14. BREAST MILK INTAKE
- 14.1. BACKGROUND
- 14.2. KEY STUDIES ON BREAST MILK INTAKE
- 14.3. RELEVANT STUDIES ON BREAST MILK INTAKE
- 14.4. KEY STUDIES ON LIPID CONTENT AND FAT INTAKE FROM BREAST MILK
- 14.5. OTHER FACTORS
- 14.6. RECOMMENDATIONS

REFERENCES FOR CHAPTER 14

Table 14-1. Daily Intakes of Breast Milk
Table 14-2. Breast Milk Intake for Infants Aged 1 to 6 Months
Table 14-3. Breast Milk Intake Among Exclusively Breast-fed Infants During the First 4 Months of Life
Table 14-4. Breast Milk Intake During a 24-Hour Period
Table 14-5. Breast Milk Intake Estimated by the DARLING Study
Table 14-6. Milk Intake for Bottle- and Breast-fed Infants by Age Group
Table 14-7. Milk Intake for Boys and Girls
Table 14-8. Intake of Breast Milk and Formula
Table 14-9. Lipid Content of Human Milk and Estimated Lipid Intake Among Exclusively Breast-fed Infants
Table 14-10. Predicted Lipid Intakes for Breast-fed Infants Under 12 Months of Age
Table 14-11. Number of Meals Per Day
Table 14-12. Percentage of Mothers Breast-feeding Newborn Infants in the Hospital and Infants at 5 or 6 Months of Age in the United States in 1989, by Ethnic Background and Selected Demographic Variables
Table 14-13. Breast Milk Intake Studies
Table 14-14. Confidence in Breast Milk Intake Recommendations
Table 14-15. Breast Milk Intake Rates Derived From Key Studies
Table 14-16. Summary of Recommended Breast Milk and Lipid Intake Rates

14. BREAST MILK INTAKE

14.1. BACKGROUND

Breast milk is a potential source of exposure to toxic substances for nursing infants. Lipid soluble chemical compounds accumulate in body fat and may be transferred to breast-fed infants in the lipid portion of breast milk. Because nursing infants obtain most (if not all) of their dietary intake from breast milk, they are especially vulnerable to exposures to these compounds. Estimating the magnitude of the potential dose to infants from breast milk requires information on the quantity of breast milk consumed per day and the duration (months) over which breast-feeding occurs. Information on the fat content of breast milk is also needed for estimating dose from breast milk residue concentrations that have been indexed to lipid content.

Several studies have generated data on breast milk intake. Typically, breast milk intake has been measured over a 24-hour period by weighing the infant before and after each feeding without changing its clothing (test weighing). The sum of the difference between the measured weights over the 24-hour period is assumed to be equivalent to the amount of breast milk consumed daily. Intakes measured using this procedure are often corrected for evaporative water losses (insensible water losses) between infant weighings (NAS, 1991). Neville et al. (1988) evaluated the validity of the test weight approach among bottle-fed infants by comparing the weights of milk taken from bottles with the differences between the infants' weights before and after feeding. When test weight data were corrected for insensible water loss, they were not significantly different from bottle weights. Conversions between weight and volume of breast milk consumed are made using the density of human milk (approximately 1.03 g/mL) (NAS, 1991). Recently, techniques for measuring breast milk intake using stable isotopes have been developed. However, few data based on this new technique have been published (NAS, 1991).

Studies among nursing mothers in industrialized countries have shown that intakes among infants average approximately 750 to 800 g/day (728 to 777 mL/day) during the first 4 to 5 months of life with a range of 450 to 1,200 g/day (437 to 1,165 mL/day) (NAS, 1991). Similar intakes have also been reported for developing countries (NAS, 1991). Infant birth weight and nursing frequency have been shown to influence the rate of intake (NAS, 1991). Infants who are larger at birth and/or nurse more frequently have been shown to have higher intake rates. Also, breast milk production among nursing mothers has been reported to be somewhat higher than the amount actually consumed by the infant (NAS, 1991).

The available studies on breast milk intake are summarized in the following sections. Studies on breast milk intake rates have been classified as either key studies or relevant studies based on the criteria described in the Introduction (Volume I, Section 1.3.1).

Recommended intake rates are based on the results of key studies, but relevant studies are also presented to provide the reader with added perspective on the current state of knowledge pertaining to breast milk intake.

Relevant data on lipid content and fat intake, breast-feeding duration and frequency, and the estimated percentage of the U.S. population that breast-feeds are also presented.

14.2. KEY STUDIES ON BREAST MILK INTAKE

Pao et al. (1980) - Milk Intakes and Feeding Patterns of Breast-fed Infants - Pao et al. (1980) conducted a study of 22 healthy breast-fed infants to estimate breast milk intake rates. Infants were categorized as completely breast-fed or partially breast-fed. Breast feeding mothers were recruited through LaLeche League groups. Except for one black infant, all other infants were from white middle-class families in southwestern Ohio. The goal of the study was to enroll infants as close to one month of age as possible and to obtain records near one, three, six, and nine months of age (Pao et al., 1980). However, not all mother/infant pairs participated at each time interval. Data were collected for these 22 infants using the test weighing method. Records were collected for three consecutive 24-hour periods at each test interval. The weight of breast milk was converted to volume by assuming a density of 1.03 g/mL. Daily intake rates were calculated for each infant based on the mean of the three 24-hour periods. Mean daily breast milk intake rates for the infants surveyed at each time interval are presented in Table 14-1. For completely breast-fed infants, the mean intake rates were 600 mL/day at 1 month of age and 833 mL/day at 3 months of age. Partially breast-fed infants had mean intake rates of 485 mL/day, 467 mL/day, 395 mL/day, and 554 mL/day at 1, 3, 6, and 9 months of age, respectively. Pao et al. (1980) also noted that intake rates for boys in both groups were slightly higher than for girls.

The advantage of this study is that data for both exclusively and partially breast-fed infants were collected for multiple time periods. Also, data for individual infants were collected over 3 consecutive days which would account for some individual variability. However, the number of infants in the study was relatively small and may not be entirely representative of the U.S. population, based on race and socioeconomic status, which may introduce some bias in the results. In addition, this study did not account for insensible water loss which may underestimate the amount of breast milk ingested.

Dewey and Lönnerdal (1983) - Milk and Nutrient Intakes of Breast-fed Infants from 1 to 6 Months - Dewey and Lönnerdal (1983) monitored the dietary intake of 20 breast-fed infants between the ages of 1 and 6 months. Most of the infants in the study were exclusively breast-fed (five were given some formula, and several were given small amounts of solid foods after 3 months of age). According to Dewey and Lönnerdal (1983), the mothers were all well educated and recruited through Lamaze childbirth classes in the

Davis area of California. Breast milk intake volume was estimated based on two 24-hour test weighings per month. Breast milk intake rates for the various age groups are presented in Table 14-2. Breast milk intake averaged 673, 782, and 896 mL/day at 1, 3, and 6 months of age, respectively.

The advantage of this study is that it evaluated breast-fed infants for a period of 6 months based on two 24-hour observations per infant per month. Corrections for insensible water loss apparently were not made. Also, the number of infants in the study was relatively small and may not be representative of U.S. population, based on race and socioeconomic status.

Butte et al. (1984) - Human Milk Intake and Growth in Exclusively Breast-fed Infants - Breast milk intake was studied in exclusively breast-fed infants during the first 4 months of life (Butte et al., 1984). Breastfeeding mothers were recruited through the Baylor Milk Bank Program in Texas. Forty-five mother/infant pairs participated in the study. However, data for some time periods (i.e., 1, 2, 3, or 4 months) were missing for some mothers as a result of illness or other factors. The mothers were from the middle- to upper-socioeconomic stratum and had a mean age of 28.0 ± 3.1 years. A total of 41 mothers were white, 2 were Hispanic, 1 was Asian, and 1 was West Indian. Infant growth progressed satisfactorily over the course of the study. The amount of milk ingested over a 24-hour period was determined using the test weighing procedure. Test weighing occurred over a 24-hour period for most participants, but intake among several infants was studied over longer periods (48 to 96 hours) to assess individual variation in intake. The study did not indicate whether the data were corrected for insensible water loss. Mean breast milk intake ranged from 723 g/day (702 mL/day) at 3 months to 751 g/day (729 mL/day) at 1 month, with an overall mean of 733 g/day (712 mL/day) for the entire study period (Table 14-3). Intakes were also calculated on the basis of body weight (Table 14-3). Based on the results of test weighings conducted over 48 to 96 hours, the mean variation in individual daily intake was estimated to be 7.9±3.6 percent.

The advantage of this study is that data for a larger number of exclusively breast-fed infants were collected than were collected by Pao et al. (1980). However, data were collected over a shorter time period (i.e., 4 months compared to 6 months) and day-to-day variability was not characterized for all infants. In addition, the population studied may not be representative of the U.S. population based on race and socioeconomic status.

Neville et al. (1988) - Studies on Human Lactation - Neville et al. (1988) studied breast milk intake among 13 infants during the first year of life. The mothers were all multiparous, nonsmoking, Caucasian women of middle- to upper-socioeconomic status living in Denver, Colorado (Neville et al., 1988). All women in the study practiced exclusive breast-feeding for at least 5 months. Solid foods were introduced at mean age of 7 months. Daily milk intake was estimated by the test weighing method with corrections

for insensible weight loss. Data were collected daily from birth to 14 days, weekly from weeks 3 through 8, and monthly until the study period ended at 1 year after inception. The estimated breast milk intakes for this study are listed in Table 14-4. Mean breast milk intakes were 770 g/day (748 mL/day), 734 g/day (713 mL/day), 766 g/day (744 mL/day), and 403 g/day (391 mL/day) at 1, 3, 6, and 12 months of age, respectively.

In comparison to the previously described studies, Neville et al. (1988) collected data on numerous days over a relatively long time period (12 months) and they were corrected for insensible weight loss. However, the intake rates presented in Table 14-4 are estimated based on intake during only a 24-hour period. Consequently, these intake rates are based on short-term data that do not account for day-to-day variability among individual infants. Also, a smaller number of subjects was included than in the previous studies, and the population studied may not be representative of the U.S. population, based on race and socioeconomic status.

Dewey et al. (1991a; 1991b) - The DARLING Study - The Davis Area Research on Lactation, Infant Nutrition and Growth (DARLING) study was conducted in 1986 to evaluate growth patterns, nutrient intake, morbidity, and activity levels in infants who were breast-fed for at least the first 12 months of life (Dewey et al., 1991a; 1991b). Seventy-three infants aged 3 months were included in the study. The number of infants included in the study at subsequent time intervals was somewhat lower as a result of attrition. All infants in the study were healthy and of normal gestational age and weight at birth, and did not consume solid foods until after the first 4 months of age. The mothers were highly educated and of "relatively high socioeconomic status" from the Davis area of California (Dewey et al., 1991a; 1991b). Breast milk intake was estimated by weighing the infants before and after each feeding and correcting for insensible water loss. Test weighings were conducted over a 4-day period every 3 months. The results of the study indicate that breast milk intake declines over the first 12 months of life. Mean breast milk intake was estimated to be 812 g/day (788 mL/day) at 3 months and 448 g/day (435 mL/day) at 12 months (Table 14-5). Based on the estimated intakes at 3 months of age, variability between individuals (coefficient of variation (CV) = 16.3 percent) was higher than individual day-to-day variability (CV = 5.4 percent) for the infants in the study (Dewey et al., 1991a).

The advantages of this study are that data were collected over a relatively long-time (4 days) period at each test interval which would account for some day-to-day infant variability, and corrections for insensible water loss were made. However, the population studied may not be representative of the U.S. population, based on race and socioeconomic status.

14.3. RELEVANT STUDIES ON BREAST MILK INTAKE

Hofvander et al. (1982) - The Amount of Milk Consumed by 1- to 3-Month Old Breast- or Bottle-Fed Infants - Hofvander et al. (1982) compared milk intake among breast-fed and bottle-fed infants at ages 1, 2, and 3 months of age. Intake of breast milk and breast milk substitutes was tabulated for 25 Swedish infants in each age group. Daily intake among breast-fed infants was estimated using the test weighing method. Test weighings were conducted over a 24-hour time period at each time interval. Daily milk intake among bottle-fed infants was estimated by measuring the volumetric differences in milk contained in bottles at the beginning and end of all feeding sessions in a 24-hour period. The mean intake rates for bottle-fed infants were slightly higher than for breast-fed infants for all age groups (Table 14-6). Also, boys consumed breast milk or breast milk substitutes at a slightly higher rate than girls (Table 14-7). Breast milk intake was estimated to be 656 g/day (637 mL/day) at 1 month and 776 g/day (753 mL/day) at 3 months.

This study was conducted among a small number of Swedish infants, but the results are similar to those summarized previously for U.S. studies. Insensible water losses were apparently not considered in this study, and only short-term data were collected.

Köhler et al. (1984) - Food Intake and Growth of Infants Between Six and Twenty-six Weeks of Age on Breast Milk, Cow s Milk, Formula, and Soy Formula - Köhler et al. (1984) evaluated breast milk and formula intake among normal infants between the ages of 6 and 26 weeks. The study included 25 fully breast-fed and 34 formula-fed infants from suburban communities in Sweden. Intake among breast-fed infants was estimated using the test weighing method over a 48-hour test period. Intake among formula-fed infants was estimated by feeding infants from bottles with known volumes of formula and recording the amount consumed over a 48-hour period. Table 14-8 presents the mean breast milk and formula intake rates for the infants studied. Data were collected for both cow's milk-based formula and soy-based formula. The results indicated that the daily intake for bottle-fed infants was greater than for breast-fed infants.

The advantages of this study are that it compares breast milk intake to formula intake and that test weightings were conducted over 2 consecutive days to account for variability in individual intake. Although the population studied was not representative of the U.S. population, similar intake rates were observed in the studies that were previously summarized.

Axelsson et al. (1987) - Protein and Energy Intake During Weaning - Axelsson et al. (1987) measured food consumption and energy intake in 30 healthy Swedish infants between the ages of 4 and 6 months. Both formula-fed and breast-fed infants were studied. All infants were fed supplemental foods (i.e., pureed fruits and vegetables after 4 months, and pureed meats and fish after 5 months). Milk intake among breast-fed

infants was estimated by weighing the infants before and after each feeding over a 2-day period at each sampling interval. Breast milk intake averaged 765 mL/day at 4.5 months of age, and 715 mL/day at 5.5 months of age.

This study is based on short-term data, a small number of infants, and may not be representative of the U.S. population. However, the intake rates estimated by this study are similar to those generated by the U.S. studies that were summarized previously.

14.4. KEY STUDIES ON LIPID CONTENT AND FAT INTAKE FROM BREAST MILK

Human milk contains over 200 constituents including lipids, various proteins, carbohydrates, vitamins, minerals, and trace elements as well as enzymes and hormones (NAS, 1991). The lipid content of breast milk varies according to the length of time that an infant nurses. Lipid content increases from the beginning to the end of a single nursing session (NAS, 1991). The lipid portion accounts for approximately 4 percent of human breast milk (39 ± 4.0 g/L) (NAS, 1991). This value is supported by various studies that evaluated lipid content from human breast milk. Several studies also estimated the quantity of lipid consumed by breast-feeding infants. These values are appropriate for performing exposure assessments for nursing infants when the contaminant(s) have residue concentrations that are indexed to the fat portion of human breast milk.

Butte et al. (1984) - Human Milk Intake and Growth in Exclusively Breast-fed Infants - Butte et al., (1984) analyzed the lipid content of breast milk samples taken from women who participated in a study of breast milk intake among exclusively breast-fed infants. The study was conducted with over 40 women during a 4-month period. The mean lipid content of breast milk at various infants' ages is presented in Table 14-9. The overall lipid content for the 4-month study period was 34.3 ± 6.9 mg/g (3.4 percent). Butte et al. (1984) also calculated lipid intakes from 24-hour breast milk intakes and the lipid content of the human milk samples. Lipid intake was estimated to range from 23.6 g/day (3.8 g/kg-day) to 28.0 g/day (5.9 g/kg-day).

The number of women included in this study was small, and these women were selected primarily from middle- to upper-socioeconomic classes. Thus, data on breast milk lipid content from this study may not be entirely representative of breast milk lipid content among the U.S. population. Also, these estimates are based on short-term data and day-to-day variability was not characterized.

Maxwell and Burmaster (1993) - A Simulation Model to Estimate a Distribution of Lipid Intake from Breast Milk Intake During the First Year of Life -Maxwell and Burmaster (1993) used a hypothetical population of 5,000 infants between birth and 1 year of age to simulate a distribution of daily lipid intake from breast milk. The hypothetical population

represented both bottle-fed and breast-fed infants aged 1 to 365 days. A distribution of daily lipid intake was developed based on data in Dewey et al. (1991b) on breast milk intake for infants at 3, 6, 9, and 12 months and breast milk lipid content, and survey data in Ryan et al. (1991) on the percentage of breast-fed infants under the age of 12 months (i.e., approximately 22 percent). A model was used to simulate intake among 1,113 of the 5,000 infants that were expected to be breast-fed. The results of the model indicated that lipid intake among nursing infants under 12 months of age can be characterized by a normal distribution with a mean of 26.8 g/day and a standard deviation of 7.4 g/day (Table 14-10). The model assumes that nursing infants are completely breast-fed and does not account for infants who are breast-fed longer than 1 year. Based on data collected by Dewey et al. (1991b), Maxwell and Burmaster (1993) estimated the lipid content of breast milk to be 36.7 g/L at 3 months (35.6 mg/g or 3.6%) and 40.2 g/L (39.0 mg/g or 3.9%) at 12 months.

The advantage of this study is that it provides a "snapshot" of daily lipid intake from breast milk for breast-fed infants. These results are, however, based on a simulation model and there are uncertainties associated with the assumptions made. The estimated mean lipid intake rate represents the average daily intake for nursing infants under 12 months of age. These data are useful for performing exposure assessments when the age of the infant cannot be specified (i.e., 3 months or 6 months). Also, because intake rates are indexed to the lipid portion of the breast milk, they may be used in conjunction with residue concentrations indexed to fat content.

14.5. OTHER FACTORS

Other factors associated with breast milk intake include: the frequency of breast-feeding sessions per day, the duration of breast-feeding per event, the duration of breast-feeding during childhood, and the magnitude and nature of the population that breast-feeds.

Frequency and Duration of Feeding - Hofvander et al. (1982) reported on the frequency of feeding among 25 bottle-fed and 25 breast-fed infants at ages 1, 2, and 3 months. The mean number of meals for these age groups was approximately 5 meals/day (Table 14-11). Neville et al. (1988) reported slightly higher mean feeding frequencies. The mean number of meals per day for exclusively breast-fed infants was 7.3 at ages 2 to 5 months and 8.2 at ages 2 weeks to 1 month. Neville et al. (1988) reported that, for infants between the ages of 1 week and 5 months, the average duration of a breast feeding session is 16-18 minutes.

Population of Nursing Infants and Duration of Breast-Feeding During Infancy - According to NAS (1991), the percentage of breast-feeding women has changed dramatically over the years. Between 1936 and 1940, approximately 77 percent of infants

were breast fed, but the incidence of breast-feeding fell to approximately 22 percent in 1972. The duration of breast-feeding also dropped from about 4 months in the early 1930s to 2 months in the late 1950s. After 1972, the incidence of breast-feeding began to rise again, reaching its peak at approximately 61 percent in 1982. The duration of breast-feeding also increased between 1972 and 1982. Approximately 10 percent of the mothers who initiated breast-feeding continued for at least 3 months in 1972; however, in 1984, 37 percent continued breast-feeding beyond 3 months. In 1989, breast-feeding was initiated among 52.2 percent of newborn infants, and 40 percent continued for 3 months or longer (NAS, 1991). Based on the data for 1989, only about 20 percent of infants were still breast fed by age 5 to 6 months (NAS, 1991). Data on the actual length of time that infants continue to breast-feed beyond 5 or 6 months are limited (NAS, 1991). However, Maxwell and Burmaster (1993) estimated that approximately 22 percent of infants under 1 year of age are breast-fed. This estimate is based on a reanalysis of survey data in Ryan et al. (1991) collected by Ross Laboratories (Maxwell and Burmaster, 1993). Studies have also indicated that breast-feeding practices may differ among ethnic and socioeconomic groups and among regions of the United States. The percentages of mothers who breast feed, based on ethnic background and demographic variables, are presented in Table 14-12 (NAS, 1991).

Intake Rates Based on Nutritional Status - Information on differences in the quality and quantity of breast milk consumed based on ethnic or socioeconomic characteristics of the population is limited. Lönnerdal et al. (1976) studied breast milk volume and composition (nitrogen, lactose, proteins) among underprivileged and privileged Ethiopian mothers. No significant differences were observed between the data for these two groups; and similar data for well-nourished Swedish mothers were observed. Lönnerdal et al. (1976) stated that these results indicate that breast milk quality and quantity are not affected by maternal malnutrition. However, Brown et al. (1986a; 1986b) noted that the lactational capacity and energy concentration of marginally-nourished women in Bangladesh were "modestly less than in better nourished mothers." Breast milk intake rates for infants of marginally-nourished women in this study were 690±122 g/day at 3 months, 722±105 g/day at 6 months, and 719±119 g/day at 9 months of age (Brown et al., 1986a). Brown et al. (1986a) observed that breast milk from women with larger measurements of arm circumference and triceps skinfold thickness had higher concentrations of fat and energy than mothers with less body fat. Positive correlations between maternal weight and milk fat concentrations were also observed. These results suggest that milk composition may be affected by maternal nutritional status.

14.6. RECOMMENDATIONS

The key studies described in this section were used in selecting recommended values for breast milk intake, fat content and fat intake, and other related factors. Although different survey designs, testing periods, and populations were utilized by the key and

relevant studies to estimate intake, the mean and standard deviation estimates reported in these studies are relatively consistent. There are, however, limitations with the data. Data are not available for infants under 1 month of age. This subpopulation may be of particular concern since a larger number of newborns are totally breast fed. In addition, with the exception of Butte (1984), data were not presented on a body weight basis. This is particularly important since intake rates may be higher on a body weight basis for younger infants. Also, the data used to derive the recommendations are over 10 years old and the sample size of the studies was small. Other subpopulations of concern such as mothers highly committed to breast feeding, sometimes for periods longer than 1 year, may not be captured by the studies presented in this chapter. Further research is needed to identify these subgroups and to get better estimates of breast milk intake rates. The general designs of both key and relevant studies and their limitations are summarized in Table 14-13. Table 14-14 presents the confidence rating for breast milk intake recommendations.

Breast Milk Intake - The breast milk intake rates for nursing infants that have been reported in the key studies described in this section are summarized in Table 14-15. Based on the combined results of these studies, 742 mL/day is recommended to represent an average breast milk intake rate, and 1,033 mL/day represents an upper-percentile intake rate (based on the middle range of the mean plus 2 standard deviations) for infants between the ages of 1 and 6 months of age. The average value is the mean of the average intakes at 1, 3, and 6 months from the key studies listed in Table 14-15. It is consistent with the average intake rate of 718 to 777 mL/day estimated by NAS (1991) for infants during the first 4 to 5 months of life. Intake among older infants is somewhat lower, averaging 413 mL/day for 12-month olds (Neville et al. 1988; Dewey et al. 1991a; 1991b). When a time weighted average is calculated for the 12-month period, average breast milk intake is approximately 688 mL/day, and upper-percentile intake is approximately 980 mL/day. Table 14-16 summarizes these recommended intake rates.

Lipid Content and Lipid Intake - Recommended lipid intake rates are based on data from Butte et al. (1984) and Maxwell and Burmaster (1993). Butte et al. (1984) estimated that average lipid intake ranges from 23.6 ± 7.2 g/day (22.9 ± 7.0 mL/day) to 28.0 ± 8.5 g/day (27.2 ± 8.3 mL/day) between 1 and 4 months of age. These intake rates are consistent with those observed by Burmaster and Maxwell (1993) for infants under 1 year of age [(26.8 ± 7.4 g/day (26.0 ± 7.2 mL/day)]. Therefore, the recommended breast milk lipid intake rate for infants under 1 year of age is 26.0 mL/day and the upper-percentile value is 40.4 mL/day (based on the mean plus 2 standard deviations). The recommended value for breast milk fat content is 4.0 percent based on data from NAS (1991), Butte et al. (1984), and Maxwell and Burmaster (1993).

Table 14-1. Daily Intakes of Breast Milk

Age	Number of Infants Surveyed at Each Time Period	Mean Intake (mL/day) [a]	Range of Daily Intake (mL/day)
Completely Breast-fed			
1 month	11	600 ± 159	426 - 989
3 months	2	833	645 - 1,000
6 months	1	682	616 - 786
Partially Breast-fed			
1 month	4	485 ± 79	398 - 655
3 months	11	467 ± 100	242 - 698
6 months	6	395 ± 175	147 - 684
9 months	3	<554	451 - 732

[a] Data expressed as mean ± standard deviation.
Source: Pao et al., 1980.

Table 14-2. Breast Milk Intake for Infants Aged 1 to 6 Months

Age (months)	Number of Infants	Mean (mL/day)	SD (mL/day) [a]	Range (mL/day)
1	16	673	192	341-1,003
2	19	756	170	449-1,055
3	16	782	172	492-1,053
4	13	810	142	593-1,045
5	11	805	117	554-1,045
6	11	896	122	675-1,096

[a] Standard deviation.
Source: Dewey and Lönnerdal, 1983.

Table 14-3. Breast Milk Intake Among Exclusively Breast-fed Infants During the First 4 Months of Life

Age (months)	Number of Infants	Breast Milk Intake[a] (g/day)	Breast Milk Intake[a] (g/kg-day)	Body Weight[b] (kg)
1	37	751.0 ± 130.0	159.0 ± 24.0	4.7
2	40	725.0 ± 131.0	129.0 ± 19.0	5.6
3	37	723.0 ± 114.0	117.0 ± 20.0	6.2
4	41	740.0 ± 128.0	111.0 ± 17.0	6.7

[a] Data expressed as mean ± standard deviation.
[b] Calculated by dividing breast milk intake (g/day) by breast milk intake (g/kg-day).
Source: Butte et al., 1984.

Table 14-4. Breast Milk Intake During a 24-Hour Period

Age (days)	Number of Infants	Mean (g/day)	Standard Deviation (g/day)	Range (g/day)
1	7	44	71	-31-149 [a]
2	10	182	86	44-355
3	11	371	153	209-688
4	11	451	176	164-694
5	12	498	129	323-736
6	10	508	167	315-861
7	8	573	167	406-842
8	9	581	159	410-923
9	10	580	76	470-720
10	10	589	132	366-866
11	8	615	168	398-934
14	10	653	154	416-922
21	10	651	84	554-786
28	13	770	179	495-1144
35	12	668	117	465-930
42	12	711	111	554-896
49	10	709	115	559-922
56	13	694	98	556-859
90	12	734	114	613-942
120	13	711	100	570-847
150	13	838	134	688-1173
180	13	766	121	508-936
210	12	721	154	486-963
240	10	622	210	288-1002
270	12	618	220	223-871
300	11	551	234	129-894
330	9	554	240	120-860
360	9	403	250	65-770

[a] Negative value due to insensible water loss correction.
Source: Neville et al., 1988.

Table 14-5. Breast Milk Intake Estimated by the DARLING Study

Age (months)	Number of Infants	Mean Intake (g/day)	Standard Deviation (g/day)
3	73	812	133
6	60	769	171
9	50	646	217
12	42	448	251

Source: Dewey et al. (1991b).

Table 14-6. Milk Intake for Bottle- and Breast-fed Infants by Age Group

Age (months)	Breast Milk Substitutes Mean (g/day)[a]	Breast Milk Mean (g/day)[a]
1	713 (500-1,000)	656 (360-860)
2	811 (670-1,180)	773 (575-985)
3	853 (655-1,065)	776 (600-930)

[a] Range given in parentheses.
Source: Hofvander et al., 1982.

Table 14-7. Milk Intake for Boys and Girls

	Boys		Girls	
Age	Mean (g/day)	N	Mean (g/day)	N
Breast milk				
1	663	12	649	13
2	791	14	750	11
3	811	12	743	13
Breast milk substitute				
1	753	10	687	15
2	863	13	753	12
3	862	13	843	12

Source: Hofvander et al., 1982.

Table 14-8. Intake of Breast Milk and Formula

	Breast Milk			Cow's Formula			Soy Formula		
Age (wks)	N	Mean (g/day)	SD (g/day)	N	Mean (g/day)	SD (g/day)	N	Mean (g/day)	SD (g/day)
6	26	746	101	20	823	111	13	792	127
14	21	726	143	19	921	95	13	942	78
22	13	722	114	18	818	201	13	861	196
26	12	689	120	18	722	209	12	776	159

Source: Köhler et al., 1984.

Table 14-9. Lipid Content of Human Milk and Estimated Lipid Intake Among Exclusively Breast-fed Infants

Age (months)	Number of Observations	Lipid Content (mg/g) [a]	Lipid Content (percent) [b]	Lipid Intake (g/day) [a]	Lipid Intake (g/kg-day) [a]
1	37	36.2 ± 7.5	3.6	28.0 ± 8.5	5.9 ± 1.7
2	40	34.4 ± 6.8	3.4	25.2 ± 7.1	4.4 ± 1.2
3	37	32.2 ± 7.8	3.2	23.6 ± 7.2	3.8 ± 1.2
4	41	34.8 ± 10.8	3.5	25.6 ± 8.6	3.8 ± 1.3

[a] Data expressed as means ± standard deviations.
[b] Percents calculated from lipid content reported in mg/g.

Source: Butte, et al., 1984.

Table 14-10. Predicted Lipid Intakes for Breast-fed Infants Under 12 Months of Age

Statistic	Value
Number of Observations in Simulation	1,113
Minimum Lipid Intake	1.0 g/day
Maximum Lipid Intake	51.5 g/day
Arithmetic Mean Lipid Intake	26.8 g/day
Standard Deviation Lipid Intake	7.4 g/day

Source: Maxwell and Burmaster, 1993.

Table 14-11. Number of Meals Per Day

Age (months)	Bottle-fed Infants (meals/day) [a]	Breast-fed (meals/day) [a]
1	5.4 (4-7)	5.8 (5-7)
2	4.8 (4-6)	5.3 (5-7)
3	4.7 (3-6)	5.1 (4-8)

[a] Data expressed as mean with range in parentheses.
Source: Hofvander et al., 1982.

Table 14-12. Percentage of Mothers Breast-feeding Newborn Infants in the Hospital and Infants at 5 or 6 Months of Age in the United States in 1989[a], by Ethnic Background and Selected Demographic Variables[b]

	Total		White		Black		Hispanic[c]	
Category	Newborns	5-6 Mo Infants	Newborns	5-6 Mo Infants	Newborns	5-6 Mo Infants	Newborns	5-6 Mo Infants
All mothers	52.2	19.6	58.5	22.7	23.0	7.0	48.4	15.0
Parity								
Primiparous	52.6	16.6	58.3	18.9	23.1	5.9	49.9	13.2
Multiparous	51.7	22.7	58.7	26.8	23.0	7.9	47.2	16.5
Marital status								
Married	59.8	24.0	61.9	25.3	35.8	12.3	55.3	18.8
Unmarried	30.8	7.7	40.3	9.8	17.2	4.6	37.5	8.6
Maternal age								
<20 yr	30.2	6.2	36.8	7.2	13.5	3.6	35.3	6.9
20-24 yr	45.2	12.7	50.8	14.5	19.4	4.7	46.9	12.6
25-29 yr	58.8	22.9	63.1	25.0	29.9	9.4	56.2	19.5
30-34 yr	65.5	31.4	70.1	34.8	35.4	13.6	57.6	23.4
≥35 yr	66.5	36.2	71.9	40.5	35.6	14.3	53.9	24.4
Maternal education								
No college	42.1	13.4	48.3	15.6	17.6	5.5	42.6	12.2
College[d]	70.7	31.1	74.7	34.1	41.1	12.2	66.5	23.4
Family income								
<$7,000	28.8	7.9	36.7	9.4	14.5	4.3	35.3	10.3
$7,000-$14,999	44.0	13.5	49.0	15.2	23.5	7.3	47.2	13.0
$15,000-$24,999	54.7	20.4	57.7	22.3	31.7	8.7	52.6	16.5
≥$25,000	66.3	27.6	67.8	28.7	42.8	14.5	65.4	23.0
Maternal employment								
Full time	50.8	10.2	54.8	10.8	30.6	6.9	50.4	9.5
Part time	59.4	23.0	63.8	25.5	26.0	6.6	59.4	17.7
Not employed	51.0	23.1	58.7	27.5	19.3	7.2	46.0	16.7
U.S. census region								
New England	52.2	20.3	53.2	21.4	35.6	5.0	47.6	14.9
Middle Atlantic	47.4	18.4	52.4	21.8	30.6	9.7	41.4	10.8
East North Central	47.6	18.1	53.2	20.7	21.0	7.2	46.2	12.6
West North Central	55.9	19.9	58.2	20.7	27.7	7.9	50.8	22.8
South Atlantic	43.8	14.8	53.8	18.7	19.6	5.7	48.0	13.8
East South Central	37.9	12.4	45.1	15.0	14.2	3.7	23.5	5.0
West South Central	46.0	14.7	56.2	18.4	14.5	3.8	39.2	11.4
Mountain	70.2	30.4	74.9	33.0	31.5	11.0	53.9	18.2
Pacific	70.3	28.7	76.7	33.4	43.9	15.0	58.5	19.7

[a] Mothers were surveyed when their infants were 6 months of age. They were asked to recall the method of feeding the infant when in the hospital, at age 1 week, at months 1 through 5, and on the day preceding completion of the survey. Numbers in the columns labeled "5-6 Mo Infants" are an average of the 5-month and previous day responses.

[b] Based on data from Ross Laboratories.

[c] Hispanic is not exclusive of white or black.

[d] College includes all women who reported completing at least 1 year of college.

Source: NAS, 1991.

Table 14-13. Breast Milk Intake Studies

Study	Number of Individuals	Type of Feeding	Sampling Time and Interval	Population Studied	Comments
KEY STUDIES					
Butte et al., 1984	45	Exclusively breast-fed for first 4 months	Most infants studied over 1 day only, at 1, 2, 3, 4 months some studied over 48 to 96 hours to study individual variability	Mid- to upper-socioeconomic stratum	Estimated breast milk intake; corrected for insensible water loss
Dewey et al., 1991a; 1991b	73	Breast-fed for 12 months; exclusively breast-fed for at least first 4 months	Test weighing over 4-day period every 3 months for 1 year	Highly educated, high-socioeconomic class from Davis area of California	Estimated breast milk intake; corrected for insensible water loss
Dewey and Lönnerdal, 1983	20	Most infants exclusively breast-fed	Two test weighings per month for 6 months	Mid to upper class from Davis area of California	Estimated breast milk intake; did not correct for insensible water loss
Neville et al., 1988	13	Exclusively breast-fed infants	Infants studied over 24-hour period at each sampling interval; numerous sampling intervals over first year of life	Nonsmoking Caucasian mothers; middle- to upper-socioeconomic status	Estimated breast milk intake and lipid intake; corrected for insensible water loss; estimated frequency and duration of feeding
Pao et al., 1980	22	Completely or partially breast-fed infants	Three consecutive days at 1, 3, 6, and 9 months	White middle class from southeastern Ohio	Estimated breast milk intake; did not correct for insensible water loss

Table 14-13. Breast Milk Intake Studies (continued)

Study	Number of Individuals	Type of Feeding	Sampling Time and Interval	Population Studied	Comments
RELEVANT STUDIES					
Axelsson et al., 1987	30	Breast-fed infants and infants fed formula with two different energy contents	Studied over 2-day periods at 4.5 and 5.5 months of age	Swedish infants	Measured intake rates; not corrected for insensible water loss
Brown et al., 1986a; 1986b	58, 60	Breast-fed infants	Studied over 3 days at each interval	Bangledeshi infants; marginally nourished mothers	Measured milk and nutrient intake based on nutritional status; not corrected for insensible water loss
Hofvander et al., 1982	50	25 breast-fed and 25 formula-fed infants	Studied 24-hour period at 1, 2, and 3 months	Swedish infants	Estimated breast milk and formula intake; no corrections for insensible water loss among breast-fed infants; estimated frequency of feeding
Köhler et al., 1984	59	25 fully breast-fed and 34 formula-fed infants	Studied over 48-hour periods at 6, 14, 22, and 26 weeks of age	Swedish infants	Estimated breast milk and formula intake based on nutritional status; no corrections for insensible water loss among breast-fed infants
Maxwell and Burmaster, 1993	1,113	Population of 1,113 breast-fed infants based on a hypothetical population of 5,000 breast-fed and bottle-fed infants	NA	NA	Simulated distribution of breast milk intake based on data from Dewey 1991a; estimated percent of breast-fed infants under 12 months of age
NAS, 1991	NA	Breast-fed infants	NA	NA	Summarizes current state-of-knowledge on breast milk volume, composition and breast-feeding populations

Table 14-14. Confidence in Breast Milk Intake Recommendations		
Considerations	Rationale	Rating
Study Elements		
• Level of peer review	All key studies are from peer review literature.	High
• Accessibility	Papers are widely available from peer review journals.	High
• Reproducibility	Methodology used was clearly presented.	High
• Focus on factor of interest	The focus of the studies was on estimating breast milk intake.	High
• Data pertinent to U.S.	Subpopulations of the U.S. were the focus of all the key studies.	High
• Primary data	All the studies were based on primary data.	High
• Currency	Studies were conducted between 1980-1986. Although incidence of breast feeding may change with time, breast milk intake among breastfed infants may not.	Medium
• Adequacy of data collection period	Infants were not studied long enough to fully characterize day to day variability.	Medium
• Validity of approach	Methodology uses changes in body weight as a surrogate for total ingestion. This is the best methodology there is to estimate breast milk ingestion. Mothers were instructed in the use of infant scales to minimize measurement errors. Three out of the 5 studies corrected data for insensible water loss.	Medium
• Study size	The sample sizes used in the key studies were fairly small (range 13-73).	
• Representativeness of the population	Population is not representative of the U.S.; only mid-upper class, well nourished mothers were studied. Socioeconomic factors may affect the incidence of breastfeeding. Mother's nourishment may affect milk production.	Low
• Characterization of variability	Not very well characterized. Infants under 1 month not captured, mothers committed to breast feeding over 1 year not captured.	Low
• Lack of bias in study design (high rating is desirable)	Bias in the studies was not characterized. Three out of 5 studies corrected for insensible water loss. Not correcting for insensible water loss may underestimate intake. Mothers selected for the studies were volunteers; therefore response rate does not apply. Population studied may introduce some bias in the results (see above).	Low
• Measurement error	All mothers were well educated and trained in the use of the scale which helped minimize measurement error.	Medium
Other Elements		
• Number of studies	There are 5 key studies.	High
• Agreement between researchers	There is good agreement among researchers.	High
Overall Rating	Studies were well designed. Results were consistent. Sample size was fairly low and not representative of U.S. population or population of nursing mothers. Variability cannot be characterized due to limitations in data collection period.	Medium

Table 14-15. Breast Milk Intake Rates Derived From Key Studies

Mean (mL/day)	N	Upper Percentile (mL/day) (mean plus 2 standard deviations)	Reference
Age: 1 Month			
600	11	918	Pao et al., 1980
729	37	981	Butte et al., 1984
747	13	1,095	Neville et al., 1988
673	16	1,057	Dewey and Lönnerdal, 1983
weighted avg = 702		1,007[a]	
Age: 3 Months			
833	2	---	Pao et al., 1980
702	37	923	Butte et al., 1984
712	12	934	Neville et al., 1988
782	16	1,126	Dewey and Lönnerdal, 1983
788	73	1,046	Dewey et al., 1991b
weighted avg = 759		1,025[a]	
Age: 6 Months			
682	1	---	Pao et al., 1980
744	13	978	Neville et al., 1988
896	11	1,140	Dewey and Lönnerdal, 1983
747	60	1,079	Dewey et al., 1991b
weighted avg = 765		1,059[a]	
Age: 9 Months			
600	12	1,027	Neville et al., 1988
627	50	1,049	Dewey et al., 1991b
avg = 622		1,038	
Age: 12 Months			
391	9	877	Neville et al., 1988
435	42	923	Dewey et al., 1991a; 1991b
weighted avg = 427		900	
12-MONTH TIME WEIGHTED AVERAGE		Range 900-1,059 (middle of the range 980)	
688			

[a] Middle of the range.

Table 14-16. Summary of Recommended Breast Milk and Lipid Intake Rates

Age	Mean	Upper Percentile
Breast Milk		
1-6 Months	742 mL/day	1,033 mL/day
12 Month Average	688 mL/day	980 mL/day
Lipids[a]		
<1 Year	26.0 mL/day	40.4 mL/day

[a] The recommended value for the lipid content of breastmilk is 4.0 percent.

REFERENCES FOR CHAPTER 14

Axelsson, I.; Borulf, S.; Righard, L.; Räihä, N. (1987) Protein and energy intake during weaning: effects and growth. Acta Paediatr. Scand. 76:321-327.

Brown, K.H.; Akhtar, N.A.; Robertson, A.D.; Ahmed, M.G. (1986a) Lactational capacity of marginally nourished mothers: relationships between maternal nutritional status and quantity and proximate composition of milk. Pediatrics. 78: 909-919.

Brown, K.H.; Robertson, A.D.; Akhtar, N.A. (1986b) Lactational capacity of marginally nourished mothers: infants' milk nutrient consumption and patterns of growth. Pediatrics. 78: 920-927.

Butte, N.F.; Garza, C.; Smith, E.O.; Nichols, B.L. (1984) Human milk intake and growth in exclusively breast-fed infants. Journal of Pediatrics. 104:187-195.

Dewey, K.G.; Lönnerdal, B. (1983) Milk and nutrient intake of breast-fed infants from 1 to 6 months: relation to growth and fatness. Journal of Pediatric Gastroenterology and Nutrition. 2:497-506.

Dewey, K.G.; Heinig, J.; Nommsen, L.A.; Lönnerdal, B. (1991a) Maternal versus infant factors related to breast milk intake and residual volume: the DARLING study. Pediatrics. 87:829-837.

Dewey, K.G.; Heinig, J.; Nommsen, L.; Lönnerdal, B. (1991b) Adequacy of energy intake among breast-fed infants in the DARLING study: relationships to growth, velocity, morbidity, and activity levels. The Journal of Pediatrics. 119:538-547.

Hofvander, Y.; Hagman, U.; Hillervik, C.; Sjolin, S. (1982) The amount of milk consumed by 1-3 months old breast- or bottle-fed infants. Acta Paediatr. Scand. 71:953-958.

Köhler, L.; Meeuwisse, G.; Mortensson, W. (1984) Food intake and growth of infants between six and twenty-six weeks of age on breast milk, cow's milk formula, and soy formula. Acta Paediatr. Scand. 73:40-48.

Lönnerdal, B.; Forsum, E.; Gebre-Medhim, M.; Hombraes, L. (1976) Breast milk composition in Ethiopian and Swedish mothers: lactose, nitrogen, and protein contents. The American Journal of Clinical Nutrition. 29:1134-1141.

Maxwell, N.I.; Burmaster, D.E. (1993) A simulation model to estimate a distribution of lipid intake from breast milk during the first year of life. Journal of Exposure Analysis and Environmental Epidemiology. 3:383-406.

National Academy of Sciences (NAS). (1991) Nutrition during lactation. Washington, DC. National Academy Press.

Neville, M.C.; Keller, R.; Seacat, J.; Lutes, V.; Neifert, M.; et al. (1988) Studies in human lactation: milk volumes in lactating women during the onset of lactation and full lactation. American Journal of Clinical Nutrition. 48:1375-1386.

Pao, E.M.; Hines, J.M.; Roche, A.F. (1980) Milk intakes and feeding patterns of breast-fed infants. Journal of the American Dietetic Association. 77:540-545.

Ryan, A.S.; Rush, D.; Krieger, F.W.; Lewandowski, G.E. (1991) Recent declines in breastfeeding in the United States, 1984-1989. Pediatrics. 88:719-727.