TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (continued)

This page intentionally left blank

15. HUMAN MILK INTAKE

15.1. INTRODUCTION

Human lactation 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 (Gartner et al., 2005). Ingestion of human milk also has been associated with a reduction in risk of post-neonatal death in the United States. (Chen and Rogan, 2004). The American Academy of Pediatrics (AAP) recommends exclusive breast-feeding for approximately the first 6 months and supports the continuation of breast-feeding for the first year and beyond if desired by the mother and child (Gartner et al., 2005). However, contaminants may find their way into human milk of lactating mothers because mothers are themselves exposed, thus making human milk 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 human milk. Water soluble chemicals also may partition into the aqueous phase and be excreted via human milk. Because nursing infants obtain most—if not all—of their dietary intake from human milk, they are especially vulnerable to exposures to these compounds. Estimating the magnitude of the potential dose to infants from human milk requires information on the milk intake rate (quantity of human milk consumed per day) and the duration (months) over which breast-feeding occurs. Information on the fat content of human milk also is needed for estimating dose from human milk residue concentrations that have been indexed to lipid content.

Several studies have generated data on human milk intake. Typically, human 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 human 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 human milk consumed are made using the density of human milk (approximately 1.03 g/mL) (NAS, 1991). Techniques for measuring human milk intake using stable isotopes such as deuterium have been developed. The advantages of these techniques over test weighing procedures are that they are less burdensome for the mother and do not interfere with normal behavior (Albernaz et al., 2003). However, few data based on this technique were found in the literature.

Among infants born in 2004, 73.8% were breast-fed postpartum, 41.5% at 6 months, and 20.9% at 12 months. Studies of nursing mothers in industrialized countries have shown that average intakes among infants ranged from approximately 500 to 800 mL/day, with the highest intake reported for infants 3 to <6 months old (see Table 15-1).

The recommendations for human milk intake rates and lipid intake rates are provided in the next section along with a summary of the confidence ratings for these recommendations. The recommended values are based on key studies identified by U.S. Environmental Protection Agency (EPA) for this factor. Following the recommendations, key studies on human milk intake are summarized. Relevant data on lipid content and fat intake, breast-feeding duration, and the estimated percentage of the U.S. population that breast-feeds also are presented.

A number of other studies exist in the literature, but they focus on other aspects of lactation such as growth patterns of nursing infants, supplementary food and energy intake, and nutrition of lactating mothers (González-Cossío et al., 1998; Drewett et al., 1993; Dewey et al., 1992). These studies are not included in this chapter because they do not focus on the exposure factor of interest. Other studies in the literature focus on formula intake. Because some baby formula is prepared by adding water, these data are presented in Chapter 3-Ingestion of Water and Other Select Liquids.

15.2. RECOMMENDATIONS

The studies described in Section 15.3 were used in selecting recommended values for human milk intake and lipid intake. Although different survey designs, testing periods, and populations were used by the studies to estimate intake, the mean and standard deviation estimates reported in these studies are relatively consistent. There are, however, limitations with the data. With the exception of Butte et al. (1984) and Arcus-Arth et al. (2005), data were not presented on a body weight basis. This is particularly important because intake rates may be higher on a body weight basis for younger infants

than older infants. Also, the data used to derive the recommendations are more than 15 years old and the sample size of the studies was small. Other populations 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. Note that data for infants 12 months old are not included in the recommendation table because the U.S. EPA's standard age group for children, as described in Chapter 1 of this handbook, is 6 to <12 months and it may not be appropriate to use this value to represent the next age group of 1 to <2 years old.

15.2.1. Human Milk Intake

Table 15-1 presents a summary of recommended values for human milk and lipid intake rates, and Table 15-2 presents the confidence ratings for these recommendations. The human milk intake rates for nursing infants that have been reported in the studies described in this section are summarized in Table 15-3 in units of mL/day and in Table 15-4 in units of mL/kg-day (i.e., indexed to body weight). It should be noted that the decrease in human milk with age is likely a result of complementary foods being introduced as the child grows and not necessarily a decrease in total energy intake. To conform to the new standardized age groupings used in this handbook (see Chapter 1), data from Pao et al. (1980), Dewey and Lönnerdal (1983), Butte et al. (1984), Neville et al. (1988), Dewey et al. (1991a), Dewey et al. (1991b), Butte et al. (2000), and Arcus-Arth et al. (2005) were compiled for each month of the first year of life. Recommendations were converted to mL/day by using a density of human milk of 1.03 g/mL, and rounded to two significant figures. Only two studies [i.e., Butte et al. (1984), and Arcus-Arth et al. (2005)] provided data on a body weight basis. For some months, multiple studies were available; for others only one study was available. Weighted means were calculated for each age in months. When upper percentiles were not available from a study, they were estimated by adding two standard deviations to the mean value. When multiple studies were available, recommendations for upper percentiles were calculated as the midpoint of the range of upper percentile values of the studies available for each age in months. These month-by-month intakes were composited to yield intake rates for the standardized age groups by calculating a weighted average. Recommendations are provided for the population of exclusively breast-fed infants because this population may have higher exposures than partially breast-fed infants. *Exclusively breast-fed* in this chapter refers to infants whose sole source of milk comes from human milk, with no other milk substitutes. *Partially breast-fed* refers to infants whose source of milk comes from both human milk and other milk substitutes (i.e., formula). Note that some studies define partially breast-fed as infants whose dietary intake comes from not only human milk and formula, but also from other solid foods (e.g., strained fruits, vegetables, meats).

15.2.2. Lipid Content and Lipid Intake

Table 15-5 presents recommended lipid intake rates in units of mL/day. The table parallels the human milk intake tables (see Table 15-3). With the exception of the data from Butte et al. (1984), the rates were calculated assuming a lipid content of 4% (Kent et al., 2006; Arcus-Arth et al., 2005; Mitoulas et al., 2003; Mitoulas et al., 2002; NAS, 1991; Butte et al., 1984). In the case of the Butte et al. (1984) study, lipid intake rates were provided and were used in place of the estimated lipid intakes. Table 15-6 presents lipid intake rates on a body weight basis (mL/kg-day). These were calculated from the values presented in Table 15-4 multiplied by 4% lipid content.

Table 15-1. Recommended Values for Human Milk and Lipid Intake Rates for Exclusively Breast-Fed Infants

	Mean		Upper Percentile[a]		
Age Group	mL/day	mL/kg-day	mL/day	mL/kg-day	Source
		Human Milk Intake			
Birth to <1 month	510	150	950	220	b, c
1 to <3 months	690	140	980	190	b, c, d, e, f
3 to <6 months	770	110	1,000	150	b, c, d, e, f, g, h
6 to <12 months	620	83	1,000	130	b, c, d, f, g, h
		Lipid Intake[i]			
Birth to <1 month	20	6.0	38	8.7	b, c
1 to <3 months	27	5.5	40	8.0	b, c, d, e, f
3 to <6 months	30	4.2	42	6.1	b, c, d, e, f, g, h
6 to <12 months	25	3.3	42	5.2	b, c, d, f, g, h

[a] Upper percentile is reported as mean plus 2 standard deviations.
[b] Neville et al. (1988).
[c] Arcus-Arth et al. (2005).
[d] Pao et al. (1980).
[e] Butte et al. (1984).
[f] Dewey and Lönnerdal (1983).
[g] Butte et al. (2000).
[h] Dewey et al. (1991b).
[i] The recommended value for the lipid content of human milk is 4.0%. See Section 15.4

Table 15-2. Confidence in Recommendations for Human Milk Intake

General Assessment Factors	Rationale	Rating
Soundness		Medium
Adequacy of Approach	Methodology uses changes in body weight as a surrogate for total ingestion. More sophisticated techniques measuring stable isotopes have been developed, but data with this technique were not available. Sample sizes from individual studies were relatively small (7–108). Mothers selected for the studies were volunteers. The studies analyzed primary data.	
Minimal (or defined) Bias	Mothers were instructed in the use of infant scales to minimize measurement errors. Three out of the eight studies indicated correcting data for insensible water loss. Some biases may be introduced by including partially breast-fed infants.	
Applicability and Utility		Medium
Exposure Factor of Interest	The studies focused on estimating human milk intake.	
Representativeness	Most studies focused on the U.S. population, but were not national samples. Populations studied were mainly from high socioeconomic status. One study included populations from Sweden and Finland. However, this may not affect the amount of intake, but, rather, the prevalence and initiation of lactation.	
Currency	Studies were conducted between 1980 and 2000. However, this may not affect the amount of intake but rather the prevalence and initiation of lactation.	
Data Collection Period	Infants were not studied long enough to fully characterize day-to-day variability.	
Clarity and Completeness		Medium
Accessibility	All key studies are available from the peer-reviewed literature.	
Reproducibility	The methodology was clearly presented, but some studies did not discuss adjustments due to insensible weight loss.	
Quality Assurance	Some steps were taken to ensure data quality. For example, mothers were trained to use the scales. However, this element could not be fully evaluated from the information presented in the published studies.	
Variability and Uncertainty		Low
Variability in Population	Variability was not very well-characterized. Mothers committed to breast-feeding more than 1 year were not captured.	
Uncertainty	Not correcting for insensible water loss may underestimate intake.	
Evaluation and Review		High
Peer Review	The studies appeared in peer-reviewed journals.	
Number and Agreement of Studies	There are eight key studies. The results of studies from different researchers are in agreement.	
Overall Rating		**Medium**

Table 15-3. Human Milk Intake Rates Derived From Key Studies for Exclusively Breast-Fed Infants (mL/day)

Age (months)	Number of Children	Mean Intake (mL/day)	Upper Percentile Consumption (mL/day)[a]	Source	Weighted Mean Intake and Upper Percentile Consumption (across all key studies) (mL/day)			
					Individual Age		Composite Age Groups	
					Mean[b]	Upper[c]	Mean[b]	Upper[c]
0 <1	6 to 13	511	951	Neville et al. (1988)	511	951	511	951
1	11	600	918	Pao et al. (1980)	670	973	692	983
	37	729	981	Butte et al. (1984)				
	10 to 12	679[d]	889	Neville et al. (1988)				
	16	673	1,057	Dewey and Lönnerdal (1983)				
2	10 to 12	679[d]	889	Neville et al. (1988)	713	992		
	19	756	1,096	Dewey and Lönnerdal (1983)				
	40	704	958	Butte et al. (1984)				
3	2	833	–[e]	Pao et al. (1980)	758	1,025	769	1,024
	37	702	924	Butte et al. (1984)				
	10	713	935	Neville et al. (1988)				
	16	782	1,126	Dewey and Lönnerdal (1983)				
	73	788	1,047	Dewey et al. (1991b)				
	40	728	988	Butte et al. (2000)				
4	12	690	888	Neville et al. (1988)	739	991		
	13	810	1,094	Dewey and Lönnerdal (1983)				
	41	718	996	Butte et al. (1984)				
5	12	814	1,074	Neville et al. (1988)	810	1,057		
	11	805	1,039	Dewey and Lönnerdal (1983)				
6	1	682	–[e]	Pao et al. (1980)	741	1,059		
	13	744	978	Neville et al. (1988)				
	11	896	1,140	Dewey and Lönnerdal (1983)				
	60	747	1,079	Dewey et al. (1991b)				
	30	637	1,050	Butte et al. (2000)				
7	12	700	1,000	Neville et al. (1988)	700	1,000	622	1,024
8	9	604	1,012	Neville et al. (1988)	604	1,012		
9	12	600	1,028	Neville et al. (1988)	614	1,039		
	50	627	1,049	Dewey et al. (1991b)				
10	11	535	989	Neville et al. (1988)	535	989		
11	8	538	1,004	Neville et al. (1988)	538	1,004		
12	8	391	877	Neville et al. (1988)	410	904	410	904
	42	435	922	Dewey et al. (1991b; 1991a)				
	13	403	931	Butte et al. (2000)				

[a] Upper percentile is reported as mean plus 2 standard deviations.
[b] Calculated as the mean of the means.
[c] Middle of the range of upper percentiles.
[d] Calculated for infants 1 to <2 months old.
[e] Standard deviations and upper percentiles not calculated for small sample sizes.

Table 15-4. Human Milk Intake Rates Derived From Key Studies for Exclusively Breast-Fed Infants (mL/kg-day)

Age (months)	Number of Children	Mean Intake (mL/kg-day)	Upper Percentile Consumption (mL/kg-day)[a]	Source	Weighted Mean Intake and Upper Percentile Consumption (cross all key studies) (mL/kg-day)			
					Individual Age		Composite Age Groups	
					Mean[b]	Upper[c]	Mean	Upper[c]
0 <1	9 to 25	150	217	Arcus-Arth et al. (2005)	150	217	150	217
1	37	154	200	Butte et al. (1984)	152	199	144	187
	25	150	198	Arcus-Arth et al. (2005)				
2	40	125	161	Butte et al. (1984)	135	175		
	25	144	188	Arcus-Arth et al. (2005)				
3	37	114	152	Butte et al. (1984)	121	158	110	149
	108	127	163	Arcus-Arth et al. (2005)				
4	41	108	142	Butte et al. (1984)	110	145		
	57	112	148	Arcus-Arth et al. (2005)				
5	26	100	140	Arcus-Arth et al. (2005)	100	140		
6	39	101	141	Arcus-Arth et al. (2005)	101	141	83	130
7	8	75	125	Arcus-Arth et al. (2005)	75	125		
9	57	72	118	Arcus-Arth et al. (2005)	72	118		
12	42	47	101	Arcus-Arth et al. (2005)	47	101	47	101

[a] Upper percentile is reported as mean plus two standard deviations.
[b] Calculated as the mean of the means.
[c] Middle of the range of upper percentiles.

Table 15-5. Lipid Intake Rates Derived From Key Studies for Exclusively Breast-Fed Infants (mL/day)[a]

Age (months)	Number of Children	Mean Intake (mL/day)	Upper Percentile Consumption (mL/day)[b]	Source	Weighted Mean Intake and Upper Percentile Consumption (across all key studies) (mL/day)			
					Individual Age		Composite Age Groups	
					Mean[c]	Upper[d]	Mean[c]	Upper[d]
0 <1	6 to 13	20	38	Neville et al. (1988)	20	38	20	38
1	11	24	37	Pao et al. (1980)	26	39	27	40
	37	27	43	Butte et al. (1984)				
	10 to 12	27	36	Neville et al. (1988)				
	16	27	42	Dewey and Lönnerdal (1983)				
2	10 to 12	27	36	Neville et al. (1988)	27	40		
	19	30	44	Dewey and Lönnerdal (1983)				
	40	24	38	Butte et al. (1984)				
3	2	33	–[e]	Pao et al. (1980)	30	41	30	42
	37	23	37	Butte et al. (1984)				
	10	29	37	Neville et al. (1988)				
	16	31	45	Dewey and Lönnerdal (1983)				
	73	32	42	Dewey et al. (1991b)				
	40	29	40	Butte et al. (2000)				
4	12	28	36	Neville et al. (1988)	28	40		
	13	32	44	Dewey and Lönnerdal (1983)				
	41	25	41	Butte et al. (1984)				
5	12	33	43	Neville et al. (1988)	33	43		
	11	32	42	Dewey and Lönnerdal (1983)				
6	1	27	–[e]	Pao et al. (1980)	30	40		
	13	30	39	Neville et al. (1988)				
	11	36	46	Dewey and Lönnerdal (1983)				
	60	30	43	Dewey et al. (1991b)				
	30	25	42	Butte et al. (2000)				
7	12	28	40	Neville et al. (1988)	28	40	25	42
8	9	24	40	Neville et al. (1988)	24	40		
9	12	24	41	Neville et al. (1988)	24	41		
	50	25	42	Dewey et al. (1991b)				
10	11	21	40	Neville et al. (1988)	21	40		
11	9	22	40	Neville et al. (1988)	22	40		
12	9	16	35	Neville et al. (1988)	16	36	16	36
	42	17	37	Dewey et al. (1991b; 1991a)				
	13	16	37	Butte et al. (2000)				

[a] Except for Butte et al. (1984), values were calculated from Table 15-3 using 4% lipid content.
[b] Upper percentile is reported as mean plus 2 standard deviations.
[c] Calculated as the mean of the means.
[d] Middle of the range of upper percentiles.
[e] Standard deviations and upper percentiles not calculated for small sample sizes.

Table 15-6. Lipid Intake Rates Derived From Key Studies for Exclusively Breast-Fed Infants (mL/kg-day)[a]

Age (months)	Number of Children	Mean Intake (mL/kg-day)	Upper Percentile Consumption (mL/kg-day)[b]	Source	Weighted Mean Intake and Upper Percentile Consumption[b] (across all key studies) (mL/kg-day)			
					Individual Age		Composite Age Groups	
					Mean[c]	Upper[d]	Mean[e]	Upper[d]
0 <1	9 to 25	6.0	8.7	Arcus-Arth et al. (2005)	6.0	8.7	6.0	8.7
1	37 25	5.7 6.0	9.1 8.7	Butte et al. (1984) Arcus-Arth et al. (2005)	5.9	8.9	5.5	8.0
2	40 25	4.3 5.8	6.7 7.5	Butte et al. (1984) Arcus-Arth et al. (2005)	5.1	7.1		
3	37 108	3.7 5.1	6.1 6.5	Butte et al. (1984) Arcus-Arth et al. (2005)	4.4	6.3	4.2	6.1
4	41 57	3.7 4.5	6.3 5.9	Butte et al. (1984) Arcus-Arth et al. (2005)	4.1	6.1		
5	26	4.0	5.6	Arcus-Arth et al. (2005)	4.0	5.8		
6	39	4.0	5.6	Arcus-Arth et al. (2005)	4.0	5.6	3.3	5.2
7	8	3.0	5.0	Arcus-Arth et al. (2005)	3.0	5.0		
9	57	2.9	4.7	Arcus-Arth et al. (2005)	2.9	4.7		
12	42	1.9	4.0	Arcus-Arth et al. (2005)	1.9	4.0	1.9	4.0

[a] Except for Butte et al. (1984), values were calculated from Table 15-4 using 4% lipid content.
[b] Upper percentile is reported as mean plus two standard deviations.
[c] Calculated as the mean of the means.
[d] Middle of the range of upper percentiles.

15.3. KEY STUDIES ON HUMAN MILK INTAKE

15.3.1. Pao et al. (1980)—Milk Intakes and Feeding Patterns of Breast-Fed Infants

Pao et al. (1980) conducted a study of 22 healthy nursing infants to estimate human milk intake rates. Infants were categorized as completely breast-fed or partially breast-fed. Breast-feeding mothers were recruited through La Leche 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 1 month of age as possible and to obtain records near 1, 3, 6, and 9 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 human 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. Table 15-7 presents mean daily human milk intake rates for the infants surveyed at each time interval. These data are presented as they are reported in Pao et al. (1980). For completely breast-fed infants, the mean intake rates were 600 mL/day at 1 month of age, 833 mL/day at 3 months of age, and 682 mL/day at 6 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. In addition, this study did not account for insensible weight loss, which may underestimate the amount of human milk ingested.

15.3.2. Dewey and Lönnerdal (1983)—Milk and Nutrient Intake of Breast-Fed Infants From 1 to 6 Months: Relation to Growth and Fatness

Dewey and Lönnerdal (1983) monitored the dietary intake of 20 nursing infants between age 1 and 6 months. The number of study participants dropped to 13 by the end of the 6th month. Most of the infants in the study were exclusively breast-fed. One infant's intake was supplemented by formula during the first and second month of life. During the 3rd, 4th, and 5th months, three, four, and five infants, respectively, were given some formula to supplement their intake. Two infants were given only formula (no human milk) during the 6th month. According to Dewey and Lönnerdal (1983), the mothers were all well-educated and recruited through Lamaze childbirth classes in the Davis area of California. Human milk intake volume was estimated based on two 24-hour test weighings per month. Table 15-8 presents human milk intake rates for the various age groups. Human 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 nursing infants for a period of 6 months based on two 24-hour observations per infant per month. However, corrections for insensible weight loss apparently were not made. Also, the number of infants in the study was relatively small, and the study participants were not representative of the general population. During the study period, some infants were given some formula (i.e., up to five infants during the 5th month). Without the raw data, these subjects could not be excluded from the study results. Thus, these subjects may affect the results when deriving recommendations for exclusively breast-fed infants.

15.3.3. Butte et al. (1984)—Human Milk Intake and Growth in Exclusively Breast-Fed Infants

Human milk intake was studied in exclusively breast-fed infants during the first 4 months of life (Butte et al., 1984). Nursing 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 during the course of the study.

The amount of milk ingested over a 24-hour period was determined by weighing the infant before and after feeding. The study did not indicate whether the data were corrected for insensible water or weight loss. The study evaluated the accuracy of the test weighing procedure using a bottle-fed infant. Test weighing occurred over a 24-hour period for most study participants, but intake among several infants was studied over longer periods (48 to 96 hours) to

assess individual variation in intake. Eight of the infants received some food supplementation during the study period. Six of them received less than 60 kcal/day of formula, oatmeal, glucose water, or rice water for 1 or 2 days. One infant received an additional 90 kcal/day of infant formula and rice water for 6 days during the 4th month because of inadequate milk production. When converting values reported as g/day to mL/day, using a conversion factor of 1.03 g/mL, mean human milk intake ranged from 702 mL/day at 3 months to 729 mL/day at 1 month, with an overall mean of 712 mL/day for the entire study period (see Table 15-9). Intakes also were calculated on the basis of body weight (see Table 15-9).

The advantage of this study is that data for a larger number of exclusively breast-fed infants were collected than in previous studies. However, data were collected for infants up to 4 months and day-to-day variability was not characterized for all infants. Eighteen percent (i.e., 8 out of 45) of the infants received some formula supplementation during the study period. Without the raw data, these subjects could not be excluded from the study results. Therefore, values derived from this study for exclusively breast-fed infants may be somewhat underestimated.

15.3.4. Neville et al. (1988)—Studies in Human Lactation: Milk Volumes in Lactating Women During the Onset of Lactation and Full Lactation

Neville et al. (1988) studied human milk intake among 13 infants during the 1st year of life. The mothers were all multiparous, non-smoking, White women of middle- to upper-socioeconomic status living in Denver, CO. 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. One infant was weaned at 8 months, while all others were weaned on or after the 12 months. Formula was used occasionally (≤ 240 mL/week) after 4 months in three infants. Table 15-10 lists the estimated human milk intakes for this study. Converting values reported as g/day to mL/day, using a conversion factor of 1.03 g/mL, mean human milk intakes were 748 mL/day, 713 mL/day, 744 mL/day, and 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 15-10 are estimated based on intake only during 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. Three infants were given some formula after 4 months. Without the raw data, these subjects could not be excluded from the study results. Thus, data presented for infants between 5 and 12 months may underestimate the intake of exclusively breast-fed infants.

15.3.5. Dewey et al. (1991b; 1991a)—(a) Maternal Versus Infant Factors Related to Human Milk Intake and Residual Volume: The DARLING Study; (b) Adequacy of Energy Intake Among Breast-Fed Infants in the DARLING Study: Relationships to Growth, Velocity, Morbidity, and Activity Levels

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 their first 12 months of life (Dewey et al., 1991b; Dewey et al., 1991a). Subjects were non-randomly selected through letters to new parents using birth listings. One of the criteria used for selection was that mothers did not plan to feed their infants more than 120 mL/day of other milk or formula for the first 12 months of life. Seventy-three infants aged 3 months were included in the study. At subsequent time intervals, the number of infants included in the study 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 they did not consume solid foods until after they were 4 months old. The mothers were highly educated and of "relatively high socioeconomic status."

Human 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 human milk intake declines over the first 12 months of life. This decline is associated with the intake of solid food. When converting values reported as g/day to mL/day, using a conversion factor of 1.03 g/mL, mean human

milk intake was estimated to be 788 mL/day, 747 mL/day, 627 mL/day, and 435 mL/day at 3, 6, 9, and 12 months, respectively (see Table 15-11). Based on the estimated intakes at 3 months of age, variability between individuals (coefficient of variation [CV] = 16.3%) was higher than the average day-to-day variability (CV = 8.9 ± 5.4%) 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. Data from this study are assumed to represent exclusively breast-fed infants because mothers were specifically recruited for that purpose. It is, however, unclear from the Dewey et al. (1991a) study if this criterion was met throughout the length of the study period.

15.3.6. Butte et al. (2000)—Infant Feeding Mode Affects Early Growth and Body Composition

Butte et al. (2000) conducted a study to assess the effect of infant feeding mode on growth and body composition during the first 2 years of life. The study was conducted in the Houston, TX, area, recruited through the Children's Nutrition Research Center (CNRC) referral system. The study was approved by the Baylor Affiliates Review Boards for Human Subject Research. The overall sample was 76 healthy term infants at 0.5, 3, 6, 9, 12, 18, and 24 months of age. The sample size varied between 71 to 76 infants for each age group. Repeated measurements for body composition and anthropometric were performed. The mothers agreed to either exclusively breast-feed or formula feed the infants for the first 4 months of life.

At 3-month or 6-month study intervals, the feeding history was taken. The mothers or caretakers were questioned about breast-feeding frequency, and the use of formula, milk, juice, solids, water, and vitamin or mineral supplements. Also, infant food intake was quantified at 3, 6, 12, and 24 months with a 3-day weighted intake record completed by the mother or caretaker (Butte et al., 2000). The intake of human milk was assessed by test weighing; the infant weights were calculated before and after each feeding. Using a pre-weighing and post-weighing method, the intake of formula and other foods and beverages was measured for 3 days by the mothers using a digital scale and recorded on predetermined forms.

The average duration of breast-feeding was 11.4 months (standard deviation [SD] = 5.8). Butte et al. (2000) reported that infants were exclusively breast-fed for at least the first 4 months—except for one who was weaned at 109 days, another who received formula at 102 days, and another who was given cereal at 106 days. Table 15-12 shows the infant feeding characteristics. Table 15-13 shows the intakes of human milk for the infants. When converting values reported as g/day to mL/day, using a conversion factor of 1.03 g/mL, mean human milk intake was estimated to be 728 mL/day at 3 months (weighted average of boys and girls), 637 mL/day at 6 months (weighted average of boys and girls), and 403 mL/day at 12 months (weighted average of boys and girls) (see Table 15-13). Table 15-14 shows feeding practices by percentage for infants. Table 15-15 provides the mean body weights of breast-fed infants.

Advantages of this study are that it provides intake data for breast-fed infants for their first 4 months. The study also provides the mean weights for the infants by feeding type and by sex. The limitations of the study are that the sample size is small and limited to one geographical location. The authors did not indicate if results were corrected for insensible weight loss. Because mothers could introduce formula after 4 months, only the data for the 3-month old infants can be considered exclusively breast-fed.

15.3.7. Arcus-Arth et al. (2005)—Breast Milk and Lipid Intake Distributions for Assessing Cumulative Exposure and Risk

Arcus-Arth et al. (2005) derived population distributions for average daily milk and lipid intakes in g/kg-day for infants age 0–6 months and 0–12 months for infants fed according to the AAP recommendations. The AAP recommends exclusively breast-feeding for the first 6 months of life, with human milk as the only source of milk until age 1 year and the introduction of solid foods after 6 months. The distributions were derived based on data in the peer-reviewed literature and data sets supplied by the publication authors for infants 7 days and older (Arcus-Arth et al., 2005). As cited in Arcus-Arth et al. (2005), data sources included Dewey et al. (1991b; 1991a), Hofvander et al. (1982), Neubauer et al. (1993), Ferris et al. (1993), Salmenpera et al. (1985), and Stuff and Nichols (1989). The authors also evaluated intake rates for infants breast-fed exclusively over the 1st year and provided a regression line of intake versus age for estimating short-term exposures. Arcus-Arth et al. (2005) derived human milk intake rates for the entire infant population (nursing and non-nursing) from

U.S. data on consumption, prevalence and duration. Arcus-Arth et al. (2005) defined *exclusive breast-feeding* (EBF) as "breast milk is the sole source of calories, with no or insignificant calories from other liquid or solid food sources," and *predominant breast-feeding* as "breast milk is the sole milk source with significant calories from other foods." The data that were consistent with AAP advice were used to construct the AAP data set (Arcus-Arth et al., 2005). The 0–12 months EBF data set was created using 0–6 month AAP data and data from the EBF infants older than 6 months of age. Because there are no data in the AAP data set for any individual infant followed at regular, frequent intervals during the 12-month period, population distributions were derived with assumptions regarding individual intake variability over time (Arcus-Arth et al., 2005). Two methods were used. In Method 1, the average population daily intake at each age was described by a regression line, assuming normality. Arcus-Arth et al. (2005) noted that age specific intake data were consistent with the assumption of normality. In Method 2, intake over time was simulated for 2,500 hypothetical infants and the distribution intakes derived from 2,500 individual intakes (Arcus-Arth et al., 2005). The population intake distribution was derived following Method 1. Table 15-16 presents the means and standard deviations for intake data at different ages; the variability was greatest for the two youngest and three oldest age groups. The values in Table 15-16 using Method 1 were used to derive the recommendations presented in Table 15-1 because it provides data for the fine age categories. When converting values reported as g/day to mL/day, using a conversion factor of 1.03 g/mL, mean human milk intake was estimated to be 150 mL/kg-day at 1 month, 127 mL/kg-day at 3 months, 101 mL/kg-day at 6 months, and 47 mL/kg-day at 12 months (see Table 15-16). Time weighted average intakes for larger age groups (i.e., 0–6 months, 0–12 months) are presented in Table 15-17.

An advantage of this study is that it was designed to represent the infant population whose mothers follow the AAP recommendations. Intake was calculated on a body weight basis. In addition, the data used to derive the distributions were from peer-reviewed literature and data sets supplied by the publication authors. The distributions were derived from data for infants fed in accordance to AAP recommendations, and they most likely represent daily average milk intake for a significant portion of breast-fed infants today (Arcus-Arth et al., 2005). The limitations of the study are that the data used were from mothers who were predominantly White, well-nourished, and from middle or high socioeconomic status. Arcus-Arth et al. (2005) also included data from Sweden and Finland. However, human milk volume in mL/day is similar among all women except for severely malnourished women (Arcus-Arth et al., 2005). According to Arcus-Arth et al. (2005): "Although few infants are exclusively breast-fed for 12 months, the EBF distributions may represent a more highly exposed subpopulation of infants exclusively breast-fed in excess of 6 months."

15.4. KEY STUDIES ON LIPID CONTENT AND LIPID INTAKE FROM HUMAN MILK

Human milk contains more than 200 constituents, including lipids, various proteins, carbohydrates, vitamins, minerals, and trace elements as well as enzymes and hormones. The lipid content of human milk varies according to the length of time that an infant nurses, and it increases from the beginning to the end of a single nursing session (NAS, 1991). The lipid portion accounts for approximately 4% of human milk (3.9% ± 0.4%) (NAS, 1991). This value is supported by various studies that evaluated lipid content from human milk (Kent et al., 2006; Arcus-Arth et al., 2005; Mitoulas et al., 2003; Mitoulas et al., 2002; Butte et al., 1984). 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 milk.

15.4.1. Butte et al. (1984)—Human Milk Intake and Growth in Exclusively Breast-Fed Infants

Butte et al. (1984) analyzed the lipid content of human milk samples taken from women who participated in a study of human milk intake among exclusively breast-fed infants. The study was conducted with more than 40 women during a 4-month period. Table 15-18 presents the mean lipid content of human milk at various infants' ages. The overall lipid content for the 4-month study period was 3.43 ± 0.69% (3.4%). Butte et al. (1984) also calculated lipid intakes from 24-hour human milk intakes and the lipid content of the human milk samples. Lipid intake was estimated to range from 22.9 mL/day (3.7 mL/kg-day) to 27.2 mL/day (5.7 mL/kg-day).

The number of women included in this study was small, and these women were selected primarily from middle to high socioeconomic classes. Thus, data on human milk lipid content from this study may not be entirely representative of human 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.

15.4.2. Mitoulas et al. (2002)—Variation in Fat, Lactose, and Protein in Human Milk Over 24 h and Throughout the First Year of Lactation

Mitoulas et al. (2002) conducted a study of healthy nursing women to determine the volume and composition of human milk during the 1st year of lactation. Nursing mothers were recruited through the Nursing Mothers' Association of Australia. All infants were completely breast-fed on demand for at least 4 months. Complementary solid food was introduced between 4 and 6 months of age. Mothers consumed their own ad libitum diets throughout the study. Seventeen mothers initially provided data for milk production and fat content, whereas lactose, protein, and energy were initially obtained from nine mothers. The number of mothers participating in the study decreased at 6 months because of the cessation of sample collection from 11 mothers, the maximum period of exclusive breast-feeding.

Milk samples were collected before and after each feed from each breast over a 24–28 hour period. Milk yield was determined by weighing the mother before and after each feed from each breast. Insensible water loss was accounted for by weighing the mother 20 minutes after the end of each feeding. The rate of water loss during this 20-minute period was used to calculate insensible water loss during the feeding. Samples of milk produced at the beginning of the feeding (foremilk) and at the end of the feeding (hindmilk) were averaged to provide the fat, protein, lactose, and energy content for each feed. In all cases the left and right breasts were treated separately; therefore, *N* represents the number of individual breasts sampled.

Table 15-19 presents mean human milk production and composition at each age interval. The mean fat, lactose, and protein contents (g/L) were 37.4 (standard error [SE] = 0.6), 61.4 (SE = 0.6), and 9.2 (SE = 0.2), respectively. Composition did not vary between left and right breasts or preferred and non-preferred breasts. Milk production was constant for the first 6 months and thereafter steadily declined. Mitoulas et al. (2002) reported a mean 24-hour milk production from both breasts was 798 (SD = 232) mL. The fat content of milk decreased between 1 and 4 months before increasing to 12 months of lactation. The concentration of protein decreased to 6 months and then remained steady. Lactose remained constant throughout the 12 months of lactation. The decrease of energy at 2 months and subsequent increase by 9 months can be attributed to changes in fat content. Assuming a density of human milk of 1.03 g/mL, the overall fat content in human milk was 3.6%. Milk production, as well as concentrations of fat, lactose, protein, and energy, differed significantly between women.

The focus of this study was on human milk composition and production, not on infant's human milk intake. The advantage of this study is that it evaluated nursing mothers for a period of 12 months. However, the number of mother-infant pairs in the study was small (17 mothers with infants) and may not be entirely representative of the U.S. population. This study accounted for insensible water loss, which increases the accuracy of the amount of human milk produced.

15.4.3. Mitoulas et al. (2003)—Infant Intake of Fatty Acids From Human Milk Over the First Year of Lactation

Mitoulas et al. (2003) conducted a study of five healthy nursing women to determine the content of fat in human milk and fat intake by infants during the 1st year of lactation. Thirty nursing mothers were recruited through the Australian Breast-feeding Association or from private healthcare facilities. All infants were completely breast-fed on demand for at least 4 months. Complementary solid food was introduced between 4 and 6 months of age. Mothers consumed their own ad libitum diets throughout the study.

Milk samples were collected before and after each feed from each breast over a 24–28 hour period. Fore- and hind-milk samples were averaged to provide the fat content for each feed. Milk yield was determined by weighing the mother before and after each feed from each breast. Insensible water loss was accounted for by weighing the mother 20 minutes after the end of each feeding. The rate of water loss during those 20 minutes was used to calculate insensible water loss during the feeding.

Table 15-20 presents changes in volume of human milk produced and milk fat content over the 1st year of lactation. The mean volumes of milk produced for both breasts combined were 813, 791, 912, 810, 677, and 505 mL/day at 1, 2, 4, 6, 9, and 12 months, respectively. The average daily production over the 12 months was 751 mL/day with a mean fat content of 35.5 g/L. Assuming a density of human milk of 1.03 g/mL, the fat content in human milk was 3.4% over the 12 month period. There was a significant difference in the proportional composition of fatty acids during the course of lactation. Table 15-21

provides average fatty acid composition during the first 12 months of lactation. Additionally, fatty acid composition varied during the course of the day.

The focus of this study was on human milk composition and production—not on infant's human milk intake. The advantage of this study is that it evaluated the human milk composition for a period of 12 months. However, the number of mother-infant pairs in the study was small (five mothers with infants) and may not be entirely representative of the entire U.S. population. This study accounted for insensible water loss, which increases the accuracy of the amount of human milk produced.

15.4.4. Arcus-Arth et al. (2005)—Breast Milk and Lipid Intake Distributions for Assessing Cumulative Exposure and Risk

Arcus-Arth et al. (2005) derived population distributions for average daily milk and lipid intakes in g/kg a day for infants 0–6 months and 0–12 months of age for infants fed according to the AAP recommendations. Lipid intakes were calculated from lipid content and milk intakes measured on the same infant (Arcus-Arth et al., 2005). Table 15-22 provides lipid intakes based on data from Dewey et al. (1991a) and Table 15-23 provides lipid intakes calculated assuming 4% lipid content and milk intake in the AAP data set. The mean measured lipid content ranged from 3.67%–4.16%, with a mean of 3.9% over the 12 month period. Arcus-Arth et al. (2005) noted that the distributions presented are intended to represent the U.S. infant population.

An advantage of this study is that it was designed to represent the population of infants who are breast-fed according to the AAP recommendations. In addition, the data used to derive the distributions were from peer-review literature and data sets supplied by the publication authors. The limitation of the study are that the data used were from mothers that were predominantly white, well-nourished, and from mid- or upper-socioeconomic status; however, human milk volume in mL/day is similar among all women except for severely malnourished women (Arcus-Arth et al., 2005). The authors noted that "although few infants are exclusively breast-fed for 12 months, the exclusively breast-fed distributions may represent a more highly exposed subpopulation of infants exclusively breast-fed in excess of 6 months." The distributions were derived from data for infants fed in accordance to AAP recommendations, and they most likely represent daily average milk intake for a significant portion of breast-fed infants today (Arcus-Arth et al., 2005).

15.4.5. Kent et al. (2006)—Volume and Frequency of Breast-Feeding and Fat Content of Breast Milk Throughout the Day

Kent et al. (2006) collected data from 71 Australian mothers who were exclusively nursing their 1–6 month-old infants. The study focused on examining the variation of milk consumed from each breast, the degree of fullness of each breast before and after feeding, and the fat content of milk consumed from each breast during daytime and nighttime feedings. The volume of milk was measured using test-weighing procedures with no correction for infant insensible water loss. On average, infants had 11 ± 3 breast-feedings per day (range = 6–18). The interval between feedings was 2 hours and 18 minutes ± 43 minutes (range = 4 minutes to 10 hours, 58 minutes). The 24-hour average human milk intake was 765 ± 164 mL/day (range = 464–1,317 mL/day). The fat content of milk ranged from 22.3 g/L to 61.6 g/L (2.2%–6.0%) with an average of 41.1 g/L (4.0%).

This study examined breast-feeding practices of volunteer mothers in Australia. Although amounts of milk consumed by Australian infants may be similar to infants in the U.S. population, results could not be broken out by smaller age groups to examine variability with age. The study provides estimates of fat content from a large number of samples.

15.5. RELEVANT STUDY ON LIPID INTAKE FROM HUMAN MILK

15.5.1. Maxwell and Burmaster (1993)—A Simulation Model to Estimate a Distribution of Lipid Intake From Human Milk 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 human milk. The hypothetical population represented both bottle-fed and breast-fed infants aged 1–365 days. A distribution of daily lipid intake was developed based on data in Dewey et al. (1991b) on human milk intake for infants at 3, 6, 9, and 12 months and human milk lipid content, and survey data in Ryan et al. (1991) on the percentage of breast-fed infants under 12 months (i.e., approximately 22%). A model was used to simulate intake among 1,113 of the 5,000 infants expected to be breast-fed. The results indicated that lipid intake among nursing infants under 12 months can be characterized by a normal distribution with a mean of

26.0 mL/day and a standard deviation of 7.2 mL/day (see Table 15-24). 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 human milk to be 36.7 g/L at 3 months (35.6 mg/g or 3.6%), 39.2 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 12 months (39.0 mg/g or 3.9%).

The limitation of this study is that it provides a snapshot of daily lipid intake from human milk for breast-fed infants. These results also are based on a simulation model and there are uncertainties associated with the assumptions made. Another limitation is that lipid intake was not derived for the U.S. EPA recommended age categories. The estimated mean lipid intake rate represents the average daily intake for nursing infants under 12 months. The study also did not generate new data. A reanalysis of previously reported data on human milk intake and human milk lipid intake were provided.

15.6. OTHER FACTORS

Many factors influence the initiation, continuation, and amount of human milk intake. These factors are complex and may include considerations such as maternal nutritional status, parity, parental involvement, support from lactation consultants, mother's working status, infant's age, weight, sex, food supplementation, the frequency of breast-feeding sessions each day, the duration of breast-feeding for each event, the duration of breast-feeding during childhood, ethnicity, geographic area, and other socioeconomic factors. For example, a study conducted in the United Kingdom found that social and educational factors most influenced the initiation and continuation of lactation (Wright et al., 2006). Prenatal and postnatal lactation consultant intervention was found to be effective in increasing lactation duration and intensity (Bonuck et al., 2005).

15.6.1. Population of Nursing Infants

Breast-feeding rates in the United States have consistently increased since 1993. McDowell et al. (2008) reported that the percentage of infants who were ever breast-fed increased from 60% in 1993–1994 to 77% among infants born in 2005–2006 according to the data from the National Health and Nutrition Examination Surveys (NHANES). This exceeded the goal of 75% set in the Healthy People 2010 McDowell et al. (2008). Rates among non-Hispanic black women increased significantly from 36% in 1993–1994 to 65% in 2005–2006. Income and age had a significant impact on breast-feeding rates. Breast-feeding rates among higher income women were 74% compared to 57% among lower income women (McDowell et al., 2008).

In another study to monitor progress toward achieving the Centers for Disease Control and Prevention (CDC) *Healthy People 2010* breast-feeding objectives (initiation and duration), Scanlon et al. (2007) analyzed data from the National Immunization Survey (NIS). NIS uses random-digit dialing to survey households to survey age-eligible children, followed by a mail survey to eligible children's vaccination providers to validate the vaccination information. NIS is conducted annually by the CDC to obtain national, state, and selected urban area estimation on vaccinations rates among U.S. children ages 19–35 months. The interview response rate for years 2001–2006 ranged between 64.5% and 76.1%. Questions regarding breast-feeding were added to the NIS survey in 2001. The sample population was infants born during 2000–2004. Scanlon et al. (2007) noted that because data in their analysis are for children ages 19–35 months at the time of the NIS interview, each cross-sectional survey includes children from birth cohorts that span 3 calendar years; the breast-feeding data were analyzed by year-of-birth during 2000–2004 (birth year cohort instead if survey year).

Among infants born in 2000, breast-feeding rates were 70.9% (CI = 69.0–72.8) for the postpartum period (in hospital before discharge), 34.2% (CI = 32.2–36.2) at 6 months, and 15.7 (CI = 14.2–17.2) at 12 months. For infants born in 2004, these rates had increased to 73.8% (CI = 72.8–74.8) for the postpartum period, 41.5% (CI = 40.4–42.6) at 6 months, and 20.9 (CI = 20.0–21.8) at 12 months. Rates of breast-feeding through 3 months were lowest among black infants (19.8%), infants whose mothers were <20 years of age (16.8%), those whose mothers had a high school education or less (22.9% and 23.9%), those whose mothers were unmarried (18.8%), those who resided in rural areas (23.9%), and those whose families had an income-to-poverty ratio of <100% (23.9%). Table 15-25 shows data for exclusive breast-feeding through 3 and 6 months by socioeconomic characteristics for infants born in 2004.

Scanlon et al. (2007) noted the following limitations could affect the utility of these data: (1) breast-feeding behavior was based on retrospective self-report by mothers or other caregivers, whose responses might be subject to recall bias; (2) the NIS question defining early

postpartum breast-feeding or initiation—"Was [child's name] ever breast-fed or fed breast milk?"—collects information that might differ from the HP2010 objective for initiation; and (3) although survey data were weighted to make them representative of all U.S. children ages 19–35 months, some bias might remain. The advantage of the study is that is representative of the U.S. infant population.

In 2007, CDC released the CDC Breast-feeding Report Card, which has been updated every year since. The CDC National Immunization Program in partnership with the CDC National Center for Health Statistics conducts the NIS within all 50 states, the District of Columbia, and selected geographic areas within the states. Five breast-feeding goals are in the *Healthy People 2010* report. The Breast-feeding Report Card presents data for each state for the following categories of infants: ever breast-fed, breast-fed at 6 months, breast-fed at 12 months, exclusive breast-feeding through 3 months, and exclusive breast-feeding through 6 months (CDC, 2009). These indicators are used to measure a state's ability to promote, protect, and support breast-feeding. Table 15-26 presents these data for the estimated percentage of infants born in 2006. The advantage of this report is that it provides data for each state and is representative of the U.S. infant population.

Analysis of breast-feeding practices in other developing countries also was found in the literature. Marriott et al. (2007) researched feeding practices in developing countries in the first year of life, based on 24-hour recall data. Marriott et al. (2007) used secondary data from the Demographic and Health Surveys (DHS) for more than 35,000 infants in 20 countries. This survey has been conducted since 1986 and was expanded to provide a standardized survey instrument that can be used by developing countries to collect data on maternal-infant health and intake and household variables, as well as to build national health statistics (Marriott et al., 2007). The analysis was based on the responses of the survey mothers for questions on whether they were currently breast-feeding and had fed other liquids and solid foods to their infants in the previous 24 hours. The data incorporated were from between 1999 and 2003. Marriott et al. (2007) selected the youngest infant (i.e., less than 1 year old) in each of the families; multiples were included such as twins or triplets. Separate analyses were conducted for infants less than 6 months old and infants 6 months and older, but less than 12 months old. Food and liquid variables other than water and infant formulas were collapsed into broader food categories for cross-country comparisons (Marriott et al., 2007). Tinned, powdered, and any other specified animal milks were collapsed. In addition, all other liquids such as herbal teas, fruit juices, and sugar water (excluding unique country-specific liquids) were collapsed into other liquids and the 10 types of solid food groups into an any-solid-foods category (Marriott et al., 2007). Data were pooled from the 20 countries to provide a large sample size and increase statistical power. Table 15-27 and Table 15-28 present the percentage of mothers who were currently breast-feeding and separately had fed their infants other liquids or solid food by age groups. Table 15-29 presents the pooled data summary for the study period. The current breast-feeding was consistent across countries for both age groups; the countries that reported the highest percentages of current breast-feeding for the 0- to 6-month-old infants also reported the highest percentages in the 6- to 12-month-old infants. Pooled data show that 96.6% of the 0- to 6-month-old infants and 87.9% of the 6- to 12-month-old infants were breast-feeding. Feeding of other fluids was lowest in the 0- to 6-month-old infants, with the percentage feeding water the highest of this category. The percentage of mothers feeding commercial infant formulas was the lowest in most countries.

There are other older studies that analyze ethnic and racial differences in breast-feeding practices. Li and Grummer-Strawn (2002) investigated ethnic and racial disparities in lactation in the United States using data from the NHANES III that was conducted between 1988 and 1994. NHANES II participants were ages 2 months and older. The data were collected during a home interview from a parent or a proxy respondent for the child (Li and Grummer-Strawn, 2002). The sample population consisted of children 12–71 months of age at time of interview. The NHANES III response rate for children participating was approximately 94% (Li and Grummer-Strawn, 2002). Data for a total of 2,863 exclusively breast-fed, 6,140 ever breast-fed, and 6,123 continued breast-fed children were included in the analysis (Li and Grummer-Strawn, 2002). The percentage of children ever breast-fed was 60% among non-Hispanic Whites, 26% among non-Hispanic Blacks, and 54% among Mexican Americans. This percentage decreased to 27%, 9%, and 23% respectively by 6 months. The percentage of children fed exclusively human milk at 4 months also was significantly lower for Blacks at 8.5%, compared to 22.6% for Whites and 14.1% for Mexican Americans. The racial and ethnic differences in proportion of children ever breast-fed is presented in Table 15-30, the proportion of children who received any breast milk at 6 months are presented in

Table 15-31, and the proportion of children exclusively breast-fed at 4 months is presented in Table 15-32.

Li and Grummer-Strawn (2002) noted that there may have been some lag time between birth and the time of the interview. This may have caused misclassification if the predicator variables changed considerably between birth and the time of interview. Also, NHANES III did not collect information on maternal education. Instead, the educational level of the household head was used as a proxy. The advantage of this study is that it is representative of the U.S. children's population.

Data from some older studies provide historical information on breast-feeding practices in the United States. These data are provided in this chapter to show trends in the U.S. population. In 1991, the National Academy of Sciences (NAS) reported that the percentage of breast-feeding women has changed dramatically over the years (NAS, 1991). The Ross Products Division of Abbott Laboratories conducted a large national mail survey in 1995 to determine patterns of breast-feeding during the first 6 months of life. The Ross Laboratory Mothers' Survey was first developed in 1955 and has been expanded to include many more infants. Before 1991, the survey was conducted on a quarterly basis, and approximately 40,000 to 50,000 questionnaires were mailed each quarter (Ryan, 1997). Beginning in 1991, the survey was conducted monthly; 35,000 questionnaires were mailed each month. Over time, the response rate has been consistently in the range of 50 ± 5%. In 1989 and 1995, 196,000 and 720,000 questionnaires were mailed, respectively. Ryan (1997) reported rates of breast-feeding through 1995 and compared them with those in 1989.

The survey demonstrates increases in both the initiation of breast-feeding and continued breast-feeding at 6 months of age between 1989 and 1991. Table 15-33 presents the percentage of breast-feeding in hospitals and at 6 months of age by selected demographic characteristics. In 1995, the incidence of breast-feeding at birth and at 6 months for all infants was approximately 59.7% and 21.6%, respectively. The largest increases in the initiation of breast-feeding between 1989 and 1995 occurred among women who were black, were less than 20 years of age, earned less than $10,000 per year, had no more than a grade school education, were living in the South Atlantic region of the United States, had infants of low birth weight, were employed full time outside the home at the time they received the survey, and participated in the Women, Infants, and Children program (WIC). In 1995, as in 1989, the initiation of breast-feeding was highest among women who were more than 35 years of age, earned more than $25,000 per year, were college-educated, did not participate in the WIC program, and were living in the Mountain and Pacific regions of the United States.

Data on the actual length of time that infants continue to breast-feed beyond 5 or 6 months were limited (NAS, 1991). However, Maxwell and Burmaster (1993) estimated that approximately 22% of infants under 1 year are breast-fed. This estimate was based on a reanalysis by Ryan et al. (1991) of survey data collected by Ross Laboratories (Maxwell and Burmaster, 1993). Studies also have indicated that breast-feeding practices may differ among ethnic and socioeconomic groups and among regions of the United States. More recently, the Ross Products Division of Abbott Laboratories reported the results of their ongoing *Ross Mothers Survey* in 2003 (Abbott Labs, 2003). Table 15-34 presents the percentages of mothers who breast-feed, based on ethnic background and demographic variables. These data update the values presented in the NAS (1991) report.

15.6.2. Intake Rates Based on Nutritional Status

Information on differences in the quality and quantity of human milk on the basis of ethnic or socioeconomic characteristics of the population is limited. Lönnerdal et al. (1976) studied human 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. Similar data were observed for well-nourished Swedish mothers. Lönnerdal et al. (1976) stated that these results indicate that human milk quality and quantity are not affected by maternal malnutrition. However, Brown et al. (1986b; 1986a) noted that the lactational capacity and energy concentration of marginally nourished women in Bangladesh were "modestly less than in better nourished mothers." Human 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 (Brown et al., 1986a). Brown et al. (1986a) observed that human 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 also were observed. These results suggest that milk composition may be affected by maternal nutritional status.

15.6.3. 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 five meals a day (see Table 15-35). 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 2–5 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.

Buckley (2001) studied the breast-feeding patterns, dietary intake, and growth measurement of children who continued to breast-feed beyond 1 year of age. The sample was 38 mother-child pairs living in the Washington, DC, area. The criteria for inclusion in the study were that infants or their mothers had no hospitalization of either subject 3 months prior to the study and that the mother was currently breast-feeding a 1-year-old or older child (Buckley, 2001). The participants were recruited through local medical consultants and the La Leche League members. The children selected as the final study subjects consisted of 22 boys and 16 girls with ages ranging from 12 to 43 months old. The data were collected using a 7-day breast-feeding diary. The frequency and length of breast-feeding varied with the age of the child (Buckley, 2001). The author noted a statistically significant difference in the mean number of breast-feeding episodes each day and the average total minutes of breast-feeding between the 1-, 2-, and 3-year-old groups. Table 15-36 provides the comparison of breast-feeding patterns between age groups. An advantage of this study is that the frequency and duration data are based primarily on a 7-day diary and some dietary recall. Limitations of the study are the small sample size and that it is limited to one geographical area.

15.7. REFERENCES FOR CHAPTER 15

Abbott Labs (Abbott Laboratories). (2003). Breastfeeding trends - 2003. In Ross mothers survey. Columbus, OH: Ross Products Division of Abbott Laboratories. http://abbottnutrition.com/Downloads/NewsAndMedia/MediaCenter/BF_Trends_2003.pdf.

Albernaz, E; Victora, CG; Haisma, H; Wright, A; Coward, WA. (2003). Lactation counseling increases breast-feeding duration but not breast milk intake as measured by isotopic methods. J Nutr 133: 205-210.

Arcus-Arth, A; Krowech, G; Zeise, L. (2005). Breast milk and lipid intake distributions for assessing cumulative exposure and risk. J Expo Anal Environ Epidemiol 15: 357-365. http://dx.doi.org/10.1038/sj.jea.7500412.

Bonuck, KA; Trombley, M; Freeman, K; Mckee, D. (2005). Randomized, controlled trial of a prenatal and postnatal lactation consultant intervention on duration and intensity of breastfeeding up to 12 months. Pediatrics 116: 1413-1426. http://dx.doi.org/10.1542/peds.2005-0435.

Brown, KH; Akhtar, NA; Robertson, AD; Ahmed, MG. (1986a). Lactational capacity of marginally nourished mothers: Relationships between maternal nutritional status and quantity and proximate composition of milk. Pediatrics 78: 909-919.

Brown, KH; Robertson, AD; Akhtar, NA. (1986b). Lactational capacity of marginally nourished mothers: Infants' milk nutrient consumption and patterns of growth. Pediatrics 78: 920-927.

Buckley, KM. (2001). Long-term breastfeeding: Nourishment or nurturance? J Hum Lact 17: 304-312.

Butte, NF; Garza, C; Smith, EO; Nichols, BL. (1984). Human milk intake and growth in exclusively breast-fed infants. J Pediatr 104: 187-195.

Butte, NF; Wong, WW; Hopkinson, JM; Smith, EO; Ellis, KJ. (2000). Infant feeding mode affects early growth and body composition. Pediatrics 106: 1355-1366.

CDC (Centers for Disease Control and Prevention). (2009). Breastfeeding report card 2009: Breastfeeding practices – results from the National Immunization Survey. Atlanta, GA. http://www.cdc.gov/breastfeeding/pdf/2009BreastfeedingReportCard.pdf.

Chen, A; Rogan, WJ. (2004). Breastfeeding and the risk of postneonatal death in the United States. Pediatrics 113: e435-e439.

Dewey, KG; Heinig, MJ; Nommsen, LA; Lonnerdal, B. (1991a). Maternal versus infant factors related to breast milk intake and residual milk volume: the DARLING study. Pediatrics 87: 829-837.

Dewey, KG; Heinig, MJ; Nommsen, LA; Lönnerdal, B. (1991b). Adequacy of energy intake among breast-fed infants in the DARLING study: relationships to growth velocity, morbidity, and activity levels. Davis Area Research on Lactation, Infant Nutrition and

Growth. J Pediatr 119: 538-547.

Dewey, KG; Lönnerdal, B. (1983). Milk and nutrient intake of breast-fed infants from 1 to 6 months: relation to growth and fatness. J Pediatr Gastroenterol Nutr 2: 497-506.

Dewey, KG; Peerson, JM; Heinig, MJ; Nommsen, LA; Lönnerdal, B; Lopez de Romaña, G; de Kanashiro, HC; Black, RE; Brown, KH. (1992). Growth patterns of breast-fed infants in affluent (United States) and poor (Peru) communities: implications for timing of complementary feeding. Am J Clin Nutr 56: 1012-1018.

Drewett, R; Amatayakul, K; Wongsawasdii, L; Mangklabruks, A; Ruckpaopunt, S; Ruangyuttikarn, C; Baum, D; Imong, S; Jackson, D; Woolridge, M. (1993). Nursing frequency and the energy intake from breast milk and supplementary food in a rural Thai population: a longitudinal study. Eur J Clin Nutr 47: 880-891.

Ferris, AM; Neubauer, SH; Bendel, RB; Green, KW; Ingardia, CJ; Reece, EA. (1993). Perinatal lactation protocol and outcome in mothers with and without insulin-dependent diabetes mellitus. Am J Clin Nutr 58: 43-48.

Gartner, LM; Morton, J; Lawrence, RA; Naylor, AJ; O'Hare, D; Schanler, RJ; Eidelman, AI; Breastfeeding, AAO, PSO. (2005). Breastfeeding and the use of the human milk. Pediatrics 115: 496-506. http://dx.doi.org/10.1542/peds.2004-2491.

González-Cossío, T; Habicht, JP; Rasmussen, KM; Delgado, HL. (1998). Impact of food supplementation during lactation on infant breast-milk intake and on the proportion of infants exclusively breast-fed. J Nutr 128: 1692-1702.

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

Kent, JC; Mitoulas, LR; Cregan, MD; Ramsay, DT; Doherty, DA; Hartmann, PE. (2006). Volume and frequency of breastfeedings and fat content of breast milk throughout the day. Pediatrics 117: e387-e395. http://dx.doi.org/10.1542/peds.2005-1417.

Li, R; Grummer-Strawn, L. (2002). Racial and ethnic disparities in breastfeeding among United States infants: Third National Health and Nutrition Examination Survey, 1988-1994. Birth 29: 251-257.

Lönnerdal, B; Forsum, E; Gebre-Medhin, M; Hambraeus, L. (1976). Breast milk composition in Ethiopian and Swedish mothers. II. Lactose, nitrogen, and protein contents. Am J Clin Nutr 29: 1134-1141.

Marriott, BM; Campbell, L; Hirsch, E; Wilson, D. (2007). Preliminary data from demographic and health surveys on infant feeding in 20 developing countries. J Nutr 137: 518S-523S.

Maxwell, NI; Burmaster, DE. (1993). A simulation model to estimate a distribution of lipid intake from breast milk during the first year of life. J Expo Anal Environ Epidemiol 3: 383-406.

McDowell, MM; Wang, CY; Kennedy-Stephenson, J. (2008). Breastfeeding in the United States: Findings from the National Health and Nutrition Examination Surveys, 1999-2006. NCHS1-8.

Mitoulas, LR; Gurrin, LC; Doherty, DA; Sherriff, JL; Hartmann, PE. (2003). Infant intake of fatty acids from human milk over the first year of lactation. Br J Nutr 90: 979-986. http://dx.doi.org/10.1079/BJN2003979.

Mitoulas, LR; Kent, JC; Cox, DB; Owens, RA; Sherriff, JL; Hartmann, PE. (2002). Variation in fat, lactose and protein in human milk over 24 h and throughout the first year of lactation. Br J Nutr 88: 29-37. http://dx.doi.org/10.1079/BJNBJN2002579.

NAS (National Academy of Sciences). (1991). Nutrition during lactation. Washington, DC: The National Academies Press. http://www.nap.edu/catalog.php?record_id=1577.

Neubauer, SH; Ferris, AM; Chase, CG; Fanelli, J; Thompson, CA; Lammi-Keefe, CJ; Clark, RM; Jensen, RG; Bendel, RB; Green, KW. (1993). Delayed lactogenesis in women with insulin-dependent diabetes mellitus. Am J Clin Nutr 58: 54-60.

Neville, MC; Keller, R; Seacat, J; Lutes, V; Neifert, M; Casey, C; Allen, J; Archer, P. (1988). Studies in human lactation: milk volumes in lactating women during the onset of lactation and full lactation. Am J Clin Nutr 48: 1375-1386.

Pao, EM; Himes, JM; Roche, AF. (1980). Milk intakes and feeding patterns of breast-fed infants. J Am Diet Assoc 77: 540-545.

Ryan, AS. (1997). The resurgence of breastfeeding in the United States. Pediatrics 99: E12.

Ryan, AS; Rush, D; Krieger, FW; Lewandowski, GE. (1991). Recent declines in breast-feeding in the United States, 1984 through 1989. Pediatrics 88: 719-727.

Salmenperä, L; Perheentupa, J; Siimes, MA. (1985). Exclusively breast-fed healthy infants grow slower than reference infants. Pediatr Res 19: 307-312.

Scanlon, K; Grummer-Strawn, L; Shealy, K; Jefferds, M; Chen, J; Singleton, J; Philip, C. (2007). Breastfeeding trends and updated national health objectives for exclusive breastfeeding—United States, birth years 2000-2004. 56: 760-763.

Stuff, JE; Nichols, BL. (1989). Nutrient intake and growth performance of older infants fed human milk. J Pediatr 115: 959-968.

Wright, CM; Parkinson, K; Scott, J. (2006). Breast-feeding in a UK urban context: who breast-feeds, for how long and does it matter? Public Health Nutr 9: 686-691.

Table 15-7. Daily Intakes of Human Milk

Age	Number of Infants	Intake	
		Mean ± SD (mL/day) [a]	Intake Range (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 15-8. Human Milk Intakes for Infants Aged 1–6 Months

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

Source: Dewey and Lönnerdal (1983).

Table 15-9. Human Milk Intake Among Exclusively Breast-Fed Infants During the First 4 Months of Life

Age	Number of Infants	Intake (mL/day)[a] Mean ± SD	Intake (mL/kg-day)[a] Mean ± SD	Feedings/Day	Body Weight[b] (kg)
1 month	37	729 ± 126	154 ± 23	8.3 ± 1.9	4.7
2 months	40	704 ± 127	125 ± 18	7.2 ±1.9	5.6
3 months	37	702 ± 111	114 ± 19	6.8 ± 1.9	6.2
4 months	41	718 ± 124	108 ± 17	6.7 ± 1.8	6.7

[a] Values reported by the author in units of g/day and g/kg-day were converted to units of mL/day and mL/kg-day by dividing by 1.03 g/mL (density of human milk).

[b] Calculated by dividing human milk intake (g/day) by human milk intake (g/kg-day).

SD = Standard deviation.

Source: Butte et al. (1984).

Table 15-10. Human Milk Intake During a 24-Hour Period

Age (days)	Number of Infants	Intake (mL/day)[a]		Intake by Age Category (mL/day)[a, b]
		Mean ± SD	Range	
1	6	43 ± 68	–30–145[c]	511 ± 220
2	9	177 ± 83	43–345	
3	10	360 ± 149	203–668	
4	10	438 ± 171	159–674	
5	11	483 ± 125	314–715	
6	9	493 ± 162	306–836	
7	7	556 ± 162	394–817	
8	8	564 ± 154	398–896	
9	9	563 ± 74	456–699	
10	9	569 ± 128	355–841	
11	8	597 ± 163	386–907	
14	9	634 ± 150	404–895	
21	10	632 ± 82	538–763	
28	13	748 ± 174	481–1,111	
35	12	649 ± 114	451–903	679 ± 105
42	12	690 ± 108	538–870	
49	10	688 ± 112	543–895	
56	12	674 ± 95	540–834	
90	10	713 ± 111	595–915	713 ± 111
120	12	690 ± 97	553–822	690 ± 97
150	12	814 ± 130	668–1,139	814 ± 130
180	13	744 ± 117	493–909	744 ± 117
210	12	700 ± 150	472–935	700 ± 150
240	9	604 ± 204	280–973	604 ± 204
270	12	600 ± 214	217–846	600 ± 214
300	11	535 ± 227	125–868	535 ± 227
330	8	538 ± 233	117–835	538 ± 233
360	8	391 ± 243	63–748	391 ± 243

[a] Values reported by the author in units of g/day were converted to units of mL/day by dividing by 1.03 g/mL (density of human milk).

[b] Multiple 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.

[c] Negative value due to insensible weight loss correction.

SD = Standard deviation.

Source: Neville et al. (1988).

Table 15-11. Human Milk Intake Estimated by the Darling Study

Age	Number of Infants	Intake (mL/day)[a] Mean ± SD
3 months	73	788 ± 129
6 months	60	747 ± 166
9 months	50	627 ± 211
12 months	42	435 ± 244

[a] Values reported by the author in units of g/day were converted to units of mL/day by dividing by 1.03 g/mL (density of human milk).
SD = Standard deviation.

Source: Dewey et al. (1991b).

Table 15-12. Mean Breast-Fed Infants Characteristics[a]

	Boys (*N* = 14)	Girls (*N* = 26)
Ethnicity (White, Black, Hispanic, Asian) (*N*)	10/1/2/1	21/1/3/1
Duration of Breast-Feeding (days)	315 ± 152	362 ± 190
Duration of Formula Feeding (days)	184 ± 153	105 ± 121
Age at Introduction of Formula (months)	6.2 ± 2.9	5.2 ± 2.3
Age at Introduction of Solids (months)	5.0 ± 1.5	5.0 ± 0.09
Age at Introduction of Cow's Milk (months)	13.1 ± 3.1	12.5 ± 3.8

[a] Mean ± standard deviation.
N = Number of infants.

Source: Butte et al. (2000).

Table 15-13. Mean Human Milk Intake of Breast-Fed Infants (mL/day)[a]

Age Group	Boys	Girls
3 months	790 ± 172 (*N* = 14)	694 ± 108 (*N* = 26)
6 months	576 ± 266 (*N* = 12)	678 ± 250 (*N* = 18)
12 months	586 ± 286 (*N* = 2)	370 ± 260 (*N* = 11)
24 months	–	–

[a] 3-day average; values reported by the author in units of g/day were converted to units of mL/day by dividing by 1.03 g/mL (density of human milk); mean ± standard deviation.
N = Number of infants.
– = Not quantitated.

Source: Butte et al. (2000).

Table 15-14. Feeding Practices by Percent of Infants

Infants	Age					
	3 months	6 months	9 months	12 months	18 months	24 months
Percentage						
Infants Still Breast-Fed	100	80	58	38	25	5
Breast-Fed Infants Given Formula	0	40	48	30	10	2
Formula-Fed Infants Given Breast Milk	100	100	94	47	6	0
Use of Cow's Milk for Breast-Fed Infants	–	–	8	65	82	88
Use of Cow's Milk for Formula-Fed Infants	–	–	28	67	89	92

Source: Butte et al. (2000).

Table 15-15. Body Weight of Breast-Fed Infants[a]

Age	Weight (kg)	
	Boys	Girls
0.5 months	3.9 ± 0.4 (*n* = 14)	3.7 ± 0.5 (*n* = 19)
3 months	6.4 ± 0.6 (*n* = 14)	6.0 ± 0.6 (*n* = 19)
6 months	8.1 ± 0.8 (*n* = 14)	7.5 ± 0.6 (*n* = 18)
9 months	9.3 ± 1.0 (*n* = 14)	8.4 ± 0.6 (*n* = 19)
12 months	10.1 ± 1.1 (*n* = 14)	9.2 ± 0.7 (*n* = 19)
18 months	11.6 ± 1.2 (*n* = 14)	10.7 ± 1.0 (*n* = 19)
24 months	12.7 ± 1.3 (*n* = 12)	11.8 ± 1.1 (*n* = 19)

[a] Mean ± standard deviation.
n = Number of infants.

Source: Butte et al. (2000).

Table 15-16. AAP Data Set Milk Intake Rates at Different Ages

Age	Mean (mL/kg-day)[a]	SD (mL/kg-day)[a]	CV	Skewness Statistic[b]	*N*
7 days	143	37	0.26	0.598	10
14 days	156	40	0.26	–1.39	9
30 days	150	24	0.16	0.905	25
60 days	144	22	0.15	0.433	25
90 days	127	18	0.14	–0.168	108
120 days	112	18	0.16	0.696	57
150 days	100	21	0.21	–1.077	26
180 days	101	20	0.20	–1.860	39
210 days	75	25	0.33	–0.844	8
270 days	72	23	0.32	–0.184	57
360 days	47	27	0.57	0.874	42

[a] Values reported by the author in units of g/kg-day were converted to units of mL/kg-day by dividing by 1.03 g/mL (density of human milk).
[b] Statistic/SE: -2 < Statistic/SE < +2 suggests a normal distribution.
SD = Standard deviation.
CV = Coefficient of variation.
N = Number of infants.

Source: Arcus-Arth et al. (2005).

Table 15-17. Average Daily Human Milk Intake (mL/kg-day)[a]

Averaging Period	Mean (SD)	Population Percentile							
		5	10	25	50	75	90	95	99
AAP 0 to 6 months									
Method 1	126 (21)	92	99	112	126	140	152	160	174
Method 2	123 (7)	112	114	118	123	127	131	133	138
AAP 0 to 12 months									
Method 1	98 (22)	61	69	83	98	113	127	135	150
Method 2	99 (5)	90	92	95	99	102	105	107	110
EBF 0 to 12 months	110 (21)	75	83	95	110	124	137	144	159
General Pop.									
0 to 6 months	79	0	0	24	92	123	141	152	170
0 to 12 months	51	0	0	12	49	85	108	119	138

[a] Values reported by the author in units of g/kg-day were converted to units of mL/kg-day by dividing by 1.03 g/mL (density of human milk).
AAP = American Academy of Pediatrics.
EBF = Exclusively breast-fed.

Source: Arcus-Arth et al. (2005).

Table 15-18. Lipid Content of Human Milk and Estimated Lipid Intake Among Exclusively Breast-Fed Infants

Age (months)	Number of Observations	Lipid Content (mg/g) Mean ± SD	Lipid Content %[a]	Lipid Intake (mL/day)[b] Mean ± SD	Lipid Intake (mL/kg-day)[b] Mean ± SD
1	37	36.2 ± 7.5	3.6	27 ± 8	5.7 ± 1.7
2	40	34.4 ± 6.8	3.4	24 ± 7	4.3 ± 1.2
3	37	32.2 ± 7.8	3.2	23 ± 7	3.7 ± 1.2
4	41	34.8 ± 10.8	3.5	25 ± 8	3.7 ± 1.3

[a] Percents calculated from lipid content reported in mg/g.
[b] Values reported by the author in units of g/day and g/kg-day were converted to units of mL/day and mL/kg-day by dividing by 1.03 g/mL (density of human milk).

Source: Butte et al. (1984).

Table 15-19. Human Milk Production and Composition During the First 12 Months of Lactation[a]

Age Group (months)	Volume, per Breast (mL/24 hours)			Fat (g/L)			Lactose (g/L)			Protein (g/L)			Energy (kJ/mL)		
	Mean	SE	*N*	Mean	SE	*N*	Mean	SE	*N*	Mean	SE	*N*	Mean	SE	*N*
1	416	24	34	39.9	1.4	34	59.7	0.8	18	10.5	0.4	18	2.7	0.06	18
2	408	23	34	35.2	1.4	34	60.4	1.1	18	9.6	0.4	18	2.5	0.06	18
4	421	20	34	35.4	1.4	32	62.6	1.3	16	9.3	0.4	18	2.6	0.09	16
6	413	25	30	37.3	1.4	28	62.5	1.7	16	8.0	0.4	16	2.6	0.09	16
9	354	47	12	40.7	1.7	12	62.8	1.5	12	8.3	0.5	12	2.8	0.09	12
12	252	51	10	40.9	3.3	10	61.4	2.9	10	8.3	0.6	10	2.8	0.14	10
1 to 12	399	11	154	37.4	0.6	150	61.4	0.6	90	9.2	0.2	92	2.7	0.04	90

[a] Infants were completely breast-fed to 4 months and complementary solid food was introduced between 4 and 6 months.
SE = Standard error.
N = Number of individual breasts.

Source: Mitoulas et al. (2002).

Table 15-20. Changes in Volume of Human Milk Produced and Milk Fat Content During the First Year of Lactation[a]

Age Group (months)	*N*	Volume, Left Breast (mL/day)		Volume, Right Breast (mL/day)		Fat, Left Breast (g/L)		Fat, Right Breast (g/L)	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE
1	5	338	52	475	69	38	1.5	38	2.6
2	5	364	52	427	42	31	2.2	30	2.9
4	5	430	51	482	58	32	3.3	29	2.6
6	5	373	75	437	56	33	2.5	33	2.5
9	5	312	65	365	94	43	2.2	38	3.3
12	5	203	69	302	85	40	4.8	42	5.0
1 to 12	30	337	26	414	28	36	1.4	35	1.5
Statistical significance: *P*		NS		NS		0.004		0.008	

[a] Infants were completely breast-fed to 4 months, and complementary solid food was introduced between 4 and 6 months.

N = Number of mothers.
SE = Standard error.
NS = No statistical difference.
P = Probability.

Source: Mitoulas et al. (2003).

Table 15-21. Changes in Fatty Acid Composition of Human Milk During the First Year of Lactation (g/100 g total fatty acids)

Fatty Acid	1 month		2 months		4 months		6 months		9 months		12 months	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Medium-Chain Saturated	14.2	0.4	13.9	0.6	12.0	0.5	11.5	0.2	14.1	0.3	17.0	0.4
Odd-Chain Saturated	0.9	0.01	0.9	0.02	0.8	0.02	0.8	0.03	0.8	0.02	0.8	0.02
Long-Chain Saturated	34.1	0.3	33.7	0.3	32.8	0.3	31.8	0.6	31.4	0.6	33.9	0.6
Mono-Unsaturated	37.5	0.2	33.7	0.4	38.6	0.5	37.5	0.5	37.3	0.5	33.0	0.5
Trans	2.0	0.08	2.2	0.1	2.2	0.09	4.6	0.02	1.7	0.2	1.8	0.09
Poly-Unsaturated	12.7	0.2	9.5	0.2	11.8	0.4	13.4	0.6	8.0	0.1	6.7	0.03

SE = Standard error.

Source: Mitoulas et al. (2003).

Table 15-22. Comparison Daily Lipid Intake Based on Lipid Content Assumptions (mL/kg-day)[a, b]

Lipid Content Used in Calculation	Mean	Population Percentile							
		5	10	25	50	75	90	95	99
Measured Lipid Content[c]	3.6	2.0	2.3	2.9	3.6	4.3	4.9	5.2	5.9
4% Lipid Content[d]	3.9	2.5	2.8	3.3	3.8	4.4	4.9	5.2	5.8

[a] Values reported by the author in units of g/kg-day were converted to units of mL/kg-day by dividing by 1.03 g/mL (density of human milk).
[b] Estimates based on data from Dewey et al. (1991a).
[c] Lipid intake derived from lipid content and milk intake measurements.
[d] Lipid intake derived using 4% lipid content value and milk intake.

Source: Arcus-Arth et al. (2005).

Table 15-23. Distribution of Average Daily Lipid Intake (mL/kg-day) Assuming 4% Milk Lipid Content[a]

	Mean	Population Percentile							
		5	10	25	50	75	90	95	99
AAP Infants 0–12 months	3.9	2.4	2.8	3.3	3.9	4.5	5.1	5.4	6.0

[a] Values reported by the author in units of g/kg-day were converted to units of mL/kg-day by dividing by 1.03 g/mL (density of human milk).
AAP = American Academy of Pediatrics.

Source: Arcus-Arth et al. (2005).

Table 15-24. 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 mL/day[a]
Maximum Lipid Intake	51.0 mL/day[a]
Arithmetic Mean Lipid Intake	26.0 mL/day[a]
Standard Deviation Lipid Intake	7.2 mL/day[a]

[a] Values reported by the author in units of g/day were converted to units of mL/day by dividing by 1.03 g/mL (density of human milk).

Source: Maxwell and Burmaster (1993).

Table 15-25. Socioeconomic Characteristics of Exclusively Breast-Fed Infants Born in 2004

	Percent of Exclusive Breast-Feeding Infants through 3 and 6 Months			
	3 months		6 months	
Characteristic	%	95% CI	%	95% CI
U.S. Overall (*N* = 17,654)	30.5	29.4–31.6	11.3	10.5–12.1
Infant Sex				
Male	30.7	29.1–32.3	10.8	9.8–11.8
Female[a]	30.3	28.7–31.9	11.7	10.5–12.9
Race/Ethnicity (child)				
Hispanic	30.8	28.3–33.3	11.5	9.7–13.3
White, non-Hispanic[a]	33.0	31.6–34.4	11.8	10.9–12.7
Black, non-Hispanic	19.8[b]	17.0–22.6	7.3[b]	5.5–9.1
Asian, non-Hispanic	30.6	25.0–36.2	14.5	10.0–19.0
Other	29.3	24.9–33.7	12.2	9.2–15.2
Maternal Age (years)				
<20	16.8[b]	10.3–23.3	6.1[b]	1.5–10.7
20 to 29	26.2[b]	24.4–28.0	8.4[b]	7.3–9.5
≥30[a]	34.6	33.2–36.0	13.8	12.7–14.9
Household Head Education				
<High school	23.9[b]	21.0–26.8	9.1[b]	7.1–11.1
High school	22.9[b]	20.9–24.9	8.2[b]	7.0–9.4
Some college	32.8[b]	30.3–35.3	12.3[b]	10.2–14.4
College graduate[a]	41.5	39.7–43.3	15.4	14.1–16.7
Marital Status				
Married[a]	35.4	34.0–36.8	13.4	12.4–14.4
Unmarried	18.8[b]	16.9–20.7	6.1[b]	5.0–7.2
Residence				
MSA, center city[a]	30.7	29.0–32.4	11.7	10.5–12.9
MSA, non-center city	32.8	30.9–34.7	12.1	10.8–13.4
Non-MSA	23.9[b]	21.8–26.0	8.2[b]	6.9–9.5
Poverty income ratio (%)				
<100	23.9[b]	21.6–26.2	8.3[b]	6.9–9.7
100 to <184	26.6[b]	23.8–29.4	8.9[b]	7.2–10.6
185 to <349	33.2[b]	30.9–35.5	11.8[b]	10.3–13.3
≥350[a]	37.7	35.7–39.7	14.0	12.6–15.4

[a] Referent group.
[b] $p < 0.05$ by chi-square test, compared with referent group.
N = Number of infants.
MSA = Metropolitan statistical area.

Source: Scanlon et al. (2007).

Table 15-26. Geographic-Specific Breast-Feeding Percent Rates Among Children Born in 2006[a]

State	Ever Breast-Fed	Breast-Fed at 6 Months	Breast-Fed at 12 Months	Exclusive Breast-Feeding through 3 Months	Exclusive Breast-Feeding through 6 Months
U.S. National	73.9	43.4	22.7	33.1	13.6
Alabama	58.8	26.6	11.4	24.2	6.3
Alaska	88.5	48.9	26.2	45.5	16.9
Arizona	76.5	45.3	22.3	29.7	11.9
Arkansas	61.5	26.9	10.6	23.6	6.3
California	84.7	53.0	31.1	42.4	18.6
Colorado	82.5	59.5	30.5	49.2	22.6
Connecticut	74.9	41.9	23.3	35.1	14.4
Delaware	66.7	32.8	15.4	28.1	7.5
Dist of Columbia	69.6	45.6	20.2	31.3	13.3
Florida	75.7	37.2	18.2	30.7	11.9
Georgia	62.5	36.4	18.1	28.0	14.8
Hawaii	88.2	56.3	35.0	44.9	22.4
Idaho	79.8	55.1	25.3	46.7	17.7
Illinois	69.5	38.7	15.9	28.5	11.9
Indiana	71.1	37.2	18.9	28.9	10.6
Iowa	68.1	33.2	15.8	32.3	10.6
Kansas	78.1	43.8	23.6	36.0	16.8
Kentucky	53.6	28.9	15.8	27.2	9.4
Louisiana	49.1	20.7	9.9	17.8	5.0
Maine	75.0	45.7	26.0	38.7	18.1
Maryland	76.4	43.3	25.4	28.5	10.1
Massachusetts	78.2	44.7	24.5	39.0	13.5
Michigan	64.8	31.2	14.4	23.5	10.7
Minnesota	79.9	51.6	24.7	39.8	15.0
Mississippi	48.3	20.1	8.7	16.8	4.6
Missouri	65.3	33.1	14.9	24.8	8.5
Montana	82.7	56.8	30.6	40.8	20.5

Table 15-26. Geographic-Specific Breast-Feeding Percent Rates Among Children Born in 2006[a] (continued)

State	Ever Breast-Fed	Breast-Fed at 6 Months	Breast-Fed at 12 Months	Exclusive Breast-Feeding through 3 Months	Exclusive Breast-Feeding through 6 Months
Nebraska	76.8	46.2	22.6	31.7	11.9
Nevada	79.3	45.3	22.5	31.8	9.7
New Hampshire	78.4	55.1	30.5	42.6	20.6
New Jersey	81.4	53.0	27.4	29.7	13.2
New Mexico	72.6	42.2	25.7	33.2	14.0
New York	76.4	49.4	28.9	24.9	9.6
North Carolina	66.9	36.7	18.9	30.2	13.1
North Dakota	71.1	37.6	20.6	33.7	11.1
Ohio	58.5	29.7	12.0	22.4	9.1
Oklahoma	65.6	27.4	12.4	30.6	8.4
Oregon	91.4	63.0	37.0	56.6	20.8
Pennsylvania	67.6	35.8	19.4	29.3	10.1
Rhode Island	75.4	40.4	19.8	31.8	8.7
South Carolina	61.3	30.4	13.9	25.5	9.6
South Dakota	76.8	47.5	22.1	36.5	17.6
Tennessee	58.8	37.9	14.8	28.2	12.8
Texas	78.2	48.7	25.3	34.2	14.2
Utah	92.8	69.5	33.9	50.8	24.0
Vermont	80.1	59.5	38.4	49.2	23.5
Virginia	79.7	48.3	25.8	38.7	18.8
Washington	86.4	58.0	35.0	48.8	25.3
West Virginia	58.8	27.2	12.6	21.3	8.4
Wisconsin	75.3	48.6	25.9	45.2	16.8
Wyoming	84.2	50.8	26.7	46.2	16.8

[a] Exclusive breast-feeding information is from the 2006 NIS survey data only and is defined as ONLY breast milk: no solids, no water, no other liquids.

Source: CDC (2009).

Table 15-27. Percentage of Mothers in Developing Countries by Feeding Practices for Infants 0–6 Months Old[a]

Country	Breast-Feeding	Water	Milk	Formula	Other Liquids	Solid Foods
Armenia	86.1	62.7	22.9	13.1	48.1	23.9
Bangladesh	99.6	30.2	13.6	5.3	19.7	20.3
Cambodia	98.9	87.9	2.1	3.3	6.7	16.6
Egypt	95.5	22.9	11.1	4.3	27.6	13.2
Ethiopia	98.8	26.3	19	0	10.8	5.3
Ghana	99.6	41.9	6.7	3.5	4.3	15.6
India	98.1	40.2	21.2	0	7.1	6.5
Indonesia	92.8	37	0.7	24.2	8.7	43
Jordan	92.4	58.5	3	25.1	13.8	20.2
Kazakhstan	94.4	53.7	21.4	8.2	37.4	15.4
Kenya	99.7	60	35.1	4.8	35.9	46.3
Malarwi	100	46	1.4	1.7	5.2	42.3
Nambia	95.3	65.4	0	0	17.9	33.4
Nepal	100	23.3	12.3	0	2.8	9.3
Nigeria	99.1	78.2	9.2	12.7	17.9	18.5
Philippines	80.5	53.4	4.4	30	12.4	16.8
Uganda	98.7	15.1	20.3	1.5	10.3	11.4
Vietnam	98.7	45.9	16.9	0.8	8.9	18.7
Zamibia	99.6	52.6	2.1	2.7	6.7	31.2
Zimbabwe	100	63.9	1.6	3.2	9	43.7
Pooled	96.6	45.9	11.9	9	15.1	21.9

[a] Percentage of mothers who stated that they currently breast-feed and separately had fed their infants four categories of liquid or solid food in the past 24 hours by country for infants age 0 to 6 months old.

Source: Marriott et al. (2007).

Table 15-28. Percentage of Mothers in Developing Countries by Feeding Practices for Infants 6–12 Months Old[a]

Country	Breast-Feeding	Water	Milk	Formula	Other Liquids	Solid Foods
Armenia	53.4	91.1	56.9	11.6	85.3	88.1
Bangladesh	96.2	87.7	29.8	10.1	21.9	65.2
Cambodia	94.4	97.5	3.7	6.7	29	81
Egypt	89.1	85.9	36.8	16.7	48.5	75.7
Ethiopia	99.4	69.2	37.6	0	23.9	54.7
Ghana	99.3	88.8	14.6	9.6	23.9	71.1
India	94.9	81.4	45	0	25.2	44.1
Indonesia	84.8	85.4	4.9	38.8	35.4	87.9
Jordan	65.7	99.3	24.3	28.8	57.7	94.9
Kazakhstan	81.2	74.3	85.4	11.4	91.8	85.9
Kenya	96.5	77.7	58.7	6	56.4	89.6
Malarwi	99.4	93.5	5.9	3.2	31.2	94.9
Nambia	78.7	91.9	0	0	42.7	79.5
Nepal	98.8	84.3	32	0	15.8	71.5
Nigeria	97.8	91.6	14.4	13.4	27.4	70.4
Philippines	64.4	95.1	12.2	47.1	31	88
Uganda	97.4	65.9	32.1	1.6	56.2	82.1
Vietnam	93.2	95	36.1	5.3	37.9	85.8
Zamibia	99.5	91.7	8.2	5	25.9	90.2
Zimbabwe	96.7	92.5	8.7	2.4	49.9	94.8
Pooled	87.9	87.4	29.6	15.1	41.6	80.1

[a] Percentage of mothers who stated that they currently breast-feed and separately had fed their infants four categories of liquid or solid food in the past 24 hours by country for infants age 6 to 12 months old.

Source: Marriott et al. (2007).

Table 15-29. Population Weighted Averages of Mothers Who Reported Selected Feeding Practices During the Previous 24 Hours

Feeding Practices	Infant Age	
	0–6 months	6–12 months
	Percentage (weighted *N*)	
Current Breast-Feeding	96.6 (22,781)	87.9 (18,944)
Gave Infant:		
Water	45.9 (10,767)	87.4 (18,663)
Tinned, Powdered, or Other Milk	11.9 (2,769)	29.6 (6,283)
Commercial Formula	9.0 (1,261)	15.1 (1,911)
Other Liquids	15.1 (3,531)	41.6 (8,902)
Any Solid Food	21.9 (5,131)	80.1 (17,119)

N = Number of infants.

Source: Marriott et al. (2007).

Table 15-30. Racial and Ethnic Differences in Proportion of Children Ever Breast-Fed, NHANES III (1988–1994)

	Non-Hispanic White			Non-Hispanic Black			Mexican American			Absolute Difference (%, SE)[a]			
										White vs. Black		White vs. Mexican American	
Characteristic	*N*	%	(SE)	*N*	%	(SE)	*N*	%	(SE)	%	(SE)	%	(SE)
All Infants	1,869	60.3	2.0	1,845	25.5	1.4	2,118	54.4	1.9	34.8	(2.0)[b]	6.0	(2.3)[a]
Infant Sex													
Male	901	60.4	2.6	913	24.4	1.6	1,033	53.8	1.8	35.9	(2.9)[b]	6.6	(2.8)[a]
Female	968	60.3	2.3	932	26.7	1.9	1,085	54.9	2.9	33.7	(2.6)[b]	5.4	(3.4)[c]
Infant Birth Weight (g)													
<2,500	118	40.1	5.3	221	14.9	2.6	165	34.1	3.9	25.1	(5.8)[b]	5.9	(6.4)[c]
≥2,500	1,738	62.1	2.1	1,584	26.8	1.6	1,838	55.7	2.0	35.3	(2.1)[b]	6.4	(2.5)[a]
Maternal Age (years)													
<20	175	33.7	4.4	380	13.1	2.1	381	43.7	3.0	20.6	(4.8)[b]	–10	(5.1)[c]
20–24	464	48.3	3.0	559	22.0	2.0	649	54.8	2.6	26.4	(3.7)[b]	–6.4	(4.2)[c]
25–29	651	65.4	2.2	504	30.6	2.5	624	56.9	3.3	34.8	(3.1)[b]	8.6	(4.0)[a]
≥30	575	71.9	2.7	391	36.1	2.3	454	59.6	2.8	35.8	(3.4)[b]	12.3	(3.4)[b]
Household Head Education													
<High school	313	32.3	4.0	583	14.7	2.5	1,262	51.0	2.6	17.6	(5.0)[b]	–18.8	(4.8)[b]
High school	623	52.6	2.8	773	21.9	2.0	479	51.4	3.4	30.7	(3.2)[b]	1.2	(4.1)[c]
Some college	397	63.8	2.3	317	37.2	3.5	226	68.0	5.2	26.6	(3.7)[b]	–4.1	(5.6)[c]
College graduate	505	83.0	2.4	139	54.4	4.9	74	78.3	7.4	28.6	(5.3)[b]	4.6	(7.6)[c]
Smoking During Pregnancy													
Yes	526	39.8	3.0	403	18.0	2.1	198	31.2	3.9	21.8	(3.7)[b]	8.6	(4.7)[c]
No	1,334	68.2	2.0	1,429	27.8	1.7	1,917	56.7	1.9	40.4	(2.1)[b]	11.5	(2.5)[b]
Maternal Body Mass Index													
<25.0	1,331	64.9	2.0	872	26.8	2.0	961	54.1	2.5	38.0	(2.5)[b]	10.8	(2.7)[b]
25.0–29.9	283	50.9	3.4	484	24.1	3.2	534	57.8	2.1	26.8	(4.5)[b]	–6.8	(4.1)[c]
≥30	204	48.6	4.8	415	24.3	2.7	359	47.1	4.4	24.3	(5.3)[b]	1.5	(6.1)[c]
Residence													
Metropolitan	762	67.2	3.0	943	32.0	1.9	1,384	56.1	2.0	35.3	(2.6)[b]	11.2	(2.9)[b]
Rural	1,107	54.9	3.1	902	18.3	1.9	734	51.3	3.1	36.6	(2.7)[b]	3.6	(4.0)[c]
Region													
Northeast	317	51.6	4.6	258	34.2	4.4	12	74.1	10.4	17.3	(3.6)[b]	–22.5	(14.5)[c]
Midwest	556	61.7	2.3	346	26.5	2.4	170	51.5	3.7	35.2	(3.3)[b]	10.2	(5.0)[a]
South	748	52.7	2.7	1,074	19.4	2.0	694	42.7	3.5	33.3	(2.7)[b]	10	(4.6)[a]
West	248	82.4	3.9	167	45.1	5.1	1,242	59.1	2.2	37.3	(7.1)[b]	23.4	(3.3)[b]

Table 15-30. Racial and Ethnic Differences in Proportion of Children Ever Breast-Fed, NHANES III (1988–1994) (continued)

	Non-Hispanic White			Non-Hispanic Black			Mexican American			Absolute Difference (%, SE)[a]			
										White vs. Black		White vs. Mexican American	
Poverty Income Ratio (%)	*N*	%	(SE)	*N*	%	(SE)	*N*	%	(SE)	%	(SE)	%	(SE)
<100	257	38.5	4.2	905	18.2	1.9	986	48.2	2.8	20.3	(4.4)[b]	–9.6	(4.7)[a]
100 to <185	388	55.7	2.6	391	26.8	2.1	490	54.1	3.4	28.9	(3.5)[b]	1.5	(4.2)[c]
185 to <350	672	61.9	2.5	294	32.0	3.0	288	64.7	4.7	30.0	(3.7)[b]	2.8	(5.3)[c]
≥350	444	77.0	2.5	105	58.1	5.1	74	71.9	9.0	19.0	(5.6)[b]	5.2	(9.0)[c]
Unknown	108	44.7	7.1	150	25.5	3.9	280	59.5	2.8	19.2	(7.9)[a]	–14.8	(7.9)[c]

[a] $p < 0.05$.
[b] $p < 0.01$.
[c] No statistical difference.
N = Number of infants.
SE = Standard error.

Source: Li and Grummer-Strawn (2002).

Table 15-31. Racial and Ethnic Differences in Proportion of Children Who Received Any Human Milk at 6 Months (NHANES III, 1988–1994)

	Non-Hispanic White			Non-Hispanic Black			Mexican American			Absolute Difference (%, SE)			
										White vs. Black		White vs. Mexican American	
Characteristic	*N*	%	(SE)	No.	%	(SE)	*N*	%	(SE)	%	(SE)	%	(SE)
All Infants	1,863	26.8	1.6	1,842	8.5	0.9	2,112	23.1	1.4	18.3	(1.7)[a]	3.7	(2.1)[b]
Infant Sex													
Male	900	27.6	2.3	912	8.5	1.1	1,029	22.3	1.6	19.1	(2.6)[a]	5.2	(2.6)[c]
Female	963	26.1	1.8	930	8.6	1.1	1,083	24.0	2.0	17.5	(2.1)[c]	2.1	(2.7)[b]
Infant Birth Weight (g)													
<2,500	118	10.9	3.1	221	4.2	1.8	165	15.2	4.7	6.7	(3.3)[c]	–4.3	(5.7)[b]
≥2,500	1,733	28.3	1.8	1,581	9.0	0.9	1,832	23.1	1.7	19.3	(1.8)[a]	5.2	(2.3)[c]
Maternal Age (years)													
<20	174	10.2	2.9	380	4.7	1.4	380	11.6	1.7	5.5	(3.0)[b]	–1.3	(3.8)[b]
20–24	461	13.4	2.4	559	7.5	1.1	646	23.8	2.4	5.9	(2.5)[c]	–10.4	(3.3)[a]
25–29	651	29.3	2.6	503	10.9	2.0	624	24.6	2.6	18.4	(3.5)[a]	4.8	(3.6)[b]
≥30	573	39.0	2.6	389	10.7	1.7	452	30.0	2.8	28.4	(3.3)[a]	9.0	(3.6)[c]
Household Head Education													
<High school	312	14.6	3.8	582	4.4	1.2	1,258	20.7	1.4	10.2	(4.5)[c]	–6.2	(4.1)[b]
High school	622	19.9	1.7	771	5.0	1.0	478	22.4	2.5	14.9	(2.0)[a]	2.5	(3.1)[b]
Some college	396	26.8	2.4	317	16.6	2.5	225	28.4	5.3	10.2	(3.5)[a]	–1.6	(6.1)[b]
College graduate	502	42.2	2.9	139	21.1	3.2	74	45.5	7.3	21.1	(5.2)[a]	3.4	(7.6)[b]
Smoking During Pregnancy													
Yes	524	11.3	1.5	402	4.3	1.1	198	9.3	2.2	7.0	(1.9)[a]	2.1	(2.7)[b]
No	1,331	32.7	2.1	1,427	9.8	1.1	1,911	24.5	1.5	22.9	(2.3)[a]	8.1	(2.6)[a]
Maternal Body Mass Index													
<25.0	1,326	29.6	1.8	871	8.9	1.2	959	21.9	2.1	20.7	(2.1)[a]	7.8	(2.7)[a]
25.0–29.9	282	19.0	2.4	482	8.2	1.9	534	26.4	1.9	10.8	(3.2)[a]	7.4	(3.0)[c]
≥30	204	20.4	4.1	415	7.3	1.6	357	17.2	3.0	13.1	(4.4)[a]	3.3	(5.2)[b]
Residence													
Metropolitan	760	29.7	2.5	941	11.8	1.3	1,378	23.5	1.7	17.9	(2.4)[a]	6.1	(3.1)[b]
Rural	1,103	24.6	2.4	901	4.9	0.9	734	22.5	2.8	19.7	(2.2)[a]	2.2	(3.4)[b]
Region													
Northeast	316	21.0	2.2	258	9.7	1.8	12	43.6	16.0	11.3	(1.8)[a]	–22.6	(16.5)[b]
Midwest	553	28.8	2.1	344	9.8	2.4	170	18.2	4.7	19.0	(3.7)[a]	10.6	(6.2)[b]
South	746	20.1	2.8	1,073	5.9	1.0	693	17.2	2.8	14.3	(2.8)[a]	2.9	(4.2)[b]
West	248	42.7	4.7	167	19.3	3.3	1,237	25.9	1.4	23.4	(5.3)[a]	16.8	(5.1)[a]

Table 15-31. Racial and Ethnic Differences in Proportion of Children Who Received Any Human Milk at 6 Months (NHANES III, 1988–1994) (continued)

	Non-Hispanic White			Non-Hispanic Black			Mexican American			Absolute Difference (%,SE)			
										White vs. Black		White vs. Mexican American	
Poverty Income Ratio (%)	*N*	%	(SE)	No.	%	(SE)	*N*	%	(SE)	%	(SE)	%	(SE)
100 to <185	387	23.5	2.9	390	9.9	1.8	486	23.4	2.7	13.6	(3.9)[a]	0	(4.1)[b]
185 to <350	670	30.4	2.7	293	10.0	2.4	287	27.6	4.4	20.4	(4.0)[a]	2.9	(4.8)[b]
≥350	443	33.0	3.0	105	15.2	2.8	74	32.3	9.0	17.8	(4.2)[a]	0.7	(9.5)[b]
Unknown	108	13.3	3.8	149	6.4	2.9	280	26.7	4.5	7.0	(5.3)[b]	−13.4	(6.6)[c]

[a] $p < 0.01$.
[b] No statistical difference.
[c] $p < 0.05$.
N = Number of individuals.
SE = Standard error.

Source: Li and Grummer-Strawn (2002).

Table 15-32. Racial and Ethnic Differences in Proportion of Children Exclusively Breast-Fed at 4 Months (NHANES III, 1991–1994)

	Non-Hispanic White			Non-Hispanic Black			Mexican American			Absolute Difference (%,SE)			
										White vs. Black		White vs. Mexican American	
Characteristic	*N*	%	(SE)	*N*	%	(SE)	*N*	%	(SE)	%	(SE)	%	(SE)
All Infants	824	22.6	1.7	906	8.5	1.5	957	20.4	1.4	14.1	(2.2)[a]	2.3	(1.6)[b]
Infant Sex													
Male	394	22.3	1.9	454	7.0	1.6	498	20.7	1.5	15.3	(2.6)[a]	1.5	(1.8)[b]
Female	430	23.0	2.2	452	10.0	2.2	459	20.0	1.8	12.9	(3.0)[a]	3.0	(2.1)[b]
Infant Birth Weight (g)													
<2,500	50	15.2	7.1	118	7.0	2.3	66	5.6	1.8	8.2	(8.1)[b]	9.5	(6.9)[b]
≥2,500	774	23.1	1.8	786	8.8	1.6	880	21.6	1.4	14.4	(2.2)[a]	1.5	(1.6)[b]
Maternal Age (years)													
<20	76	6.6	3.2	172	6.4	2.1	170	12.1	2.5	0.2	(3.7)[b]	–5.6	(3.8)[b]
20–24	205	11.4	2.2	273	7.4	2.4	319	21.0	2.3	4.0	(2.7)[b]	–9.6	(3.2)[a]
25–29	271	21.6	2.3	254	8.6	2.5	256	22.1	2.5	13.0	(3.2)[a]	–0.5	(3.2)[b]
≥30	270	34.8	2.7	201	11.9	2.6	210	23.6	3.1	22.9	(4.2)[a]	11.1	(3.7)[a]
Household Head Education													
<High school	146	9.5	3.5	256	2.0	0.7	563	19.7	1.8	7.5	(3.6)[c]	–10.2	(4.0)[c]
High school	277	14.5	2.7	406	7.1	2.1	222	18.8	3.6	7.4	(3.2)[c]	–4.3	(4.7)[b]
Some college	175	30.8	3.8	141	17.4	3.0	120	21.0	3.9	13.4	(4.7)[a]	9.8	(6.1)[b]
College graduate	219	34.1	3.9	92	17.4	4.7	37	31.5	4.5	16.7	(6.9)[c]	2.6	(6.3)[b]
Smoking During Pregnancy													
Yes	224	10.0	2.8	168	5.4	2.2	64	3.2	1.8	4.6	(3.7)[b]	6.8	(3.4)[b]
No	596	27.2	2.1	730	9.4	1.9	892	21.7	1.5	17.8	(2.8)[a]	5.6	(2.0)[c]
Maternal Body Mass Index													
<25.0	597	24.8	2.1	407	8.0	1.9	417	19.4	1.9	16.8	(3.0)[a]	5.4	(2.3)[c]
25.0–29.9	117	19.7	4.3	230	8.6	1.9	261	23.1	3.4	11.1	(4.6)[c]	–3.4	(4.9)[b]
≥30	91	15.4	3.8	230	9.0	2.9	184	15.9	2.3	6.4	(5.2)[b]	–0.5	(4.6)[b]
Residence													
Metropolitan	312	24.4	3	535	11.0	2.0	608	19.6	1.6	13.4	(3.5)[a]	4.8	(2.8)[b]
Rural	512	21.3	1.8	371	4.2	1.3	349	22.3	3.3	17.1	(1.8)[a]	–1.1	(3.0)[b]
Region													
Northeast	138	20.0	1.4	131	11.1	2.9	10	9.4	9.5	8.8	(2.2)[a]	10.6	(8.7)[b]
Midwest	231	26.5	3.2	143	12.6	5.6	98	19.2	4.1	13.9	(7.6)[b]	7.4	(3.7)[b]
South	378	14.1	2.8	574	5.9	1.4	383	15.9	3.1	8.2	(1.9)[a]	–1.8	(3.7)[b]
West	77	34.7	2.7	58	12.5	5.0	466	23.0	1.3	22.2	(5.4)[a]	11.7	(2.5)

Table 15-32. Racial and Ethnic Differences in Proportion of Children Exclusively Breast-Fed at 4 Months (NHANES III, 1991–1994) (continued)

	Non-Hispanic White			Non-Hispanic Black			Mexican American			Absolute Difference (%, SE)			
										White vs. Black		White vs. Mexican American	
Poverty Income Ratio (%)	*N*	%	(SE)	*N*	%	(SE)	*N*	%	(SE)	%	(SE)	%	(SE)
<100	116	13.1	3.3	448	5.7	1.6	471	18.4	1.8	7.4	(3.5)[c]	–5.3	(3.1)[b]
100 to <185	166	18.9	3.2	197	10.6	2.8	234	21.9	4.1	8.3	(3.3)[c]	–3	(6.1)[b]
185 to <350	274	25.1	3.2	145	12.9	4.3	132	26.4	4.2	12.2	(5.0)[c]	–1.3	(4.1)[b]
≥350	235	27.4	4.1	57	12.8	3.5	37	17.0	5.0	14.6	(5.0)[a]	10.4	(5.2)[b]
Unknown	33	16.5	7.6	59	7.3	3.7	83	16.1	5.1	9.2	(8.6)[b]	0.4	(9.5)[b]

[a] $p < 0.05$.
[b] $p < 0.01$.
[c] No statistical difference.
N = Number of individuals.
SE = Standard error.

Source: Li and Grummer-Strawn (2002).

Table 15-33. 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 to 24	45.2	52.6	16.4	11.5	14.6	27.0
25 to 29	58.8	63.1	7.3	21.1	22.9	8.5
30 to 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 to $14,999	47.1	51.7	9.8	13.9	15.4	10.8
$15,000 to $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
Non-participant	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: % breast-fed in 1984 – % breast-fed in 1989 ÷ % breast-fed in 1984.
[b] Figures in parentheses indicate a decrease in the rate of breast-feeding from 1989 to 1995.
[c] WIC indicates Women, Infants, and Children supplemental food program.

Source: Ryan (1997).

Table 15-34. Percentage of Mothers Breast-Feeding Newborn Infants in the Hospital and Infants at 6 and 12 Months of Age in the United States in 2003, by Ethnic Background and Selected Demographic Variables

Characteristic	Percentage of Mothers Breast-Feeding		
	In Hospital	At 6 Months	At 12 Months
All Infants	44	18	10
White	53	20	12
Black	26	10	5
Hispanic	33	15	12
Asian	39	23	12
Maternal Age (years)			
<20	28	9	4
20 to 24	40	13	8
25 to 29	48	20	10
30 to 34	50	23	14
35+	47	23	14
Maternal Education			
Any Grade School	26	13	17
Any High School	35	12	8
No College	35	12	8
College	55	24	14
Maternal Employment			
Employed Full Time	44	11	6
Employed Part Time	49	19	11
Total Employed	45	14	8
Not Employed	43	21	13
Low Birth Weight <5 lbs 9oz	27	10	6
Parity			
Primiparous	48	17	10
Multiparous	43	19	11
WIC Participation[a]			
Participant	32	11	7
Non-participant	55	25	14
U.S. Census Region			
New England	52	22	11
Middle Atlantic	36	17	9
East North Central	44	17	9
West North Central	55	18	9
South Atlantic	42	16	10
East South Central	37	11	7
West South Central	37	15	8
Mountain	53	23	16
Pacific	50	24	15

[a] WIC indicates Women, Infants, and Children supplemental food program.

Source: Abbott Labs (2003).

Table 15-35. 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 15-36. Comparison of Breast-Feeding Patterns Between Age and Groups (Mean ± SD)

Breast-Feeding Episodes per Day	5.8 ± 2.6	6.8 ± 2.4	2.5 ± 2.0
Total Time Breast-Feeding (minute/day)	65.2 ± 44.0	102.2 ± 51.4	31.2 ± 24.6
Length of Breast-Feeding (minute/episode)	10.8 ± 6.1	14.2 ± 6.1	11.6 ± 5.6

SD = Standard deviation.

Source: Buckley (2001).