TABLE OF CONTENTS

LIST OF TABLES

This page is 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 (AAP, 2005). Ingestion of human milk has also been associated with a reduction in risk of postneonatal death in the U.S. (Chen and Rogan, 2004). The American Academy of Pediatrics recommends exclusive breastfeeding for approximately the first six months and supports the continuation of breastfeeding for the first year and beyond if desired by the mother and child (AAP, 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 may also 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 is also 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., 2002). However, few data based on this technique were found in the literature.

Among infants born in 2004, 73.8% were breastfed postpartum, 41.5.% at 6 months, and 20.9% at 12 months. Studies among 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 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 are also 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 (Dewey et al., 1992; Drewett et al.,1993; Gonzalez-Cossio et al., 1998). These studies are not included in this chapter because they do no focus on the exposure factor of interest. Other studies in the literature focus on formula intake. Since some baby formula are prepared by adding water, these data are presented in chapter 3 - Water Intake.

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 utilized 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 since intake rates may be higher on a body weight basis for younger infants. Also, the data used to derive the recommendations are over 15 years old and the sample size of the studies was small. Other populations of concern such as mothers highly committed to breastfeeding, sometimes for periods longer than 1 year, may not be captured by the studies presented in this chapter.

15.2.1 Human Milk Intake

A summary of recommended values for human milk and lipid intake rates is presented in Table 15-1 and the confidence ratings for these recommendations are presented in Table 15-2. 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. In order 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 using a density of human milk of 1.03 g/mL rounded up 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, these were estimated by adding two standard deviations to the mean value. Recommendations for upper percentiles, when multiple studies were available, 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 breastfed infants since this population may have higher exposures than partially breastfed infants. **Exclusively breastfed in this chapter refers to infants whose sole source of milk comes from human milk, with no other milk substitutes. Partially breastfed 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 breastfed 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

Recommended lipid intake rates are presented in Table 15-5. The table parallels the human milk intake tables (Table 15- 3). With the exception of the data from Butte et al. (1984), the rates were calculated assuming a lipid content of 4% (Butte et al.,1984; NAS, 1991; Maxwell and Burmaster, 1993). 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. Lipid intake rates on a body weight basis are presented in Table 15-6. 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 Breastfed Infants					
Age Group	Mean		Upper Percentile[a]		Source
	mL/day	mL/kg-day	mL/day	mL/kg-day	
Human Milk Intake					
Birth to <1 month	510	150	950	220	b
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
6 to <12 months	620	83	1,000	130	b, c, e, g
Lipid Intake [h]					
Birth to <1 month	20	6.0	38	8.7	i
1 to <3 months	27	5.5	40	8.0	d, i
3 to <6 months	30	4.2	42	6.0	d, i
6 to <12 months	25	3.3	42	5.2	i

[a] Upper percentile is reported as mean plus 2 standard deviations.
[b] Neville et al., 1988.
[c] Pao et al., 1980.
[d] Butte et al., 1984.
[e] Dewey and Lönnerdal, 1983.
[f] Butte et al., 2000.
[g] Dewey et al., 1991b.
[h] The recommended value for the lipid content of human milk is 4.0 percent. See Section 15.5.
[i] Arcus- Arth et al., 2005.

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 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 8 studies indicated correcting data for insensible water loss. Some biases may be introduced by including partially-breastfed 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. Population 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 1980-2000. 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	Not very well characterized. Mothers committed to breastfeeding over 1 year were not captured.	
Uncertainty	Not correcting for insensible water loss may underestimate intake.	

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

General Assessment Factors	Rationale	Rating
Evaluation and Review		High
Peer Review	The studies appeared in peer review journals.	
Number and Agreement of Studies	There are 8 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	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	961	692	977
	37	729	981	Butte et al., 1984				
	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	740	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	-ed	Pao et al., 1980	741	1,000	622	1,024
	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	1,006		
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., 1991a; 1991b				
	13	403	931	Butte et al., 2000				

a Calculated as the mean of the means.
b Upper percentile is reported as mean plus 2 standard deviations.
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 (across 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	111	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] Calculated as the mean of the means.
[b] Upper percentile is reported as mean plus 2 standard deviations.
[c] Middle of the range of upper percentiles.

Table 15-5. Lipid Intake Rates Derived from Key Studies for Exclusively Breastfed 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	25	42
	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		
8	9	24	40	Neville et al., 1988	24	41		
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	17	35	Neville et al., 1988	16	36	16	36
	42	17	37	Dewey et al., 1991a; 1991b				
	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 a2ll Key Studies) (mL/kg-day): Individual Age, Mean[c]	Individual Age, Upper[d]	Composite Ages Groups, Mean[e]	Composite Ages Groups, Upper[d]
0 <1	9 to 25	6.0	8.7	Arcus-Arth et al, 2005	6.2	8.7	6.0	8.7
1	37	5.7	9.1	Butte et al., 1984	5.9	8.9	5.5	8.0
	25	6.0	8.7	Arcus-Arth et al, 2005				
2	40	4.3	6.7	Butte et al., 1984	5.1	7.1		
	25	5.8	7.5	Arcus-Arth et al, 2005				
3	37	3.7	6.1	Butte et al., 1984	4.4	6.3	4.2	6.0
	108	5.1	6.5	Arcus-Arth et al, 2005				
4	41	3.7	6.3	Butte et al., 1984	4.1	6.1		
	57	4.5	5.9	Arcus-Arth et al, 2005				
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	4.1

[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 2 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. Breastfeeding mothers were recruited through LaLeche League groups. Except for one black infant, all other infants were from white middle-class families in southwestern Ohio. The goal of the study was to enroll infants as close to one month of age as possible and to obtain records near one, three, six, and nine months of age (Pao et al., 1980). However, not all mother/infant pairs participated at each time interval. Data were collected for these 22 infants using the test weighing method. Records were collected for three consecutive 24-hour periods at each test interval. The weight of 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. Mean daily human milk intake rates for the infants surveyed at each time interval are presented in Table 15-7. These data (Table 15-7) 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 the ages of 1 and 6 months. The number of study participants dropped to 13 by the end of the sixth 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 third, fourth, and fifth 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 sixth 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. Human milk intake rates for the various age groups are presented in Table 15-8. 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. Some infants during the study period were given some formula (i.e., up to 5 infants during the fifth 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 breastfed 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 over 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 mean and standard deviation milk intake difference based on weighing the bottle before and after nine successive feedings, was estimated to be 3.2 ± 3.1 g. 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. It was reported that 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 fourth month because of inadequate milk production. 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 (Table 15-9). Intakes were also calculated on the basis of body weight (Table 15-9). Based on the results of test weighings conducted over 48 to 96 hours, the overall mean variation in individual daily intake was estimated to be 7.9 ± 3.6 percent.

The advantage of this study is that data for a larger number of exclusively breast-fed infants were collected than in previous studies. However, data were collected for infants up to 4 months and day-to-day variability was not characterized for all infants. It was reported that 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 breastfed 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 first year of life. The mothers were all multiparous, nonsmoking, Caucasian 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/wk) after 4 months in three infants. The estimated human milk intakes for this study are listed in Table 15-10. 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 during only a 24-hour period. Consequently, these intake rates are based on short-term data that do not account for day-to-day variability among individual infants. Also, a smaller number of subjects was included than in the previous studies. 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 be an underestimate for the intake of exclusively breastfed infants.

15.3.5 Dewey et al., 1991a, b - (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 the first 12 months of life (Dewey et al., 1991a, b). Subjects were non-randomly selected through letters to new parents using birth listing. 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 did not consume solid foods until after the first 4 months of age. 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. 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 at 3 months and 435 mL/day at 12 months (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 breastfed infants, since mothers were specifically recruited for that purpose. It is, however, unclear from the Dewey et al., 1991a 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 impact of infant feeding mode on growth and body composition during the first two years of life. The study was conducted in the Houston, Texas 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 breastfeeding 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 measured before and after each feeding. Using a pre-weighing and post-weighing method, the intake of formula and other foods and beverages was determined for 3 days by the mothers using a digital scale and recorded on predetermined forms.

The average duration of breastfeeding was 11.4 months (SD = 5.8). Butte et al.(2000) reported that infants were exclusively breastfed for at least the first four months except for the following: one was weaned at 109 days, another received formula at 102 days and another given cereal at 106 days. The infant feeding characteristics are shown in Table 15-12. The intake of human milk for the infants are shown in Table 15-13. 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) (Table 15-13). Feeding practices by percent for infants are shown in Table 15-14. The mean weights are provided in Table 15-15.

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

15.3.7 Arcus-Arth et al., 2005 - Human 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 0-6 months and 0-12 months of age for infants fed according to the American Academy of Pediatrics (AAP) recommendations. The AAP recommends exclusively breastfeeding for the first 6 months of life, human milk as the only source of milk age 1 year, with the introduction of solid foods after 6 months. The distributions were derived based on data in the peer reviewed literature and datasets 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. (1991a, 199b), 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 breastfed exclusively over the first year and provides a regression line of intake versus age for estimating short-term exposures. Arcus-Arth 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 breastfeeding (EBF) as “breast milk is the sole source of calories, with no or insignificant calories form other liquid or solid food sources.” Predominant breastfeeding was described by Arcus-Arth et al. (2005) 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 dataset (Arcus-Arth et al., 2005). The 0-12 months EBF dataset 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 dataset for any individual infant followed at regular, frequent intervals over 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 is 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 is simulated for 2500 hypothetical infants and the distribution intakes derived from 2500 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 2 youngest and 3 oldest age groups. The values in Table 15-6 using Method 1 were used to derive recommendations presented in Table 15-4 since it provides data for the fine age categories. 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 (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 datasets 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 breastfed infants today (Arcus-Arth et al., 2005). The limitations of the study are that the data used were from mothers that were predominantly white, well nourished and from mid 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 breastfed for 12 months, the EBF distributions may represent a more highly exposed subpopulation of infants exclusively breastfed in excess of 6 months.”

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

Human milk contains over 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 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. 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 over 40 women during a 4-month period. The mean lipid content of human milk at various infants' ages is presented in Table 15-18. 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 upper 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 first year of lactation. Nursing mothers were recruited through the Nursing Mothers' Association of Australia. All infants were completely breastfed on demand for at least 4 months. Complementary solid food was introduced between 4-6 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 due to 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 minutes 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.

Mean human milk production and composition at each age interval are presented in Table The mean 24 hour milk production from both breasts was 798 (SD= 232) mL. The mean fat, lactose, and protein contents (g/L) were 37.4 (SE= 0.6), 61.4 (SE =0.6), and 9.16 (SE= 0.19), 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. 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 the changes in fat content. 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 5 healthy nursing women to determine the content of fat in human milk and fat intake by infants during the first year of lactation. Nursing mothers were recruited through the Australian Breastfeeding Association or from private healthcare facilities. All infants were completely breastfed on demand for at least 4 months. Complementary solid food was introduced between 4-6 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 this 20 minutes was used to calculate insensible water loss during the feeding.

Changes in volume of human milk produced and milk fat content over the first year of lactation is presented in Table 15-20. The mean volumes of milk produced for both breasts combined were 812.13, 790.34, 911.38, 810.20, 677.35, and 505.10 mL/day at 1, 2, 4, 6, 9,and 12 months, respectively. The average daily intake over the 12 months was 751.09 mL/day with a mean fat content of 35.52 g/L. Their was a significant difference in the proportional composition of fatty acids over the course of lactation. Table 15-21 provides average fatty acid composition over the first 12 months of lactation. Additionally, fatty acid composition varied over 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 (5 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 - Human 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 0-6 months and 0-12 months of age for infants fed according to the American Academy of Pediatrics (AAP) recommendations. Lipid intakes were calculated from lipid content and milk intakes were 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 dataset. 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 breastfed according to the AAP recommendations. In addition, the data used to derive the distributions were from peer review literature and datasets 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 breastfed for 12 months, the exclusively breastfed distributions may represent a more highly exposed subpopulation of infants exclusively breastfed 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 breastfed infants today (Arcus-Arth et al., 2005).

15.4.5 Kent et al., 2006 - Volume and Frequency of Breastfeeding 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 to 6 months 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 breastfeedings per day (range= 6 to18). The intervals between feedings was 2 hours and 18 minutes ± 43 minutes (range = 4 minutes to 10 hours and 58 minutes). The 24-hour average human milk intake was 765 ± 164 mL/day (range = 464 to 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 breastfeeding 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 5000 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 to 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 the age of 12 months (i.e., approximately 22%). A model was used to simulate intake among 1113 of the 5000 infants that were expected to be breast-fed. The results of the model indicated that lipid intake among nursing infants under 12 months of age can be characterized by a normal distribution with a mean of 26.0 mL/day and a standard deviation of 7.2 mL/day (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 are also 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 EPA recommended age categories. The estimated mean lipid intake rate represents the average daily intake for nursing infants under 12 months of age. The study 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

There are many factors that 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, gender, food supplementation, the frequency of breast-feeding sessions per day, the duration of breast-feeding per 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

To monitor progress towards achieving the CDC *Healthy People 2010* breastfeeding 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 conduced annually by the CDC to obtain national, state, and selected urban area estimation on vaccinations rates among U.S. children age 19-35 months. The interview response rate for years 2001-2006 ranged between 64.5% and 76.1%. Questions regarding breastfeeding 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 aged 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 breastfeeding data were analyzed by year of birth during 2000-2004 (birth year cohort instead if survey year).

Among infants born in 2000, breastfeeding 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 breastfeeding 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 provides data for exclusive breastfeeding through 3 and 6 months by socioeconomic characteristics for infants born in 2004.

Scanlon et al. (2007) noted the following limitations that could affect the utility of these data: (1) breastfeeding behavior was based on retrospective self-report by mothers or other caregivers, whose responses might be subject to recall bias, (2) the NIS question that defines early postpartum breastfeeding or initiation, "Was [child's name] ever breastfed 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 aged 19-35 months, some bias might remain. The advantage of the study is that is representative of the U.S. infant population.

The rate of breastfeeding initiation in the United States is near the national goal of 75% established in *Healthy People 2010* (Ruowei et al. 2005). Using the data obtained from the NIS survey conducted throughout 2002 for children who were 19 to 35 months old, Ruowi et al. (2005) shows that overall, 71.4% of children surveyed had ever been breastfed. The percentage of children who are breastfed drops to 35.1% at 6 months and to 16.1% at 12 months (Rouwei et al. 2005). These data also revealed significant differences in breastfeeding participation related to race/ethnicity, day care and WIC participation, maternal age, socioeconomic status, and geographical area. Overall, 51.5% of mothers of non-Hispanic black children reported to ever breastfed their infants compared to 72.1% of mothers of non-Hispanic white children. Non-Hispanic black infants were exclusively breastfed at 6 months at a rate of 5.4% compared to 14.6% of non-Hispanic white infants and 13.8% of Hispanic infants. Infants who attended day care and infants whose mothers received WIC benefits were less likely to have ever been breastfed. Mothers with higher socioeconomic status and older mothers were more likely to have ever breastfed their infants.

CDC (2007) developed the breastfeeding report card. The CDC National Immunization Program in partnership with the CDC National Center for Health Statistics, conducts the NIS within all 50 states, District of Columbia, and selected geographic areas within the states. Five breastfeeding goals are in the Healthy People 2010 report. The Breastfeeding Report Card presents data for each state for the following categories of infants: ever breastfed, breastfed at 6 months, breastfed at 12 months, exclusive breastfeeding through 3 month, and exclusive breastfeeding through 6 months. These indicators are used to measure a state's ability to promote, protect, and support breastfeeding. These data for the estimated percentage of infants born in 2004 are presented in Table 15-26. The weighted sample number is 17,654 for the U.S. population. The advantage of this report is that it provides data for each state and is representative of the U.S. infant population.

Analysis of breastfeeding practices in other developing countries was also 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 twenty countries. This survey has 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, intake and household variables and 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 breasfeeding 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 child 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. Tables 15-27 and 15-28 present the percentage of mothers that were currently breastfeeding 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 breastfeeding was consistent across countries for both age groups; the countries that reported the highest percentages of current breastfeeding for the 0 to 6 months old infants also reported the highest percentages in the 6 to12 month old infants. Pooled data show that 96.6% of the 0 to 6 months old infants and 87.9% of the 6 to 12 month old infants were breastfeeding. Feeding of other fluids was lowest in the 0 to 6 months 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 breastfeeding practices. Li and Grummer-Strawn (2002) investigated ethnic and racial disparities in lactation in the United States using data from the Third National Health and Nutrition Examinations Survey (NHANES III) that was conducted between 1988-1994. 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 to 71 months of age at time of interview. The NHANES III response rate for children participating was approximately 94 percent (Li and Grummer-Strawn, 2002). Data for a total of 2,863 exclusively breastfed, 6,140 ever breastfed, and 6,123 continued breastfed children were included in the analysis (Li and Grummer-Strawn, 2002). The proportion of children ever-breastfed was 60% among non-Hispanic whites, 26% among non-Hispanic blacks, and 54% among Mexican Americans. This number decreased to 27, 9, and 23 respectively by 6 months. Children fed exclusively human milk at 4 months was also 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 breastfed 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 breastfed 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 household head was used as a proxy. The advantages of this study is that it is representative of the U.S. children's population.

Data from some older studies provide historical information on breastfeeding practices in the U.S. These data are provided here 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 breastfeeding during the first 6 months of life. The Ross Laboratory Mothers's 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 percent 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 U.S., 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 greater than 35 years of age, earned more than $25,000 per year, and were college educated, did not participate in the WIC program, and were living in the Mountain and Pacific regions of the U.S.

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 percent of infants under 1 year of age are breast-fed. This estimate was based on a reanalysis of survey data in Ryan et al. (1991) collected by Ross Laboratories (Maxwell and Burmaster, 1993). Studies have also indicated that breast-feeding practices may differ among ethnic and socioeconomic groups and among regions of the United States. More recently, the Ross Products Division of Abbott Laboratories reported the results of their ongoing "Ross Mothers Survey" in 2003 (Abbott 2003). The percentages of mothers who breast feed, based on ethnic background and demographic variables, are presented in Table 15-34. 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. (1986a, b) 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 of age (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 were also 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 5 meals/day (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 to 5 months and 8.2 at ages 2 weeks to 1 month. Neville et al. (1988) reported that, for infants between the ages of 1 week and 5 months, the average duration of a breastfeeding session is 16-18 minutes.

Buckley (2001) studied the breastfeeding patterns, dietary intake, and growth measurement of children who continued to breastfeed 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 breastfeeding 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 month old. The data were collected using a 7-day breastfeeding diary. The frequency and length of breastfeeding varied with the age of the child (Buckley, 2001). The author noted a statistically significant difference in the mean number of breastfeeding episodes per day and the average total minutes of breastfeeding between the 1, 2, and 3 year old groups. Table 15-36 provides the comparison of breastfeeding 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

AAP (2005) Breast feeding and the use of human milk. Policy Statement. Pediatrics. 115(2): 496-506. available on line at http://aappolicy.aappublications.org/cgi/content/full/pediatrics;115/2/496

Abbott Laboratories (2003) Breastfeeding Trends - 2003. Ross Mothers Survey, Ross Products Division,Columbus, OH.

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

Arcus-Arth, A.; Krowech, G.; Zeise, L. (2005) Human milk and Lipid Intake Distributions for assessing Cumulative Exposure and Risk. J Expos Anal Environ Epidemiol. 15: 357-365.

Bonuck, K.A.; 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.

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

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

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

Butte, N.; Wong, W.; Hopkinson, J.; Smith E.; Ellis, J. (2000) Infant feeding mode affects early growth and body composition. Pediatrics. 106; 1355-1366.

Buckley, K. (2001) Long-term breastfeeding: nourishment or nurtance. J Hum Lactat. 17(4):304-311.

CDC. (2007) Breastfeeding report card 2007. Breastfeeding practices-results from the National Immunization Survey. Available on line at http://www.cdc.gov/breastfeeding/data

Chen, A.; Rogan, W.J. (2004) Breastfeeding and the risk of postneonatal death in the United States. Pediatrics. 113: 435-439.

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

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

Dewey, K.G.; Peerson, J.M.; Heinig, M.J.; Nommsen, L.A.; Lonnerdal, B. (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, A.M.; Neubauer, S.H.; Bendel, R.B.; Green, K.W.; Ingardia, C.J.; Reece, E.A. (1993) Perinatal lactation protocol and outcome in mothers with and without insulin-dependent diabetes mellitus. Am J Clin Nutr. 58: 43–48.

Gonzalez-Cossio,T.; Habicht, J.P.; Rasmussen, K.M.; Delgado, H.L. (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.; Siolin, S. (1982) The amount of milk consumed by 1-3 months old breast or bottled-fed infants. Acta Paediatrica Scand. 71: 953-958.

Kent, J.C.; Mitoulas, L.R.; Cregan, M.D.; Ramsay, D.T.; Doherty, D.A.; Hartmann, P.E. (2006) Volume and frequency of breastfeeding and fat content of breast milk throughout the day. Pediatrics. 117:387-395.

Li, R.; Grummer-Strawn, L. (2002) Racial and ethnic disparities in breastfeeding among Unites States infants: third national health and nutrition examination survey, 1988-1994. Birth. 29(4):251-257.

Lönnerdal, B.; Forsum, E.; Gebre-Medhim, M.; Hombraes, L. (1976) Human milk composition in Ethiopian and Swedish mothers: lactose, nitrogen, and protein contents. Am J Clin Nutr. 29:1134-1141.

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

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

Mitoulas, L.; Kent, J.; Cox, D.; Owens, R.; Sherriff, J.; Hartman, P. (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.

Mitoulas, L.; Gurrin, L.; Doherty, D.; Sherriff, J.; Hartman, P. (2003) Infant intake of fatty acids from human milk over the first year of lactation. Br J Nutr. 90:979-986.

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

Neubauer, S. H.; Ferris, A.M.; Chase, C.G.; Fanelli J., Thompson, C.A.; Lammi-Keefe, C.J.; Clark, R. M.; Jensen, R. G.; Bendel, R. B.; Green, K. W. (1993) Delayed lactogenesis in women with insulin-dependent diabetes mellitus. Am J Clin Nutr. 1993: 58:54–60.

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

Pao, E.M.; Hines, J.M.; Roche, A.F. (1980) Milk intakes and feeding patterns of breast-fed infants. J Am Diet Assoc. 77:540-545.

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

Ryan, A.S. (1997) The resurgence of breastfeeding in the United States. Pediatrics. 99(4):e12. http://www.pediatrics.org/cqi/content/full/99/4/e12.

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

Scanlon, K.S.; Grummer-Strawn, L.; Shealy, K.R.; Jefferds, M.E.; Chen, J.; Singleton, J.A.. (2007) Breastfeeding Trends and Updated National Health Objectives for Exclusive Breastfeeding - United States, Birth Years 2000-2004. MMWR 56(30):760-763.

Stuff J.E.; Nichols B.L. (1989) Nutrient intake and growth performance of older infants fed human milk. J Pediatr. 1989: 115:959–968.

Wright, C.M.; 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(6):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 to 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] Mean ± SD	Intake (mL/day)[a] Range	Intake by Age Category (mL/day)[a,c]
1	6	43 ± 68	-30-145 [b]	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] Negative value due to insensible weight loss correction.

[c] 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.

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) 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 Breastfed 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 Breastfeeding (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 Breastfed 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.

Source: Butte et al., 2000.

Table 15-14. Feeding Practices by Percent of Infants						
	Age					
Infants	3 months	6 months	9 months	12 months	18 months	24 months
	Percentage					
Infants Still Breastfed	100	80	58	38	25	5
Breastfed 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 Breastfed 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 Breastfed 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 Dataset 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).

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 Over the First 12 Months of Lactation [a]

Age Group (months)	Volume, per Breast (mL/24h)			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 4-6 months.
SE = Standard error.
N = Number of infants.

Source: Mitoulas et al., 2002.

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

Age Group (months)		Volume, Left Breast (mL/day)		Volume, Right Breast (mL/day)		Fat, Left Breast (g/L)		Fat, Right Breast (g/L)	
	N	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 4-6 months.
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 Over the First Year of Lactation (g/100 g total fatty acids)

	1 month		2 months		4 months		6 months		9 months		12 months	
Fatty Acid	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 of Lipid Content Assumptions (mL/kg-day)[a]

Lipid Content Used in Calculation	Mean	Population Percentile							
		5	10	25	50	75	90	95	99
Measured Lipid Content[b]	3.6	2.0	2.3	2.9	3.6	4.3	4.9	5.2	5.9
4% Lipid Content[c]	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] Lipid intake derived from lipid content and milk intake measurements.
[c] 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

	Mean	Population Percentile							
		5	10	25	50	75	90	95	99
AAP Infants 0 to 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).

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. Socio-economic Characteristics of Exclusively Breastfed Infants Born in 2004

	Percent of Exclusive Breastfeeding 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.

Table15-26. Geographic-specific Breastfeeding Percent Rates Among Children Born in 2004 [a]

State	N	Ever Breastfed	Breastfed at 6 Months	Breastfed at 12 Months	Exclusive Breastfeeding Through 3 Months	Exclusive Breastfeeding Through 6 Months
U.S. National	17,654	73.8	41.5	20.9	30.5	11.3
Alabama	310	52.1	25.4	11.5	19.3	4.9
Alaska	217	84.8	60.9	31.8	47.2	24.3
Arizona	543	83.5	46.5	23.4	38.8	14.3
Arkansas	200	59.2	23.2	8.5	15.8	6.2
California	1,702	83.8	52.9	30.4	38.7	17.4
Colorado	249	85.9	42	23.6	36.2	10.8
Connecticut	249	79.5	44.6	23.7	35.6	10.1
Delaware	213	63.6	35.7	14.6	26.3	11.4
Dist of Columbia	292	68.0	40.0	21.4	27.8	9.8
Florida	955	77.9	37.5	15.6	27.8	9.1
Georgia	582	68.2	38.0	16.8	25.6	11
Hawaii	221	81	50.5	35.5	37.8	15.8
Idaho	183	85.9	49.0	22.6	38.7	10.3
Illinois	561	72.5	40.9	17.6	31.6	10
Indiana	472	64.7	34.6	18.0	28.3	10.4
Iowa	193	74.2	44.9	20.0	37.6	11.6
Kansas	480	74.4	42.2	16.9	30.0	9.2
Kentucky	245	59.1	26.4	14.4	25.3	7.5
Louisiana	429	50.7	19.2	8.3	15.2	2.8
Maine	203	76.3	46.6	27.6	42.1	15.9
Maryland	512	71.0	40.2	21.2	32.1	8.6
Massachusetts	469	72.4	42.1	19.0	32.7	11.9
Michigan	604	63.4	36.4	18.6	27.4	8.3
Minnesota	202	80.9	46.5	23.8	33.9	16.1
Mississippi	287	50.2	23.3	8.2	19.0	8
Missouri	327	67.3	32.5	15.8	26.6	7.4
Montana	232	87.7	53.8	28.8	50.9	18.3
Nebraska	228	79.3	47.6	21.8	31.7	9.8
Nevada	281	79.7	45.6	21.9	31.9	10.3
New Hampshire	228	73.7	48.7	27.5	34.3	13.6
New Jersey	631	69.8	45.1	19.4	27.0	11.8
New Mexico	420	80.7	41.2	21.1	32.9	14.3
New York	533	73.8	50.0	26.9	26.0	11.4
North Carolina	220	72.0	34.2	18.3	23.0	6.9
North Dakota	285	73.1	45.1	19.5	39.4	15.4
Ohio	617	59.6	33.3	12.9	27.2	9.8
Oklahoma	280	67.1	29.6	12.7	23.0	10.6
Oregon	191	88.3	56.4	33.5	41.5	19.9
Pennsylvania	757	66.6	35.2	16.8	27.1	8
Rhode Island	291	69.1	31.2	14.0	31.2	9.5
South Carolina	314	67.4	30.0	11.1	26.6	5.4
South Dakota	315	71.1	40.5	23.4	32.2	12.2
Tennessee	671	71.2	32.6	16.6	26.7	11.9
Texas	1,439	75.4	37.3	18.7	25.2	7.1
Utah	190	84.5	55.6	28.1	39.8	10.2
Vermont	190	85.2	55.3	34.1	47.3	15.9
Virginia	259	79.1	49.8	25.6	32.6	13.4
Washington	615	88.4	56.6	32.3	49.6	22.5
West Virginia	224	59.3	26.8	14.0	21.3	5.2
Wisconsin	478	72.1	39.6	19.0	32.5	13.4
Wyoming	246	80.5	42.9	18.5	36.2	11.4

[a] Exclusive breastfeeding information is from the 2006 NIS survey data only and is defined as ONLY breast milk- No solids, no water, no other liquids. Sample sizes appearing in the NIS breastfeeding tables are slightly smaller than the numbers published in other NIS publications due to the fact that in the DNPA breastfeeding analyses, the sample was limited to records with valid responses to the breastfeeding questions.

N = Number of infants.

Source: CDC, 2007.

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

Country	Breastfeeding	Water	Milk	Formula	Other Liquids	Solid Foods
Ethiopia	98.8	26.3	19	0	10.8	5.3
Ghana	99.6	41.9	6.7	3.5	4.3	15.6
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
Nigeria	99.1	78.2	9.2	12.7	17.9	18.5
Uganda	98.7	15.1	20.3	1.5	10.3	11.4
Zamibia	99.6	52.6	2.1	2.7	6.7	31.2
Zimbabwe	100	63.9	1.6	3.2	9	43.7
Armenia	86.1	62.7	22.9	13.1	48.1	23.9
Egypt	95.5	22.9	11.1	4.3	27.6	13.2
Jordan	92.4	58.5	3	25.1	13.8	20.2
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
India	98.1	40.2	21.2	0	7.1	6.5
Indonesia	92.8	37	0.7	24.2	8.7	43
Nepal	100	23.3	12.3	0	2.8	9.3
Philippines	80.5	53.4	4.4	30	12.4	16.8
Vietnam	98.7	45.9	16.9	0.8	8.9	18.7
Kazakhstan	94.4	53.7	21.4	8.2	37.4	15.4
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 4 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 to 12 Months Old[a]

Country	Breastfeeding	Water	Milk	Formula	Other Liquids	Solid Foods
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
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
Nigeria	97.8	91.6	14.4	13.4	27.4	70.4
Uganda	97.4	65.9	32.1	1.6	56.2	82.1
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
Armenia	53.4	91.1	56.9	11.6	85.3	88.1
Egypt	89.1	85.9	36.8	16.7	48.5	75.7
Jordan	65.7	99.3	24.3	28.8	57.7	94.9
Bangladesh	96.2	87.7	29.8	10.1	21.9	65.2
Cambodia	94.4	97.5	3.7	6.7	29	81
India	94.9	81.4	45	0	25.2	44.1
Indonesia	84.8	85.4	4.9	38.8	35.4	87.9
Nepal	98.8	84.3	32	0	15.8	71.5
Philippines	64.4	95.1	12.2	47.1	31	88
Vietnam	93.2	95	36.1	5.3	37.9	85.8
Kazakhstan	81.2	74.3	85.4	11.4	91.8	85.9
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 4 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 to 6 months	6 to 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 (18,6663)
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 Breastfed, 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 to 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 to 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 to 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]
Poverty income ratio (%)													
<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	1863	26.8	1.6	1,842	8.5	0.9	2,112	23.1	1.4	18.3	(1.7)[b]	3.7	(2.1)[c]
Infant sex													
Male	900	27.6	2.3	912	8.5	1.1	1,029	22.3	1.6	19.1	(2.6)[b]	5.2	(2.6)[a]
Female	963	26.1	1.8	930	8.6	1.1	1,083	24.0	2.0	17.5	(2.1)[a]	2.1	(2.7)[c]
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)[a]	-4.3	(5.7)[c]
≥ 2,500	1,733	28.3	1.8	1,581	9.0	0.9	1,832	23.1	1.7	19.3	(1.8)[b]	5.2	(2.3)[a]
Maternal age (years)													
<20	174	10.2	2.9	380	4.7	1.4	380	11.6	1.7	5.5	(3.0)[c]	-1.3	(3.8)[c]
20 to 24	461	13.4	2.4	559	7.5	1.1	646	23.8	2.4	5.9	(2.5)[a]	-10.4	(3.3)[b]
25 to 29	651	29.3	2.6	503	10.9	2.0	624	24.6	2.6	18.4	(3.5)[b]	4.8	(3.6)[c]
≥ 30	573	39.0	2.6	389	10.7	1.7	452	30.0	2.8	28.4	(3.3)[b]	9.0	(3.6)[a]
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)[a]	-6.2	(4.1)[c]
High school	622	19.9	1.7	771	5.0	1.0	478	22.4	2.5	14.9	(2.0)[b]	2.5	(3.1)[c]
Some college	396	26.8	2.4	317	16.6	2.5	225	28.4	5.3	10.2	(3.5)[b]	-1.6	(6.1)[c]
College graduate	502	42.2	2.9	139	21.1	3.2	74	45.5	7.3	21.1	(5.2)[b]	3.4	(7.6)[c]
Smoking during pregnancy													
Yes	524	11.3	1.5	402	4.3	1.1	198	9.3	2.2	7.0	(1.9)[b]	2.1	(2.7)[c]
No	1,331	32.7	2.1	1,427	9.8	1.1	1,911	24.5	1.5	22.9	(2.3)[b]	8.1	(2.6)[b]
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)[b]	7.8	(2.7)[b]
25.0 to 29.9	282	19.0	2.4	482	8.2	1.9	534	26.4	1.9	10.8	(3.2)[b]	7.4	(3.0)[a]
≥ 30	204	20.4	4.1	415	7.3	1.6	357	17.2	3.0	13.1	(4.4)[b]	3.3	(5.2)[c]
Residence													
Metropolitan	760	29.7	2.5	941	11.8	1.3	1,378	23.5	1.7	17.9	(2.4)[b]	6.1	(3.1)[c]
Rural	1,103	24.6	2.4	901	4.9	0.9	734	22.5	2.8	19.7	(2.2)[b]	2.2	(3.4)[c]
Region													
Northeast	316	21.0	2.2	258	9.7	1.8	12	43.6	16.0	11.3	(1.8)[b]	-22.6	(16.5)[c]
Midwest	553	28.8	2.1	344	9.8	2.4	170	18.2	4.7	19.0	(3.7)[b]	10.6	(6.2)[c]
South	746	20.1	2.8	1,073	5.9	1.0	693	17.2	2.8	14.3	(2.8)[b]	2.9	(4.2)[c]
West	248	42.7	4.7	167	19.3	3.3	1,237	25.9	1.4	23.4	(5.3)[b]	16.8	(5.1)[b]
Poverty income ratio (%)													
100 to <185	387	23.5	2.9	390	9.9	1.8	486	23.4	2.7	13.6	(3.9)[b]	0	(4.1)[c]
185 to <350	670	30.4	2.7	293	10.0	2.4	287	27.6	4.4	20.4	(4.0)[b]	2.9	(4.8)[c]
≥ 350	443	33.0	3.0	105	15.2	2.8	74	32.3	9.0	17.8	(4.2)[b]	0.7	(9.5)[c]
Unknown	108	13.3	3.8	149	6.4	2.9	280	26.7	4.5	7.0	(5.3)[c]	-13.4	(6.6)[a]

[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 15-32. Racial and Ethnic Differences in Proportion of Children Exclusively Breastfed 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)[b]	2.3	(1.6)[c]
Infant sex													
Male	394	22.3	1.9	454	7.0	1.6	498	20.7	1.5	15.3	(2.6)[b]	1.5	(1.8)[c]
Female	430	23.0	2.2	452	10.0	2.2	459	20.0	1.8	12.9	(3.0)[b]	3.0	(2.1)[c]
Infant birth weight (g)													
<2500	50	15.2	7.1	118	7.0	2.3	66	5.6	1.8	8.2	(8.1)[c]	9.5	(6.9)[c]
≥ 2500	774	23.1	1.8	786	8.8	1.6	880	21.6	1.4	14.4	(2.2)[b]	1.5	(1.6)[c]
Maternal age (years)													
<20	76	6.6	3.2	172	6.4	2.1	170	12.1	2.5	0.2	(3.7)[c]	-5.6	(3.8)[c]
20 to 24	205	11.4	2.2	273	7.4	2.4	319	21.0	2.3	4.0	(2.7)[c]	-9.6	(3.2)[b]
25 to 29	271	21.6	2.3	254	8.6	2.5	256	22.1	2.5	13.0	(3.2)[b]	-0.5	(3.2)[c]
≥ 30	270	34.8	2.7	201	11.9	2.6	210	23.6	3.1	22.9	(4.2)[b]	11.1	(3.7)[b]
Household head education													
<High school	146	9.5	3.5	256	2.0	0.7	563	19.7	1.8	7.5	(3.6)[a]	-10.2	(4.0)[a]
High school	277	14.5	2.7	406	7.1	2.1	222	18.8	3.6	7.4	(3.2)[a]	-4.3	(4.7)[c]
Some college	175	30.8	3.8	141	17.4	3.0	120	21.0	3.9	13.4	(4.7)[b]	9.8	(6.1)[c]
College graduate	219	34.1	3.9	92	17.4	4.7	37	31.5	4.5	16.7	(6.9)[a]	2.6	(6.3)[c]
Smoking during pregnancy													
Yes	224	10.0	2.8	168	5.4	2.2	64	3.2	1.8	4.6	(3.7)[c]	6.8	(3.4)[c]
No	596	27.2	2.1	730	9.4	1.9	892	21.7	1.5	17.8	(2.8)[b]	5.6	(2.0)[a]
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)[b]	5.4	(2.3)[a]
25.0 to 29.9	117	19.7	4.3	230	8.6	1.9	261	23.1	3.4	11.1	(4.6)[a]	-3.4	(4.9)[c]
≥ 30	91	15.4	3.8	230	9.0	2.9	184	15.9	2.3	6.4	(5.2)[c]	-0.5	(4.6)[c]
Residence													
Metropolitan	312	24.4	3	535	11.0	2.0	608	19.6	1.6	13.4	(3.5)[b]	4.8	(2.8)[c]
Rural	512	21.3	1.8	371	4.2	1.3	349	22.3	3.3	17.1	(1.8)[b]	-1.1	(3.0)[c]
Region													
Northeast	138	20.0	1.4	131	11.1	2.9	10	9.4	9.5	8.8	(2.2)[b]	10.6	(8.7)[c]
Midwest	231	26.5	3.2	143	12.6	5.6	98	19.2	4.1	13.9	(7.6)[c]	7.4	(3.7)[c]
South	378	14.1	2.8	574	5.9	1.4	383	15.9	3.1	8.2	(1.9)[b]	-1.8	(3.7)[c]
West	77	34.7	2.7	58	12.5	5.0	466	23.0	1.3	22.2	(5.4)[b]	11.7	(2.5)
Poverty income ratio (%)													
<100	116	13.1	3.3	448	5.7	1.6	471	18.4	1.8	7.4	(3.5)[a]	-5.3	(3.1)[c]
100 to <185	166	18.9	3.2	197	10.6	2.8	234	21.9	4.1	8.3	(3.3)[a]	-3	(6.1)[c]
185 to <350	274	25.1	3.2	145	12.9	4.3	132	26.4	4.2	12.2	(5.0)[a]	-1.3	(4.1)[c]
≥ 350	235	27.4	4.1	57	12.8	3.5	37	17.0	5.0	14.6	(5.0)[b]	10.4	(5.2)[c]
Unknown	33	16.5	7.6	59	7.3	3.7	83	16.1	5.1	9.2	(8.6)[c]	0.4	(9.5)[c]

[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
Nonparticipant	62.9	71.0	12.9	23.8	29.2	22.7
U.S. Census Region						
New England	52.2	61.2	17.2	18.6	22.2	19.4
Middle Atlantic	47.4	53.8	13.5	16.8	19.6	16.7
East North Central	47.6	54.6	14.7	16.7	18.9	13.2
West North Central	55.9	61.9	10.7	18.4	21.4	16.3
South Atlantic	43.8	54.8	25.1	13.7	18.6	35.8
East South Central	37.9	44.1	16.4	11.5	13.0	13.0
West South Central	46.0	54.4	18.3	13.6	17.0	25.0
Mountain	70.2	75.1	7.0	28.3	30.3	7.1
Pacific	70.3	75.1	6.8	26.6	30.9	16.2

[a] The percent change was calculated using the following formula: % breastfed in 1984 - % breastfed in 1989 / % breastfed in 1984.
[b] Figures in parentheses indicate a decrease in the rate of breastfeeding from 1989 to 1995.
[c] WIC indicates Women, Infants, and Children supplemental food program.

Source: Ryan, 1997.

Table 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
Nonparticipant	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, 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 Breastfeeding Patterns Between Age and Groups (Mean ±SD)			
Breastfeeding Episodes per Day	5.8 ± 2.6	6.8 ± 2.4	2.5 ± 2.0
Total Time Breastfeeding (min/day)	65.2 ± 44.0	102.2 ± 51.4	31.2 ± 24.6
Length of Breastfeeding (min/episode)	10.8 ± 6.1	14.2 ± 6.1	11.6 ± 5.6

SD = Standard deviation

Source: Buckley, 2001.