day only. Another problem is that if the baby is given short, frequent feeds, the weight gains will be so small as to cause unacceptable errors in the estimates of the quantity of ingested breast milk (*23*).

Infant milk intake has also been calculated from the weight of the mother before and after she suckles her child (*97*). However, the difficulty of measuring accurately small changes of maternal weight is greater than that of measuring similar changes when test-weighing infants.

A newly developed method for measuring the infant's intake of breast milk is based on the enrichment of saliva with heavy water (deuterium oxide). A precisely measured amount of heavy water is administered by mouth to the infant and the concentration of heavy water in the saliva is measured before and 24 hours after the administration. The difference in the two concentrations indicates changes in the total body water over 24 hours, and can be used as a measurement of breast-milk intake if appropriate correction is made for the intake of any other fluid. This method has the advantage of not interfering with the feeding habits of the baby or the life-styles of the mother and baby. It also has the advantage of being able to provide the average daily intake over several days (usually 11–14 days), whereas test-feeding measurements are usually done over a one-day period (*22*). The first results obtained with this method appear, however, to give somewhat higher figures for breast-milk intake than those obtained by the test-weighing method.

Breast-milk intake can also be measured by means of a flow meter connected to a nipple-shield through which the infant sucks at his mother's breast. In this way, information is obtained about the milk flow and its pattern, making it possible to calculate the quantity of breast milk ingested by the infant. This method may also be used to determine breast-milk composition at any time during the feeding period because it makes continuous sampling possible (*49*, *76*). Little, however, is known about the comparability of the results by this method with those obtained by other methods. It is likely that the presence of the shield might affect the child's willingness to suck.

2.1.2 *Factors influencing breast-milk quantity*

Psychological, physiological, and sociological factors may affect the quantity of breast milk. The fact that these factors are frequently

interrelated makes it difficult to identify the degree to which each of them is responsible for differences in the output.

Psychological factors. Of all the factors influencing breast-milk volume, the impact of psychological factors has probably been known for the longest time. It has long been known in folk experience that the shock of unpleasant news can cause a mother's milk to dry up rapidly, as Jelliffe & Jelliffe (*56*) have pointed out. Emotional disturbances and anxiety are well known to interfere with the "let-down" reflex, thus causing less milk to be secreted.[1]

Physiological factors. Physiological factors influencing breast-milk quantity include the mother's capacity to produce milk, her ability to release it, and the infant's ability to consume the milk as well as to stimulate the nipple so that more milk is secreted.

The frequency, duration, and force of the infant's sucking all affect breast-milk quantity (*123*). Belavady[2] and Athavale (*6*) have pointed out that smaller infants need less milk to maintain an adequate growth rate and therefore they suck less, allowing the breast to produce and secrete less milk; by sucking more, the higher-birth-weight newborns cause more milk to be produced and secreted. This is consistent with the theory that the quantity of milk secreted by the gland can be considerably influenced by the demand (*79*).

Fluctuations in breast-milk yields during one day, from day to day, and at different times post partum have been noted in several studies. Increase in volume over time, especially during the first few months of lactation, may be due to the greater strength of sucking by the growing infant and also to its greater nutritional needs. Hormonal factors may also play a role.

Although Habicht and coworkers (*42*) and Deem (*23*) have suggested that breast-milk secretion does not vary during the day, most studies have shown a diurnal fluctuation (*25*, *51*, *55*, *78*). Denis & Talbot (*25*) found the maximum breast-milk yield at around 09h00; Macy (*78*) found it to be in both morning and late evening. Jaso (*55*) found maximum yields at 06h00 and 23h00. Almost all these studies showed wide fluctuations in milk yield, as well as differences between mothers in the time of the peak milk yield; on average, there seemed to be a trend among the data towards higher yields in the morning. It is possible that some of the observed diurnal variation may not be only a manifestation of the circadian rhythm, but may also be related to the intervals between feeds. Variations in breast-milk volume during the day, whatever their cause, make it necessary to measure the volume over a 24-hour period in order to achieve an accurate measurement.

The amount of milk secreted varies with the period of lactation. It

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[1] *Infant and young child feeding—current issues.* Unpublished WHO document FHE/ICF/79.3, 1979.

[2] Belavady, B. Personal communication (1974).

increases sharply during the first few days post partum (*59*), reaches a plateau at about 4–6 weeks post partum, remains at this level, sometimes for several months, and then starts to decline. Belavady[1] observed in Indian women that the highest values of milk volume were attained around 4–6 weeks post partum and were maintained for about one year. Similar observations have been made by other investigators in India and elsewhere (*39*, *97*, *115*).

Hytten (*52*) observed that the yield from the two breasts differed in most women studied, the average difference being about 50 ml per day. This difference could result from the mother suckling her infant more on one breast than on the other.

An increase in plasma concentration of prolactin appears to play a key role in the initiation (*116*) and maintenance of lactation (*118*). A study in Edinburgh, Scotland, (*50*) showed that a mother's prolactin concentration remained above normal until there was a decrease in the daily frequency and duration of breast-feeding. This study found that the introduction of supplementary foods to the infant coincided with a decline in the prolactin concentration in the mother's plasma. Hennart et al. (*48*) suggest that it is the decline in sucking frequency that causes the prolactin concentration to drop. Bunner et al. (*16*), however, observed continued lactation in mothers whose basal normal concentrations of prolactin were not increased.

Some drugs and hormones are known to influence breast-milk volume. Combined oral contraceptives containing 30 μg of estrogen appear to decrease milk volume (*74*). Alcohol is known to suppress oxytocin release, and may therefore interfere with the let-down reflex. Thompson (*104*) found a correlation between heavy smoking and decreased milk production, although he pointed out that heavy smokers are often nervous and that this may lead to reduced milk production.

Most cultures use galactogogues to help stimulate milk production. In several countries beer is recommended as a galactogogue. Jelliffe & Jelliffe (*56*) suggest that part of the effectiveness of many galactogogues comes from the soothing belief that they will work, thus allowing the mother to relax and facilitating the stimulation of the let-down reflex.

Social factors. Social factors may have an influence on breast-milk quantity, though their influence is usually through psychological or physiological mechanisms, or a combination of these. For example, a society may believe that breast-feeding is distasteful and this may make the mother feel uncomfortable about doing so and thereby cause inhibition of the let-down reflex. In a society in which the mother must work away from home, there may be a negative influence on her capacity to secrete breast milk, on the amount of breast milk the infant ingests, or on both, unless special facilities for breast-feeding

[1] Belavady, B. Personal communication (1974).

are provided at the place of work. The breast-feeding working mother is often forced to give the baby breast-milk substitutes or supplements while she is away from home. This use of breast-milk substitutes or the early introduction of food supplements may also influence the quantity of breast milk ingested by the infant. When the baby's nutritional needs are partially met by foods other than breast milk, the baby will suck the breast less frequently and less vigorously, and, consequently, less breast milk will be produced (*19*, *87*).

2.1.3 *Influence of maternal nutritional status and diet on breast-milk quantity*

The relationship between breast-milk output and the maternal nutritional status is complicated by the fact that many aspects of the latter defy a clear and generally applicable definition; at the same time psychological and sociological factors may also be important. While it is safe to assume that maternal nutrition may, to some extent, influence the output of breast milk, output may also be influenced by maternal nutrition indirectly by way of a psychological effect. For instance, when a mother fears that she has lost too much weight or has not eaten well enough to produce "good" or "enough" milk for her baby, this may inhibit the let-down reflex. On the other hand, the mother's nutritional status and diet are often determined by the social norms of the society to which she belongs—e.g., there are often prescribed quantities and types of food for mothers. The mother's ability to acquire food and what is considered to be the desirable body-weight for a woman in her particular society also influence milk output. Maternal nutrition may thus influence the breast-milk volume either directly or indirectly, but it is difficult to determine whether maternal nutrition is primarily responsible for changes in breast-milk output.

To date, most of our knowledge concerning the impact of maternal nutrition on breast-milk output comes from maternal diet supplementation studies. Their interpretation is not always easy for the following reasons:

(*a*) the food supplement may replace part of the diet instead of complementing it;

(*b*) the length of diet supplementation may be too short;

(*c*) the timing of supplementation may not be right—instead of starting supplementation during lactation, it may be advisable to start earlier, for example, during pregnancy in order to build up the fat stores;

(*d*) the quantity and the composition of the supplement may not be correct in relation to the daily food intake of the mother before and during dietary supplementation; and

(*e*) the diet supplementation of a mother may not be correctly related to the degree of malnutrition.

From the above it is easy to understand why studies of the effect of maternal diet supplementation on breast milk have produced mixed results. Chavez & Martinez (*18*) were able to increase milk volume

with supplements of 1260 kJ/day (300 kcal/day) given from the 45th day of gestation until weaning; although there was a measurable positive impact on child growth, the milk became more dilute. Postpartum protein supplementation of 25–50 g of protein per day in Nigeria produced increases in infant intake and maternal secretion capacity (*30*). In this study, the mothers were able to secrete more milk than the infants consumed even before diet supplementation, and after the commencement of diet supplementation the babies' milk consumption increased for some unexplained reason. The babies showed a significant improvement in growth (both in height and in weight) compared with the growth of babies in a control group. In the Gambia, nursing mothers' diets were supplemented with over 2940 kJ/day (700 kcal/day) for 12 months so that the mean maternal intake was 9622 kJ/day (2291 kcal/day) (*92*); although the Gambian mothers showed an initial improvement in maternal body weight and subcutaneous fat stores, there was no increase in the intake of breast milk by the infant. Studies by Belavady (*12*) and Gopalan (*46*) also showed no increase in breast-milk yield with diet supplementation of the nursing mother.

A few studies have looked at maternal nutrition and breast-milk volume, and have tried to draw inferences about the influence of maternal nutritional status on the volume of breast milk. Khin Maung Naing and coworkers (*61*) found that while well-nourished mothers were able to secrete significantly more milk than infants were able to ingest, this was not the case for malnourished women. Hanafy et al. (*47*) found that malnourished women produced 22% less milk than the well-nourished ones. Bailey (*8*) was unable to find a correlation between the maternal weight:height ratio or skinfold thickness and the quantity of breast milk, except for severely malnourished women. As for the relationship between the mother's dietary intake and milk output, a recently conducted study in the Gambia showed a significant drop in breast-milk quantity during the rainy season when the already low daily food intakes of the mothers dropped by an additional 1050–1260 kJ/day (250–300 kcal/day) (*92*); however, the rainy season is also the period with the highest infant morbidity. It was pointed out in this study that for infants born during the dry season the mother's milk nourished the infant for the first three months of life so well that the infant grew faster than usual despite the fact that maternal dietary intake was well below that recommended for even non-pregnant, non-lactating women.

2.1.4 *Comparison of data on breast-milk intake in developed and developing countries.*

Several investigators have reported that the average daily intake of breast milk by infants in developed countries is in the range of 600–800 ml/day rather than 850 ml/day, which is the figure usually

used in calculations of the dietary requirements of lactating women and of infants below 6 months of age (*104*, *123*).

The highest quantities reported for a population were by Rattigan and coworkers (*97*), who used the method of test-weighing the mothers; the quantities were 1187 g/24 h, 1238 g/24 h, 1128 g/24 h, and 880 g/24 h at 1, 3, 6 and 12 months of lactation, respectively. There have been reports of wet-nurses having similarly high quantities of breast milk (*78*). Schanler & Oh (*99*), studying the breast milk of mothers of premature babies in the USA found that the mean volumes of expressed milk during the first couple of weeks post partum ranged between 1098 and 1673 ml/day.

The volume of milk the infants ingested was, of course, considerably less than the mother's supply. A comparison of breast-milk intake in developed and developing countries indicates that the intake is smaller in the latter, as illustrated in Table 1.

2.2 Composition of Breast Milk

Breast-milk quantity alone does not give a clear picture of its nutritional adequacy. To get a better picture, one must also look at the composition of the milk. The method of breast-milk collection may influence the composition, and this must be considered when comparing data from different studies. Other factors that need to be taken into account when comparing breast-milk composition data are listed in section 2.2.1 below. Table 2 gives data from some recent studies on breast-milk composition conducted mainly in developing countries.

2.2.1 *Factors affecting breast-milk composition*

The factors that may influence breast-milk composition and which may need to be considered in assessing data on the composition of breast-milk are as follows:

(*a*) changes in the composition of milk over time (according to length of time post partum);
(*b*) changes in milk composition during a single feed;
(*c*) diurnal fluctuations in composition;
(*d*) effect on composition of the interval between feeds;
(*e*) differences in milk composition between the two breasts;
(*f*) changes in composition attributed to mother's menstrual cycle or pregnancy;
(*g*) effect on composition of the degree of pressure exerted if the milk is expressed;
(*h*) effect of the length of gestation prior to the beginning of lactation; and
(*i*) effect of the interval of time between pregnancies.

Table 1. Quantity of breast milk (g/day) in various countries[a]

Month(s) of lactation	Kenya (*110*)	India (*39*)	Mexico (*82*)	Gambia (*92*)	England (*120*)	Canada (*17*)	Sweden (*117*)	
							Males	Females
0–1	778	454	423	640–653	742		571 (361–781)	533 (333–733)
1–2		476	577				685 (479–891)	657 (497–817)
2–3	619	479			787			
3–4		496	537	580–614	805	764–793	798 (572–1029)	733 (497–969)
4–5	573				803	856–887	821 (577–1065)	747 (571–1023)
5–6		499	560		855	925–969		