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2. BREAST MILK INTAKE

2.1 INTRODUCTION

Breast feeding is known to impart a wide range of benefits to nursing infants, including protection against infection, increases in cognitive development, and avoidance of allergies due to intolerance to cow's milk. The American Academy of Pediatrics recommends exclusive breast feeding for approximately the first six months and supports the continuation of breast feeding for the first year and beyond if desired by the mother and child (APP, 2005). However, contaminants may find their way into breast milk of lactating mothers. Lipid soluble chemical compounds accumulate in body fat and may be transferred to breast-fed infants in the lipid portion of breast milk. Water soluble chemicals may also partition into the aqueous phase and be excreted via 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 milk intake rate (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 weight 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).

1 Studies among nursing mothers in industrialized countries have shown that intakes
2 among infants average approximately 750 to 800 g/day (728 to 777 mL/day) during the first 4 to
3 5 months of life with a range of 450 to 1,200 g/day (437 to 1,165 mL/day) (NAS, 1991). Similar
4 intakes have also been reported for developing countries (NAS, 1991). Infant birth weight has
5 been shown to influence the rate of intake (NAS, 1991). Infants who are larger at birth and/or
6 nurse more frequently have been shown to have higher intake rates.

7 Key studies on breast milk intake are summarized in the following sections.
8 Recommended intake rates are based on the results of these key studies, as described in the
9 *Exposure Factors Handbook*. Relevant data on lipid content and fat intake, breast-feeding
10 duration, and the estimated percentage of the U.S. population that breast-feeds are also presented.

11 12 **2.2 STUDIES ON BREAST MILK INTAKE**

13 **2.2.1 Pao et al., 1980**

14 Pao et al. (1980) conducted a study of 22 healthy breast-fed infants to estimate breast
15 milk intake rates. Infants were categorized as completely breast-fed or partially breast-fed.
16 Breast feeding mothers were recruited through LaLeche League groups. Except for one black
17 infant, all other infants were from white middle-class families in southwestern Ohio. The goal of
18 the study was to enroll infants as close to one month of age as possible and to obtain records near
19 one, three, six, and nine months of age (Pao et al., 1980). However, not all mother/infant pairs
20 participated at each time interval. Data were collected for these 22 infants using the test
21 weighing method. Records were collected for three consecutive 24-hour periods at each test
22 interval. The weight of breast milk was converted to volume by assuming a density of 1.03
23 g/mL. Daily intake rates were calculated for each infant based on the mean of the three 24-hour
24 periods. Mean daily breast milk intake rates for the infants surveyed at each time interval are
25 presented in Table 2-1. These data (Table 2-1) are presented as they are in the report of Pao
26 (1980). For completely breast-fed infants, the mean intake rates were 600 mL/day at 1 month of
27 age, 833 mL/day at 3 months of age, and 682 mL/day at 6 months of age. Partially breast-fed
28 infants had mean intake rates of 485 mL/day, 467 mL/day, 395 mL/day, and <554 mL/day at 1, 3,
29 6, and 9 months of age, respectively. Pao et al. (1980) also noted that intake rates for boys in
30 both groups were slightly higher than for girls.

1 The advantage of this study is that data for both exclusively and partially breast-fed
2 infants were collected for multiple time periods. Also, data for individual infants were collected
3 over 3 consecutive days which would account for some individual variability. However, the
4 number of infants in the study was relatively small. In addition, this study did not account for
5 insensible weight loss which may underestimate the amount of breast milk ingested.

6 7 **2.2.2 Dewey and Lönnerdal, 1983**

8 Dewey and Lönnerdal (1983) monitored the dietary intake of 20 breast-fed infants
9 between the ages of 1 and 6 months. Most of the infants in the study were exclusively breast-fed
10 (five were given some formula, and several were given small amounts of solid foods after
11 3 months of age). According to Dewey and Lönnerdal (1983), the mothers were all well
12 educated and recruited through Lamaze childbirth classes in the Davis area of California. Breast
13 milk intake volume was estimated based on two 24-hour test weighings per month. Breast milk
14 intake rates for the various age groups are presented in Table 2-2. Breast milk intake averaged
15 673, 782, and 896 mL/day at 1, 3, and 6 months of age, respectively.

16 The advantage of this study is that it evaluated breast-fed infants for a period of 6 months
17 based on two 24-hour observations per infant per month. However, corrections for insensible
18 weight loss apparently were not made. Also, the number of infants in the study was relatively
19 small and the study participants were not representative of the general population.

20 21 **2.2.3. Butte et al., 1984**

22 Breast milk intake was studied in exclusively breast-fed infants during the first 4 months
23 of life (Butte et al., 1984). Breastfeeding mothers were recruited through the Baylor Milk Bank
24 Program in Texas. Forty-five mother/infant pairs participated in the study. However, data for
25 some time periods (i.e., 1, 2, 3, or 4 months) were missing for some mothers as a result of illness
26 or other factors. The mothers were from the middle- to upper-socioeconomic stratum and had a
27 mean age of 28.0 ± 3.1 years. A total of 41 mothers were white, 2 were Hispanic, 1 was Asian,
28 and 1 was West Indian. Infant growth progressed satisfactorily over the course of the study.

29 The amount of milk ingested over a 24-hour period was determined by weighing the
30 infant before and after feeding. To estimate insensible weight loss, the change in weight of a
31 bottle-fed infant during feeding was compared to the change in weight of the bottle. Based on

1 nine successive feedings, insensible weight loss in this infant was estimated to be 3.2 ± 3.1 g.
2 Test weighing occurred over a 24-hour period for most study participants, but intake among
3 several infants was studied over longer periods (48 to 96 hours) to assess individual variation in
4 intake. Mean breast milk intake ranged from 723 g/day (702 mL/day) at 3 months to 751 g/day
5 (729 mL/day) at 1 month, with an overall mean of 733 g/day (712 mL/day) for the entire study
6 period (Table 2-3). Intakes were also calculated on the basis of body weight (Table 2-3). Based
7 on the results of test weighings conducted over 48 to 96 hours, the overall mean variation in
8 individual daily intake was estimated to be $7.9 \pm 3.6\%$.

9 The advantage of this study is that data for a larger number of exclusively breast-fed
10 infants were collected than were collected by Pao et al. (1980). However, data were collected
11 over a shorter time period (i.e., 4 months compared to 6 months) and day-to-day variability was
12 not characterized for all infants.

14 **2.2.4. Neville et al., 1988**

15 Neville et al. (1988) studied breast milk intake among 13 infants during the first year of
16 life. The mothers were all multiparous, nonsmoking, Caucasian women of middle- to
17 upper-socioeconomic status living in Denver, CO. All women in the study practiced exclusive
18 breast-feeding for at least 5 months. Solid foods were introduced at mean age of 7 months.
19 Daily milk intake was estimated by the test weighing method with corrections for insensible
20 weight loss. Data were collected daily from birth to 14 days, weekly from weeks 3 through 8,
21 and monthly until the study period ended at 1 year after inception. The estimated breast milk
22 intakes for this study are listed in Table 2-4. Mean breast milk intakes were 770 g/day (748
23 mL/day), 734 g/day (713 mL/day), 766 g/day (744 mL/day), and 403 g/day (391 mL/day) at 1, 3,
24 6, and 12 months of age, respectively.

25 In comparison to the previously described studies, Neville et al. (1988) collected data on
26 numerous days over a relatively long time period (12 months) and they were corrected for
27 insensible weight loss. However, the intake rates presented in Table 2-4 are estimated based on
28 intake during only a 24-hour period. Consequently, these intake rates are based on short-term
29 data that do not account for day-to-day variability among individual infants. Also, a smaller
30 number of subjects was included than in the previous studies.

1 **2.2.5. Dewey et al., 1991a, b**

2 The Davis Area Research on Lactation, Infant Nutrition and Growth (DARLING) study
3 was conducted in 1986 to evaluate growth patterns, nutrient intake, morbidity, and activity levels
4 in infants who were breast-fed for at least the first 12 months of life (Dewey et al., 1991a, b).
5 Seventy-three infants aged 3 months were included in the study. At subsequent time intervals, the
6 number of infants included in the study at was somewhat lower as a result of attrition. All
7 infants in the study were healthy and of normal gestational age and weight at birth, and did not
8 consume solid foods until after the first 4 months of age. The mothers were highly educated and
9 of “relatively high socioeconomic status.”

10 Breast milk intake was estimated by weighing the infants before and after each feeding
11 and correcting for insensible water loss. Test weighings were conducted over a 4-day period
12 every 3 months. This decline is associated with the intake of solid food. The results of the study
13 indicate that breast milk intake declines over the first 12 months of life. Mean breast milk intake
14 was estimated to be 812 g/day (788 mL/day) at 3 months and 448 g/day (435 mL/day) at 12
15 months (Table 2-5). Based on the estimated intakes at 3 months of age, variability between
16 individuals (coefficient of variation ([CV]) = 16.3%) was higher than the average day-to-day
17 variability ([CV] = 8.9 ± 5.4%) for the infants in the study (Dewey et al., 1991a).

18 The advantages of this study are that data were collected over a relatively long-time
19 (4 days) period at each test interval which would account for some day-to-day infant variability,
20 and corrections for insensible water loss were made.

21

22 **2.3 STUDIES ON LIPID CONTENT AND FAT INTAKE FROM BREAST MILK**

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

1 contaminant(s) have residue concentrations that are indexed to the fat portion of human breast
2 milk.

3 4 **2.3.1 Butte et al., 1984**

5 Butte et al. (1984) analyzed the lipid content of breast milk samples taken from women
6 who participated in a study of breast milk intake among exclusively breast-fed infants. The study
7 was conducted with over 40 women during a 4-month period. The mean lipid content of breast
8 milk at various infants' ages is presented in Table 2-6. The overall lipid content for the 4-month
9 study period was 34.3 ± 6.9 mg/g (3.4%). Butte et al. (1984) also calculated lipid intakes from
10 24-hour breast milk intakes and the lipid content of the human milk samples. Lipid intake was
11 estimated to range from 23.6 g/day (3.8 g/kg-day) to 28.0 g/day (5.9 g/kg-day).

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

17 18 **2.3.1 Maxwell and Burmaster, 1993**

19 Maxwell and Burmaster (1993) used a hypothetical population of 5000 infants between
20 birth and 1 year of age to simulate a distribution of daily lipid intake from breast milk. The
21 hypothetical population represented both bottle-fed and breast-fed infants aged 1 to 365 days. A
22 distribution of daily lipid intake was developed, based on data in Dewey et al. (1991b) on breast
23 milk intake for infants at 3, 6, 9, and 12 months and breast milk lipid content, and survey data in
24 Ryan et al. (1991) on the percentage of breast-fed infants under the age of 12 months (i.e.,
25 approximately 22%). A model was used to simulate intake among 1113 of the 5000 infants that
26 were expected to be breast-fed. The results of the model indicated that lipid intake among
27 nursing infants under 12 months of age can be characterized by a normal distribution with a mean
28 of 26.8 g/day and a standard deviation of 7.4 g/day (Table 2-7). The model assumes that nursing
29 infants are completely breast-fed and does not account for infants who are breast-fed longer than
30 1 year. Based on data collected by Dewey et al. (1991b), Maxwell and Burmaster (1993)
31 estimated the lipid content of breast milk to be 36.7 g/L at 3 months (35.6 mg/g or 3.6%), 39.2

1 g/L at 6 months (38.1 mg/g or 3.8%), 41.6 g/L at 9 months (40.4 mg/g or 4.0%), and 40.2 g/L at
2 12 months (39.0 mg/g or 3.9%).

3 The advantage of this study is that it provides a “snapshot” of daily lipid intake from
4 breast milk for breast-fed infants. These results are, however, based on a simulation model and
5 there are uncertainties associated with the assumptions made. The estimated mean lipid intake
6 rate represents the average daily intake for nursing infants under 12 months of age. These data
7 are useful for performing exposure assessments when the age of the infant cannot be specified
8 (i.e., 3 months or 6 months). Also, because intake rates are indexed to the lipid portion of the
9 breast milk, they may be used in conjunction with residue concentrations indexed to fat content.
10 However, the study did not generate “new” data. A reanalysis of previously reported data on
11 breast milk intake and breast milk lipid intake were provided.
12

13 **2.4 OTHER FACTORS**

14 Other factors associated with breast milk intake include: the frequency of breast-feeding
15 sessions per day, the duration of breast-feeding per event, the duration of breast-feeding during
16 childhood, and the magnitude and nature of the population that breast-feeds (i.e., socioeconomic
17 factors, ethnicity, etc.).
18

19 **2.4.1. Population of Nursing Infants**

20 According to the National Academy of Sciences (NAS), the percentage of breast-feeding
21 women has changed dramatically over the years (NAS, 1991). The Ross Products Division of
22 Abbott Laboratories conducted a large national mail survey in 1995 to determine patterns of
23 breast feeding during the first 6 months of life. The Ross Laboratory Mothers’s Survey was first
24 developed in 1955 and has been expanded to include many more infants. Before 1991, the
25 survey was conducted on a quarterly basis, and approximately 40,000 to 50,000 questionnaires
26 were mailed each quarter (Ryan, 1997). Beginning in 1991, the survey was conducted monthly;
27 35,000 were mailed each month. Over time, the response rate has been consistently in the range
28 of $50 \pm 5\%$. In 1989 and 1995, 196,000 and 720,000 questionnaires were mailed, respectively.
29 Ryan (1997) reported rates of breast-feeding through 1995 and compared them with those in
30 1989.

1 The survey demonstrates recent increases in both the initiation of breast-feeding and
2 continued breast-feeding at 6 months of age. Table 2-7 presents the percent of breast-feeding in
3 hospitals and at 6 months of age by selected demographic characteristics. In 1995, the incidence
4 of breast-feeding at birth and at 6 months for all infants was approximately 60% and 22 %,
5 respectively. The largest increases in the initiation of breast-feeding between 1989 and 1995
6 occurred among women who (1) were Black, were less than 25 years of age, earned less than
7 \$10,000 per year, had no more than grade school education, and were living in the South Atlantic
8 region of the U.S.; (2) had infants of low birth weight; (3) were employed full time outside the
9 home at the time they received the survey; and (4) participated in the Women, Infants, and
10 Children program (WIC). In 1995, as in 1989, the initiation of breast-feeding was highest among
11 women who were greater than 35 years of age, earned more than \$25,000 per year, and were
12 college educated; women who did not participate in the WIC program; and women who were
13 living in the Mountain and Pacific regions of the U.S.

14 Data on the actual length of time that infants continue to breast-feed beyond 5 or 6
15 months are limited (NAS, 1991). However, Maxwell and Burmaster (1993) estimated that
16 approximately 22 percent of infants under 1 year of age are breast-fed. This estimate is based on
17 a reanalysis of survey data in Ryan et al. (1991) collected by Ross Laboratories (Maxwell and
18 Burmaster, 1993).

20 **2.4.2. Intake Rates Based on Nutritional Status**

21 Information on differences in the quality and quantity of breast milk on the basis of ethnic
22 or socioeconomic characteristics of the population is limited. Lönnerdal et al. (1976) studied
23 breast milk volume and composition (nitrogen, lactose, proteins) among underprivileged and
24 privileged Ethiopian mothers. No significant differences were observed between the data for
25 these two groups. Similar data were observed for well-nourished Swedish mothers. Lönnerdal et
26 al. (1976) stated that these results indicate that breast milk quality and quantity are not affected
27 by maternal malnutrition. However, Brown et al. (1986a, b) noted that the lactational capacity
28 and energy concentration of marginally-nourished women in Bangladesh were “modestly less
29 than in better nourished mothers.” Breast milk intake rates for infants of marginally-nourished
30 women in this study were 690 ± 122 g/day at 3 months, 722 ± 105 g/day at 6 months, and $719 \pm$
31 119 g/day at 9 months of age (Brown et al., 1986a). Brown et al. (1986a) observed that breast

1 milk from women with larger measurements of arm circumference and triceps skinfold thickness
2 had higher concentrations of fat and energy than mothers with less body fat. Positive correlations
3 between maternal weight and milk fat concentrations were also observed. These results suggest
4 that milk composition may be affected by maternal nutritional status.

5 6 **2.5 RECOMMENDATIONS**

7 The studies described in this section were used in selecting recommended values for
8 breast milk intake, fat content and fat intake, and other related factors. Although different survey
9 designs, testing periods, and populations were utilized by the studies to estimate intake, the mean
10 and standard deviation estimates reported in these studies are relatively consistent. There are,
11 however, limitations with the data. With the exception of Butte (1984), data were not presented
12 on a body weight basis. This is particularly important since intake rates may be higher on a body
13 weight basis for younger infants. Also, the data used to derive the recommendations are over 15
14 years old and the sample size of the studies was small. Other subpopulations of concern such as
15 mothers highly committed to breast feeding— sometimes for periods longer than 1 year— may
16 not be captured by the studies presented in this chapter. Further research is needed to identify
17 these subgroups and to get better estimates of breast milk intake rates. Table 2-8 presents the
18 confidence rating for breast milk intake recommendations.

19 20 **2.5.1 Breast Milk Intake**

21 The breast milk intake rates for nursing infants that have been reported in the studies
22 described in this section are summarized in Table 2-9. It should be noted that the decrease in
23 breast milk intake with age is likely a result of complementary foods being introduced as the
24 child grows and not necessarily a decrease in total energy intake. In order to conform to the new
25 standardized age groupings used in this Handbook (see Chapter 1), data from Pao et al. (1980),
26 Dewey and Lönnerdal (1983), Butte et al. (1984), Neville et al. (1988), Dewey et al. (1991a), and
27 Dewey et al. (1991b) were compiled for each month of the first year of life. For some months
28 multiple studies were available; for others only one study was available. Weighted means were
29 calculated for each age in months. Upper percentiles were calculated as the midpoint of the range
30 of upper percentiles of the studies available for each age in months. These month-by-month
31 intakes were composited to yield intakes for the standardized age groups by taking an

1 unweighted average, assuming that in the general population, each age (e.g., 3, 4, and 5 months)
2 is equally represented.

3

4 **2.5.2 Lipid Content and Lipid Intake**

5 Recommended lipid intake rates are presented in Table 2-10. The table parallels the
6 breast milk intake table (Table 2-9). Figures were calculated assuming a lipid content of 4%
7 (Butte et al.,1984; NAS, 1991; Maxwell and Burmaster, 1993). An exception to this method was
8 employed in the case of the Butte et al. (1984) study, where lipid intakes were provided in the
9 study. The values from the study were used in place of the estimated lipid intakes.

10

11

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Table 2-1. Daily Intakes of Breast Milk

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

^aData expressed as mean \pm standard deviation.

Source: Pao et al., 1980.

Table 2-2. Breast Milk Intakes for infants aged 1 to 6 months

Age (months)	Number of Infants	Intake	
		Mean \pm SD (mL/day)	Intake Range (mL/day)
1	16	673 \pm 192	341-1003
2	19	756 \pm 170	449-1055
3	16	782 \pm 172	492-1053
4	13	810 \pm 142	593-1045
5	11	805 \pm 117	554-1045
6	11	896 \pm 122	675-1096

Source: Dewey and Lönnerdal, 1983

Table 2-3. Breast Milk Intake among Exclusively Breast-fed Infants During the First 4 Months of Life

Age (months)	Number of Infants	Intake (g/day)	Intake (g/kg-day)	Body Weight ^a (kg)
		Mean ± SD	Mean ± SD	
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

^aCalculated by dividing breast milk intake (g/day) by breast milk intake (g/kg-day).

Source: Butte et al., 1984

Table 2-4. Breast Milk Intake During a 24-hour Period

Age (days)	Number of Infants	Intake (g/day)		Intake by age category (g/d) ^b
		Mean ± SD	Range	
1	6	44 ± 71	-31-149 ^a	526 ± 227
2	9	182 ± 86	44-355	
3	10	371 ± 153	209-688	
4	10	451 ± 176	164-694	
5	11	498 ± 129	323-736	
6	9	508 ± 167	315-861	
7	7	573 ± 167	406-842	
8	8	581 ± 159	410-923	
9	9	580 ± 76	470-720	
10	9	589 ± 132	366-866	
11	8	615 ± 168	398-934	
14	9	653 ± 154	416-922	
21	10	651 ± 84	554-786	
28	13	770 ± 179	495-1144	
35	12	668 ± 117	465-930	699 ± 108
42	12	711 ± 111	554-896	
49	10	709 ± 115	559-922	
56	12	694 ± 98	556-859	
90	10	734 ± 114	613-942	734 ± 114
120	12	711 ± 100	570-847	711 ± 100
150	12	838 ± 134	688-1173	838 ± 134
180	13	766 ± 121	508-936	766 ± 121
210	12	721 ± 154	486-963	721 ± 154
240	9	622 ± 210	288-1002	622 ± 210
270	12	618 ± 220	223-871	618 ± 220
300	11	551 ± 234	129-894	551 ± 234
330	8	554 ± 240	120-860	554 ± 240
360	8	403 ± 250	65-770	403 ± 250

^aNegative value due to insensible weight loss correction.

^bMultiple data sets were combined by producing simulated data sets fitting the known mean and SD for each age, compositing the data sets to correspond to age groups of 0 to <1 month and 1 to <2 months, and calculating new means and SD's on the composited data.

SD = standard deviation.

Source: Neville et al., 1988

Table 2-5. Breast Milk Intake Estimated by the DARLING Study

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

Source: Dewey et al., 1991b

Table 2-6. Lipid Content of Human Milk and Estimated Lipid Intake among Exclusively Breast-fed Infants

Age (months)	Number of Observations	Lipid Content (mg/g)	Lipid Content % ^a	Lipid Intake (g/day) Mean ± SD	Lipid Intake (g/kg-day) Mean ± SD
		Mean ± SD			
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

^aPercents calculated from lipid content reported in mg/g.

Source: Butte, et al., 1984

Table 2-7. 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 and 1995, by Ethnic Background and Selected Demographic Variables

Characteristic	Percentage of Mothers Breast-Feeding					
	In Hospital			At 6 Months		
	1989	1995	Change ^a	1989	1995	Change ^a
All Infants	52.2	59.7	14.4	18.1	21.6	19.3
White	58.5	64.3	9.9	21.0	24.1	14.8
Black	23.0	37.0	60.9	6.4	11.2	75.0
Hispanic	48.4	61.0	26.0	13.9	19.6	41.0
Maternal Age (years)						
<20	30.2	42.8	41.7	5.6	9.1	62.5
20-24	4.2	52.6	16.4	11.5	14.6	27.0
25-29	58.8	63.1	7.3	21.1	22.9	8.5
30-34	65.5	68.1	4.0	29.3	29.0	(1.0) ^b
35+	66.5	70.0	5.3	34.0	33.8	(0.6) ^b
Total Family Income						
<\$10,000	31.8	41.8	31.4	8.2	11.4	39.0
\$10,000 - \$14,999	47.1	51.7	9.8	13.9	15.4	10.8
\$15,000 - \$24,999	54.7	58.8	7.5	18.9	19.8	4.8
≥25,000	66.3	70.7	6.6	25.5	28.5	11.8
Maternal Education						
Grade School	31.7	43.8	38.2	11.5	17.1	48.7
High School	42.5	49.7	16.9	12.4	15.0	21.0
College	70.7	74.4	5.2	28.8	31.2	8.3
Maternal Employment						
Employed Full Time	50.8	60.7	19.5	8.9	14.3	60.7
Employed Part Time	59.4	63.5	6.9	21.1	23.4	10.9
Not Employed	51.0	58.0	13.7	21.6	25.0	15.7
Birth Weight						
Low (≤2,500 g)	36.2	47.7	31.8	9.8	12.6	28.6
Normal	53.5	60.5	13.1	18.8	22.3	18.6
Parity						
Primiparous	52.6	61.6	17.1	15.1	19.5	29.1
Multiparous	51.7	57.8	11.8	21.1	23.6	11.8
WIC Participation ^c						
Participant	34.2	46.6	36.3	8.4	12.7	51.2
Nonparticipant	62.9	71.0	12.9	23.8	29.2	22.7
U.S. Census Region						
New England	52.2	61.2	17.2	18.6	22.2	19.4
Middle Atlantic	47.4	53.8	13.5	16.8	19.6	16.7
East North Central	47.6	54.6	14.7	16.7	18.9	13.2
West North Central	55.9	61.9	10.7	18.4	21.4	16.3
South Atlantic	43.8	54.8	25.1	13.7	18.6	35.8
East South Central	37.9	44.1	16.4	11.5	13.0	13.0
West South Central	46.0	54.4	18.3	13.6	17.0	25.0
Mountain	70.2	75.1	7.0	28.3	30.3	7.1
Pacific	70.3	75.1	6.8	26.6	30.9	16.2

a The percent change was calculated using the following formula: % breastfed in 1989 - % breastfed in 1984 / % breastfed in 1984.

b Figures in parentheses indicate a decrease in the rate of breastfeeding from 1989 to 1995.

c WIC indicates Women, Infants, and Children supplemental food program.

Source: Ryan, 1997

Table 2-8. Confidence in Breast Milk Intake Recommendations

Considerations	Rationale	Rating
Study Elements		
Level of peer review	All key studies are from peer reviewed literature.	High
Accessibility	Papers are widely available from peer reviewed 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 1980-1997.	Medium-High
Adequacy of data collection period	Infants were not studied long enough to fully characterize day to day variability. With the exception of Neville et al. (1988), the measurements were made in frequency (e.g., once a month) and the data may not represent the potential first year of lactation (both for less than 1 month of age and for longitudinal measurements of more than 6 months).	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; however, because there are limitations to this approach, the confidence rating was judged to be low. 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.	Low
Study size	The sample sizes used in the key studies were fairly small (range 13-73).	Low
Representativeness of the population	Population are representative of the general mother-infant pair population.	High
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. Two out of 5 studies corrected for insensible water loss.	Low
Measurement error	All mothers were well educated and trained in the use of the scale which helped minimize measurement error. 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).	Medium
Other Elements		
Number of studies	There are 5 key studies.	Medium
Agreement between researchers	There is good agreement among researchers.	High
Overall Rating	Studies were well designed. Results were consistent. Sample size was fairly low. Variability cannot be characterized due to limitations in data collection period.	Medium

Table 2-9. Breast Milk Intake Rates Derived from Key Studies

Age (months)	Number of Children	Mean Intake (mL/day)	Upper Percentile Consumption (mL/day) ^a	Reference	Weighted Mean Intake and Upper Percentile Consumption ^b (across all Key Studies) (mL/day)			
					individual age		composite ages	
					Mean	Upper	Mean ^d	Upper
0	128	511	952	Neville et al., 1988	511	952	511	952
1	11	600	918	Pao et al., 1980 Butte et al., 1984 Neville et al., 1988 Dewey and Lönnerdal, 1983	687	973	703	992
	37	729	982					
	13	679	888					
	16	673	1057					
2	10	713	934	Neville et al., 1988 Dewey and Lönnerdal, 1983 Butte et al., 1984	720	1015		
	19	756	1096					
	40	704	958					
3	2	833	— ^c	Pao et al., 1980 Butte et al., 1984 Neville et al., 1988 Dewey and Lönnerdal, 1983 Dewey et al., 1991b	757	1005	761	1005
	37	702	923					
	12	690	884					
	16	782	1126					
	73	788	1047					
4	12	814	1074	Neville et al., 1988 Dewey and Lönnerdal, 1983 Butte et al., 1984	754	1031		
	13	810	1094					
	41	718	967					
5	13	744	979	Neville et al., 1988 Dewey and Lönnerdal, 1983	772	1009		
	11	805	1039					
6	1	682	— ^c	Pao et al., 1980 Neville et al., 1988 Dewey and Lönnerdal, 1983 Dewey et al., 1991b	759	1070	584	1009
	12	700	999					
	11	896	1140					
	60	747	1079					
7	9	604	1012	Neville et al., 1988	604	1012		
8	12	600	1027	Neville et al., 1988	600	1027		
9	11	535	989	Neville et al., 1988 Dewey et al., 1991b	610	1019		
	50	627	1049					
10	8	538	1004	Neville et al., 1988	538	1004		
11	8	391	877	Neville et al., 1988	391	877		
12	42	435	922	Dewey et al., 1991a; 1991b	435	922	435	922

- ^a Upper percentile is reported (mean plus 2 standard deviations), except as noted.
^b Middle of the range.
^c Standard deviations and upper percentiles not calculated for small sample sizes.
^d Calculated as an unweighted mean, assuming that in the general population, each age (e.g., 3,4, and 5 months) is equally represented.

Table 2-10. Lipid Intake Rates Derived from Key Studies

Age (months)	Number of Children	Mean Intake (mL/day)	Upper Percentile Consumption (mL/day) ^a	Reference	Weighted Mean Intake and Upper Percentile Consumption ^b (across all Key Studies) (mL/day)			
					individual age		composite ages	
					Mean	Upper	Mean ^d	Upper
0	128	20.4	38.1	Neville et al., 1988	20	38	20	38
1	11	24.0	36.7	Pao et al., 1980 Butte et al., 1984 Neville et al., 1988 Dewey and Lönnerdal, 1983	27	40	27	40
	37	27.2	43.7					
	13	27.2	35.5					
	16	26.9	42.3					
2	10	28.5	37.4	Neville et al., 1988 Dewey and Lönnerdal, 1983 Butte et al., 1984	27	41		
	19	30.2	43.8					
	40	24.5	38.3					
3	2	33.3	— ^e	Pao et al., 1980 Butte et al., 1984 Neville et al., 1988 Dewey and Lönnerdal, 1983 Dewey et al., 1991b	29	40	29	40
	37	22.9	36.9					
	12	27.6	35.4					
	16	31.3	45.0					
	73	31.5	41.9					
4	12	32.6	43.0	Neville et al., 1988 Dewey and Lönnerdal, 1983 Butte et al., 1984	28	43		
	13	32.4	43.8					
	41	24.9	41.6					
5	13	29.8	39.2	Neville et al., 1988 Dewey and Lönnerdal, 1983	31	40		
	11	32.2	41.6					
6	1	27.3	— ^e	Pao et al., 1980 Neville et al., 1988 Dewey and Lönnerdal, 1983 Dewey et al., 1991b	30	43		
	12	28.0	40.0					
	11	35.8	45.6					
	60	29.9	43.2					
7	9	24.2	40.5	Neville et al., 1988	24	40	23	40
8	12	24.0	41.1	Neville et al., 1988	24	41		
9	11	21.4	39.6	Neville et al., 1988 Dewey et al., 1991b	24	41		
	50	25.1	42.0					
10	8	21.5	40.2	Neville et al., 1988	22	40		
11	8	15.6	35.1	Neville et al., 1988	16	35		
12	42	17.4	36.9	Dewey et al., 1991a; 1991b	17	37	17	37

^a Upper percentile is reported (mean plus 2 standard deviations), except as noted.

^b Middle of the range.

^c Standard deviations and upper percentiles not calculated for small sample sizes.

^d Calculated as an unweighted mean, assuming that in the general population, each age (e.g., 3, 4, and 5 months) is equally represented.

^e Calculated from breast milk intake assuming a lipid content of 4% (NAS, 1991; Butte et al., 1984, and Maxwell and Burmaster, 1993). EXCEPT data from Butte et al. (1984), where lipid data were provided.

Table 2-11. Summary of Recommended Breast Milk And Lipid Intake Rates

Age	Breast Milk Intake, mL/day		Lipid Intake ^a , mL/day	
	Mean	Upper Percentile	Mean	Upper Percentile
birth to < 1 month	511	952	20	30
1 to < 3 months	703	992	27	40
3 to < 6 months	761	1005	29	40
6 to < 12 months	584	1009	23	40
birth to 1 year	642	973	25	39

^aThe recommended value for the lipid content of breast milk is 4.0 percent. See Section 2.5.2.

^bMiddle of the range of upper percentile values.