Breast-Feeding Lowers the Frequency and Duration of Acute Respiratory Infection and Diarrhea in Infants under Six Months of Age[1]

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ABSTRACT It remains unclear whether breast-feeding protects infants against acute respiratory infection (ARI). To determine if breast-feeding protects against ARI as it does against diarrhea, 170 healthy newborns were followed for 6 mo. Feeding mode, incidence and duration of ARI and diarrhea were recorded biweekly. Infants were classified as fully or partially breast-fed, or formula-fed. Incidence and prevalence were computed monthly. The effects of duration of breast-feeding and potential confounders were analyzed by multiple and logistic regression analyses. Incidence and prevalence of ARI were significantly lower in fully breast-fed infants than in formula-fed infants from birth up to 4 mo, as was the mean duration of individual episodes (5.1 ± 3.5 vs. 6.4 ± 3.6 d, respectively). Incidence of ARI was negatively associated with duration of breast-feeding and positively associated with the presence of siblings ($P < 0.05$). The prevalence of ARI was associated only with the duration of breast-feeding ($P < 0.05$). Infants that were never breast-fed and that had one or more siblings were more likely to have an episode of ARI than those fully breast-fed for at least 1 mo. Incidence, prevalence, and duration of individual episodes of diarrhea were also lower in breast-fed infants. Incidence ($r = -0.17$, $P < 0.02$) and prevalence ($r = -0.19$, $P < 0.008$) were negatively associated with duration of full breast-feeding. Introduction of solid food was not associated with further episodes of diarrhea. The present results demonstrate protection against ARI as a result of breast-feeding similar to that for diarrhea, i.e., lower incidence and percentage of days ill, and episodes of shorter duration. J. Nutr. 127: 436–443, 1997.

KEY WORDS: • *infants* • *breast-feeding* • *acute respiratory infection* • *diarrhea* • *humans*

The protective effect of human milk against acute infections has been addressed extensively (Brown et al. 1989, Cushing and Anderson 1982, Eager et al. 1984, Fergusen et al. 1981, France et al. 1980, Glass and Stoll 1989, Howie et al. 1990, Launer et al. 1990, López-Alarcón et al. 1992, Victora et al. 1987, Wright et al. 1989). A number of studies conducted in the last decade report a reduced incidence of infectious diseases in breast-fed infants compared with those who are fed other milks. Most of these studies claim that human milk provides such a protection against diarrhea (Brown et al. 1989, Cushing and Anderson 1982, France et al. 1980, Glass and Stoll 1989, Howie et al. 1990, Victora et al. 1987). However, whether breast feeding protects against acute respiratory infection (ARI) as well remains unclear.

Although there is no doubt that some factors present in human milk provide resistance against infections, the barrier effect of breast-feeding against the fecal-oral contamination that causes diarrhea is of great importance because high levels of environmental contamination are strong determinants for diarrhea in developing countries (Butz et al. 1984). In the case of acute respiratory infections, the barrier effect does not exist; thus, the mechanisms for such a protective effect must include substances with anti-microbial activity (Andersson et al. 1986, Fishaut et al. 1981, Ryan-Poirier and Kawaoka 1993) or that modulate the immune response of the infant (Goldman et al. 1996). The evidence of protection against respiratory tract infections (Howie et al. 1990, Pisacane et al. 1994, Wright et al. 1989) relates more to lower incidence rates, but little attention has been given to the effects on the severity and duration of individual episodes.

To investigate whether human milk is protective against acute respiratory infection as well as diarrhea, we designed a follow-up study to test the hypothesis that incidence and duration of both acute respiratory infections and diarrhea are lower in breast-fed than in formula-fed infants.

SUBJECTS AND METHODS

This study was approved by the Ethics Committee of Human Research of the Instituto Mexicano del Seguro Social. Participant mothers signed a written consent form after careful explanation of the nature and goal of the procedures. The analysis is part of a larger study in which we examined the relationship between body growth of breast-fed infants and their morbidity due to infectious diseases during the first 6 mo of life.

Subjects. Pregnant women were recruited during the last trimester in the community of Iztapalapa, a slum neighborhood located in the east of Mexico City. In that community, male partners work as day-laborers and working mothers are very uncommon. Families live predominantly in small apartments or share a house in extended

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families. Tap water, sewage, electricity and paved streets are common. Pregnant women from this community attend a prenatal care center (CIMI-Gen) associated with our research group. In the CIMI-Gen, health care is provided primarily by nurses under the supervision of a doctor. Well-child clinics are conducted on the same basis. Walk-in clinics for sick children are more closely supervised by attending physicians.

Infants were selected if they were singleton, full-term, healthy, weighed >2500 g at birth and were born in this prenatal care center. Subjects with congenital malformations and those who moved out of the neighborhood were excluded.

Study design. The day of delivery and before leaving the hospital, mothers were asked to complete a questionnaire concerning socioeconomic characteristics, as well as data about their infant's birth. Once a mother who met the selection criteria agreed to participate in the study, appointments were made for her to attend the clinic and for a nurse to visit at home. Infants were examined and mothers interviewed alternately at the clinic and at home, every 2 wk. Mothers missing a clinic appointment were visited at home. They were also advised to bring their infants to the clinic at any time when ill, where medical care was provided at no charge by nurses and physicians unrelated to the study. Examinations, interviews and data recording were conducted by three trained field nurses. Nurses instructed mothers (all of whom were literate) to keep a daily written record of the health status of their child, consisting of a 1-d grid on which mothers checked whether the infant was healthy or ill, and in a separate cell, the number of bowel movements during the day. Whenever an infant became ill, the mother checked a separate grid on which symptoms such as runny nose, cough, hoarse cry, respiratory distress (short breath, chest indrawing), liquid or semiliquid stools and fever were included. This record was discussed with the mother at each interview. Field nurses were asked to record whether an infant was brought to the clinic for medical care, if one episode of illness occurred, and if any antibiotic was prescribed. In most instances mothers complied with recording daily health status. On the few occasions that they failed to do so, the field nurses completed the form based on maternal recall for the previous 2 wk. A physician, blinded to the feeding mode, established the final diagnosis according to pre-established definitions after reviewing the nurse's and maternal records, and medical records when appropriate. In reviewing medical records, diagnosis was confirmed and information collected about antibiotics prescribed. Personnel related to the study did not prescribe medicines or treat infants. Duration of individual episodes was computed relying on the subjective judgment of the mother as registered in the daily records.

Definition of variables. Acute respiratory infection was defined as the presence of runny nose or cough for at least two consecutive days plus one or more of the following signs independent of duration: erythematous mucosa, hoarse-cry, respiratory distress or fever. Erythematous mucosa was considered to be positive only when written in medical records.

Diarrhea was defined as the presence of three or more liquid or semiliquid stools per day accompanied or not by blood, mucus or fever. The total number had to exceed the usual number of daily bowel movements.

Individual episodes were defined as an event separated from another event by at least 2 d free of symptoms.

Feeding practices. In every interview, the type of milk and food fed to the infant was recorded. Infants were classified as either fully breast-fed or formula-fed if they did not receive any other type of milk for the whole 1-mo period. Infants fed any combination of breast milk and formula were classified as partially breast-fed. At 4 mo of age, a research nutritionist, previously trained and standardized, applied a 24-h recall questionnaire. Energy and protein intake from sources other than milk was calculated from these records using local food composition tables (Hernández et al. 1977, Woot-Tsuen and Flores 1977).

Statistical analysis. Statistical analysis was performed using the following computer packages: EPIINFO release 5 (Centers for Disease Control, Atlanta, GA) and MINITAB release 10.2 (Minitab, State College, PA).

Incidence was described as the number of episodes/100 d of observation. Prevalence was calculated as the percentage of days ill in each month. Relative risks and 95% confidence intervals were computed for each month of age, stratifying the subjects according to their feeding mode for that particular month. Fully breast-fed infants were considered to be not exposed. The risks were contrasted by the chi-square test, and confidence intervals calculated by Miettinen's method (Albhom and Norell 1987). Duration of individual episodes was computed as the number of consecutive days with a defined illness. Episodes were pooled for 1–4 mo for ARI and for 2–6 mo for diarrhea and compared by feeding practice using Student's t test.

In another analysis, infants were stratified on duration in months they received full breast-feeding. Those fully breast-fed for the whole 6-mo follow-up period were the comparison group. The effect of duration of full breast-feeding was examined using a multiple linear regression model in which potential confounders were included:

$$y = b_0 + b_1X_1 + b_2X_2 + \ldots\ldots + b_nX_n$$

where the y term was alternately the number of episodes or the number of days ill with ARI and diarrhea; X_1 = total duration of full breast-feeding in months; X_2 = maternal age; X_3 = years of education; X_4 = number of individuals sleeping in the same room (crowding); and X_5 = marital status. An index of the socioeconomic level of the family (based on the availability of tap water, sewage, refrigerator and paved floor) and the presence of siblings (yes = 1, otherwise = 0) were introduced as covariates in the analysis. Because maternal age was correlated with the number of siblings living in the same household ($r = 0.52$, $P = 0.008$), it was removed from subsequent regression models.

A logistic regression model was carried out to examine the coincidence of an episode of diarrhea occurring immediately after solid food was introduced. ANOVA, median test (Siegel 1990) and χ^2 were used, where appropriate, to contrast maternal, infant and household characteristics among feeding practice groups.

RESULTS

Of 216 mother-infant pairs recruited initially, only 170 completed the 6-mo follow-up period. Of those who dropped out, 32 did so because they moved away from the neighborhood, two because they had twins, and the other because of pyloric hypertrophy. None of the mothers smoked cigarettes and all were literate. Maternal age and education, marital status, birth weight of the infants and the number of siblings living in the same household were not different between the final sample and the drop-out pairs. Household characteristics were also similar (**Table 1**).

Feeding practices. Immediately after discharge, more than 90% of the infants in the sample were fully breast-fed. This percentage declined progressively, so that at 6 mo postpartum, only 25% were doing so. By 3 mo of age, about 63% of both breast-fed and formula-fed infants had received variable amounts of food other than milk. At 2, 3 and 6 mo of age, water or tea were given to 1.1, 14.6 and 17.5% of the infants, and solid foods to 0, 63.5 and 76.0%, respectively. No differences were found among feeding mode categories. At 4 mo of age, daily energy intake from food other than milk was 737 ± 418 kJ/d for fully breast-fed, 609 ± 493 kJ/d for formula-fed and 706 ± 481 kJ/d for partially breast-fed infants. Differences were not significant (**Table 2**).

Protective effect of breast-feeding on acute respiratory infection. The survival analysis plot illustrates that at 3 mo of age, less than 30% of the children had had at least one episode of ARI. Almost 20% of the infants never experienced an episode of such illness (**Fig. 1**).

Relative risks and confidence intervals for incidence and prevalence of acute respiratory infection are presented in **Tables 3** and **4**. The probability of suffering an episode of ARI was higher for formula-fed than for fully breast-fed infants during the first 4 mo. Thereafter, differences were not significant. The risks for the partially breast-fed infants were intermediate between those of formula-fed and fully breast-fed, except

TABLE 1

Maternal, child, and household characteristics of the sample by duration of breast-feeding

Breast-feeding, *mo*	0	1	2	3	4	5	6	Total	Losses
n	53	33	15	6	12	8	43	170	46
Maternal									
Age,[1] *y*	25 ± 6	23 ± 6	22 ± 3	22 ± 6	24 ± 5	22 ± 4	23 ± 5	24 ± 10	25 ± 6
Education,[1] *y*	8 ± 4	9 ± 3	10 ± 3	9 ± 2	11 ± 3	9 ± 5	9 ± 3	9 ± 3	8 ± 3
Married,[2,3] %	85	85	73	100	100	75	93	90	80
Infant									
Birthweight,[1] *kg*	3.1 ± 0.57	3.2 ± 0.39	3.1 ± 0.31	3.2 ± 0.24	3.2 ± 0.29	2.9 ± 0.40	3.2 ± 0.33	3.1 ± 0.35	3.2 ± 0.34
Siblings,[4] *n*	1 (0–6)	0 (0–5)	0 (0–2)	0 (0–2)	1 (0–2)	0 (0–1)	0 (0–4)	0 (0–6)	0 (0–5)
Household									
Crowding[1,5]	2.9 ± 1.6	2.6 ± 1.5	2.6 ± 1.2	2.3 ± 1.8	2.1 ± 1.2	2.0 ± 0.8	2.6 ± 1.1	2.6 ± 1.4	2.6 ± 1.3
Tap water[2]	92	97	93	83	91	100	90	92	89
Sewage removal[2]	85	91	87	67	82	88	71	88	87
Refrigerator[2]	57	58	57	67	73	50	59	60	59
Paved floor[2,3]	92	100	87	67	100	87	88	89	80

[1] Mean ± SD.
[2] Percentage.
[3] $\chi^2 = P < 0.05$.
[4] Median (range).
[5] Crowding was defined as the number of persons sleeping in the same room.

for the last 2 mo of follow-up. The probability of having a larger percentage of days ill was also significantly higher for formula-fed than for breast-fed infants from birth up to 4 mo.

The mean duration of episodes occurring from birth to 4 mo of age ($n = 111$) was higher for the formula-fed than for the fully breast-fed infants (6.4 ± 3.6 vs. 5.1 ± 3.5 d, respectively, $P < 0.02$). Antibiotics were prescribed in 20 out of 233 episodes recorded (11 formula-fed and 9 fully or partially breast-fed infants).

The number of episodes of ARI was negatively associated with duration of full breast-feeding ($r = -0.17$, $P < 0.05$) and the number of siblings ($r = 0.16$, $P < 0.04$). That is, infants who never received breast-milk and had at least one sibling were more likely to have an episode of ARI than those breast-fed for at least 1 mo. The number of days ill with ARI tended to be associated with duration of full breast-feeding. This association became stronger when crowding was removed from the model ($r = -0.16$, $P = 0.04$). That is, infants who never received breast milk were more likely to have longer episodes of ARI than those breast-fed for at least 1 mo (**Table 5**).

Protective effect of breast-feeding on diarrhea. The survival analysis plot shows that 85% of the infants had had at least one episode of diarrhea by 3 mo of age. All individuals in the sample had suffered at least one episode of diarrhea at 5 mo of follow-up (Fig. 1).

TABLE 2

Feeding practices in fully, partially breast-fed and formula-fed infants from 0 to 6 mo of age

Age, *mo*	1	2	3	4	5	6
Fully breast-fed						
n	114	84	68	64	52	43
Percentage of total sample	67	50	40	38	31	25
Fed liquids, %	1.7		15			17
Fed solids, %	0		62			79
Energy intake,[1] *kJ/d*				737 ± 418		
Protein intake[1] *g/d*				6.6 ± 6.2		
Formula-fed						
n	21	36	49	61	71	83
Percentage of total sample	12	21	29	36	42	49
Fed liquids, %	0		18			20
Fed solids, %	0		61			67
Energy intake[1] *kJ/d*				609 ± 493		
Protein intake,[1] *g/d*				7.3 ± 6.9		
Partially breast-fed						
n	35	50	53	45	47	44
Percentage of total sample	21	30	21	26	27	26
Fed liquids, %	0		9			14
Fed solids, %	0		69			94
Energy,[1] *kJ/d*				706 ± 480		
Protein intake,[1] *g/d*				6.5 ± 6.5		

[1] Mean ± SD, daily intake from food other than milk.

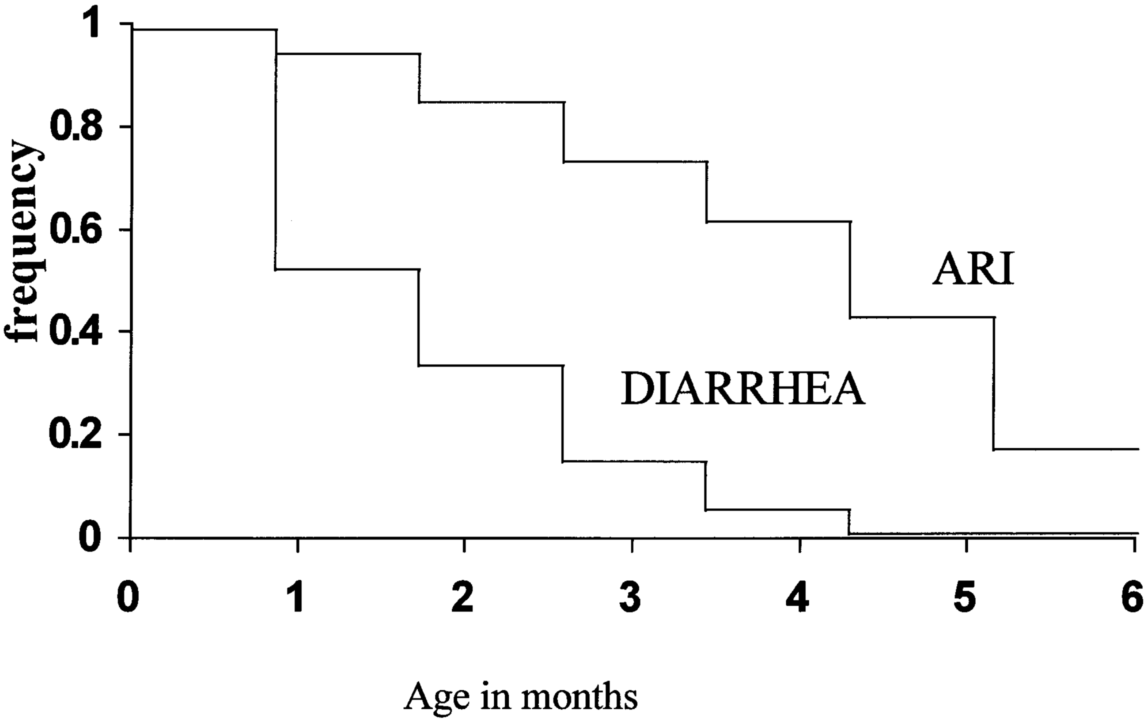

FIGURE 1 Survival analyses plot for incidence of acute respiratory infections (ARI) and diarrhea for 170 infants that were fully breast-fed, partially breast-fed or formula-fed. At 3 mo of age, <30% had had at least one episode of ARI and 85% had had one episode of diarrhea. At 6 mo of age, 20% had never experienced one episode of ARI, but all had had at least one episode of diarrhea.

Relative risks and confidence intervals for incidence and prevalence of diarrhea are presented in **Tables 6** and **7**. The probability of suffering an episode of diarrhea was higher for the formula-fed than for the fully breast-fed groups from 2 to 6 mo of age. The likelihood of having a larger percentage of days ill was also higher for the formula-fed than for the fully breast-fed infants during the entire follow-up. The relative risks for the partially breast-fed group did not show any trend.

The mean duration of episodes of diarrhea was also higher for the formula-fed than for the fully breast-fed infants (6.2 ± 4.4 vs. 3.8 ± 2.2 d, respectively, $P < 0.001$). Antibiotics were prescribed in 21 out of 95 episodes registered (seven formula-fed and 14 fully or partially breast-fed infants).

The number of episodes and the number of days ill with diarrhea were both associated with duration of full breast-feeding ($r = -0.17$, $P = 0.02$ and $r = -0.19$, $P < 0.008$, respectively). Maternal education, marital status, crowding, number of siblings, and socioeconomic level were not significantly corre-

TABLE 3

Incidence of acute respiratory infections by category of feeding practice and age in infants 0–6 mo

Age, *mo*	Feeding mode	*n*	Days of observation	Episodes	Incidence rate	Relative risk	Confidence intervals
1	Fully breast-fed[1]	114	3300	6	0.18	1.00	
	Formula-fed	21	600	6	1.00	5.56[2]	3.6–8.5
	Partially breast-fed	35	990	6	0.60	3.33[2]	2.1–5.2
2	Fully breast-fed	84	2340	11	0.47	1.00	
	Formula-fed	36	1020	9	0.88	1.87[2]	1.5–2.3
	Partially breast-fed	50	1440	14	0.97	2.06[2]	1.7–2.5
3	Fully breast-fed	68	1845	11	0.59	1.00	
	Formula-fed	49	1365	15	1.09	1.86[2]	1.6–2.2
	Partially breast-fed	53	1440	11	0.76	1.29[3]	1.1–1.6
4	Fully breast-fed	64	1680	7	0.41	1.00	
	Formula-fed	61	1590	16	1.00	2.45[2]	1.9–3.1
	Partially breast-fed	45	1110	10	0.90	2.20[2]	1.7–2.8
5	Fully breast-fed	52	1365	13	0.95	1.00	
	Formula-fed	71	2010	21	1.04	1.09	0.9–1.3
	Partially breast-fed	47	1200	16	1.33	1.40[3]	1.2–1.7
6	Fully breast-fed	43	1155	16	1.38	1.00	
	Formula-fed	83	2415	32	1.32	0.96	0.8–1.1
	Partially breast-fed	44	1245	13	1.04	0.75[3]	0.6–0.9

[1] Fully breast-fed is the reference group.
[2] χ^2, $P < 0.001$.
[3] χ^2, $P < 0.05$.

TABLE 4

Prevalence of acute respiratory infections by category of feeding practice and age in infants 0–6 mo

Age, *mo*	Feeding mode	*n*	Days of observation	Numbers of days ill	Percentage	Relative risk	Confidence intervals
1	Fully breast-fed[1]	114	3300	21	0.63	1.00	
	Formula-fed	21	600	40	6.66	11.17[2]	5.1–24
	Partially breast-fed	35	990	38	3.83	6.33[2]	2.8–14
2	Fully breast-fed	84	2340	60	2.56	1.00	
	Formula-fed	36	1020	51	5.00	2.00[2]	1.4–2.9
	Partially breast-fed	50	1440	64	4.44	1.76[2]	1.6–2.6
3	Fully breast-fed	68	1845	65	3.52	1.00	
	Formula-fed	49	1365	100	7.32	2.92[2]	2.0–4.2
	Partially breast-fed	53	1440	77	5.34	1.52[3]	1.1–2.1
4	Fully breast-fed	64	1680	32	1.90	1.00	
	Formula-fed	61	1590	115	7.23	3.80[2]	2.5–5.8
	Partially breast-fed	45	1110	50	5.52	2.75[2]	1.8–4.3
5	Fully breast-fed	52	1365	80	5.86	1.00	
	Formula-fed	71	2010	142	7.06	1.22[3]	1.0–1.5
	Partially breast-fed	47	1200	118	9.83	1.69[3]	1.4–2.0
6	Fully breast-fed	43	1155	85	7.35	1.00	
	Formula-fed	83	2415	190	7.89	1.08	0.9–1.3
	Partially breast-fed	44	1245	70	5.62	0.76	0.6–1.0

[1] Fully breast-fed is the reference group.
[2] χ^2, $P < 0.001$.
[3] χ^2, $P < 0.05$.

TABLE 5

Effect of duration of breast-feeding and potential confounders on the number and duration of acute respiratory infections and diarrhea episodes in infants 0–6 mo of age

Dependent variable	Independent variable	Coefficient	*r*	*P* value
Episodes of ARI			0.28	0.045
	Duration of fully breast-fed	−0.07422	−0.17	0.05
	Siblings	−0.3749	0.16	0.04
	Marital status	0.2938	0.13	0.28
	Maternal education	−0.0411	−0.12	0.16
	Crowding	0.0461	0.09	0.52
	Socioeconomic level	0.2938	0.02	0.37
Days ill with ARI			0.20	0.24
	Duration of fully breast-fed	−0.5817	−0.16	0.04
	Siblings	−0.959	0.13	0.49
	Marital status	2.2410	0.10	0.28
	Maternal education	−0.0347	−0.12	0.71
	Socioeconomic level	0.8600	0.05	0.55
Episodes of diarrhea			0.23	0.16
	Duration of fully breast-fed	−0.0614	−0.17	0.02
	Siblings	−0.1634	0.02	0.19
	Marital status	−0.2848	0.08	0.14
	Maternal education	0.0072	0.01	0.72
	Crowding	0.0522	0.06	0.30
	Socioeconomic level	0.0546	0.01	0.69
Days ill with diarrhea			0.24	0.05
	Duration of fully breast-fed	−0.4434	−0.19	0.008
	Siblings	−0.8005	−0.001	0.32
	Marital status	−1.8230	−0.08	0.13
	Maternal education	−0.0507	−0.04	0.35
	Socioeconomic level	1.0971	0.08	0.18

lated with diarrhea (Table 5). In the logistic analysis, only duration of full breast-feeding was correlated with the number of episodes of diarrhea; introduction of solid food and occurrence of an episode of diarrhea were not associated (odds ratio = 0.86 and 1.16, CI = 0.75–0.98 and 0.88–1.52, respectively).

DISCUSSION

Our data support the hypothesis that human milk has a protective effect for acute respiratory infections, as it does for diarrhea. Moreover, these data demonstrate that breast-fed infants have a lower incidence of ARI, a smaller percentage of days ill, and episodes of shorter duration than bottle-fed infants. Such protection against ARI was significant up to 4 mo of age and prevailed after controlling for known confounders such as maternal age, education, and marital status, nutritional status, number of siblings living in the same household and socioeconomic level, based on a construct including availability of tap water, sewage removal, refrigerator and paved floor.

These results are consistent with recent studies (Beaudry et al. 1995, Brown et al. 1989, Howie et al. 1990, Pisacane et al. 1994, Wright et al. 1989) claiming a protectve effect of breast-feeding against ARI. Efforts were made to control for known confounders mentioned in these studies. An association between breast-feeding and respiratory infections was found in a retrospective study carried out in Canada. In that study, diagnosis of otitis media and of upper and lower respiratory infections was based on a questionnaire mailed to the mother (Beaudry et al. 1995). Two more studies, one combining prospective and retrospective assessments (Wright et al. 1989) and the other a case-controlled, hospital-based study (Pisacane et al.1994), also found a lower incidence of wheezing (but not of non-wheezing respiratory illness) and pneumonia and bronchiolitis, respectively, in breast-fed infants. However, hospital-based studies may bias the results because more severely ill infants are more likely to be included. In addition, retrospective studies are not the best design to use in looking for causality; therefore the results of these studies must be confirmed with better-designed studies. In 1989, Brown et al. conducted

TABLE 6

Incidence of diarrhea by category of feeding practices and age in infants 0–6 mo

Age, *mo*	Feeding mode	*n*	Days of observation	Episodes	Incidence rate	Relative risk	Confidence intervals
1	Fully breast-fed[1]	114	3300	8	0.24	1.00	
	Formula-fed	21	600	1	0.16	0.67	0.4–1.2
	Partially breast-fed	35	990	4	0.40	1.67[2]	1.5–1.8
2	Fully breast-fed	84	2340	2	0.09	1.00	
	Formula-fed	36	1020	3	0.29	3.63[2]	1.7–7.5
	Partially breast-fed	50	1440	3	0.26	3.25[2]	1.5–6.8
3	Fully breast-fed	68	1845	3	0.16	1.00	
	Formula-fed	49	1365	6	0.43	2.69[2]	1.6–4.4
	Partially breast-fed	53	1440	4	0.27	1.69[3]	0.9–2.9
4	Fully breast-fed	64	1680	5	0.29	1.00	
	Formula-fed	61	1590	6	0.37	1.28[3]	1.1–1.4
	Partially breast-fed	45	1110	2	0.18	0.62	0.4–1.1
5	Fully breast-fed	52	1365	5	0.36	1.00	
	Formula-fed	71	2010	15	0.74	2.07[3]	1.5–2.7
	Partially breast-fed	47	1200	5	0.41	1.15	0.8–1.6
6	Fully breast-fed	43	1155	2	0.17	1.00	
	Formula-fed	83	2415	14	0.57	3.35[2]	2.1–5.2
	Partially breast-fed	44	1245	7	0.56	3.30[2]	2.1–5.3

1 Fully breast-fed is the reference group.
2 χ^2, $P < 0.001$.
3 χ^2, $P < 0.05$.

a longitudinal study in a poor neighborhood in Lima, Peru, which found that infants were protected against ARI for the first 20 wk postpartum. Although maternal smoking seemed to be uncommon in that community, it was not controlled in the study. In addition, the authors claimed that family size was comparable across feeding practice categories, but its effect was not analyzed explicitly. Protection by breast-feeding against ARI has been also reported in longitudinal studies conducted in developed countries. However, in most of these studies, the association vanished when controlling for confounders, i.e., maternal smoking and family size (Fergusen et al. 1981, Taylor et al. 1982). On the contrary, in a well-designed, longitudinal study, Howie and co-workers (1990) found that breast-fed infants were protected against ARI for the first 13 wk of age. Such protection lasted beyond the end of breast-feeding up to 40–52 wk of age if infants were breast-fed for at least 13 wk. Statistical significance persisted after allowing for confounders.

Several methodological efforts help to strengthen the conclusions in the present study. Community-based surveillance avoided the bias imposed by differences in maternal judgment to obtain health care, or in hospitalization rates according with feeding practices. Detection bias was minimized by frequent and regular surveillance, alternately at home and in the clinic, and by daily reporting of the health status of infants by their mothers. Participant mothers were instructed and super-

TABLE 7

Prevalence of diarrhea by category of feeding practice and age in infants 0–6 mo

Age, *mo*	Feeding mode	*n*	Days of observation	Numbers of days ill	Percentage	Relative risk	Confidence intervals
1	Fully breast-fed[1]	114	3300	18	0.54	1.00	
	Formula-fed	21	600	6	1.00	1.85[2]	1.4–2.5
	Partially breast-fed	35	990	24	2.45	4.48[2]	3.5–5.7
2	Fully breast-fed	84	2340	10	0.42	1.00	
	Formula-fed	36	1020	29	2.84	6.76[2]	5.1–8.9
	Partially breast-fed	50	1440	11	0.96	2.29[2]	1.9–3.2
3	Fully breast-fed	68	1845	15	0.81	1.00	
	Formula-fed	49	1365	41	3.00	3.70[2]	3.1–4.5
	Partially breast-fed	53	1440	12	0.83	1.02	0.8–1.3
4	Fully breast-fed	64	1680	14	0.83	1.00	
	Formula-fed	61	1590	47	2.95	3.56[2]	2.9–4.3
	Partially breast-fed	45	1110	16	1.44	1.73[3]	1.4–2.1
5	Fully breast-fed	52	1365	25	1.83	1.00	
	Formula-fed	71	2010	100	4.97	2.71[3]	2.4–3.1
	Partially breast-fed	47	1200	21	1.75	0.96	0.8–1.1
6	Breast-fed	43	1155	7	0.60	1.00	
	Formula-fed	83	2415	72	2.98	4.96[2]	3.9–6.3
	Partially breast-fed	44	1245	43	3.45	5.75[2]	4.6–7.2

1 Fully breast-fed is the reference group.
2 χ^2, $P < 0.001$.
3 χ^2, $P < 0.05$.

vised by the field personnel so that compliance was 95%. We were not able to find any published validation for such a procedure in developing countries, but there is merit in the fact that it is based on written information during an active surveillance. Misdiagnoses are probably unusual because it is unlikely to misclassify a respiratory infection event as a diarrhea event, except when respiratory infections present with vomiting. In addition, a physician blinded to the feeding practice category assigned the final diagnosis based on maternal observations, nurses records, and pre-established definitions of illness. Assessment of diagnosis concordance between the assigned diagnosis by the researcher and the diagnosis written in the medical records was possible only in a limited number of events (50 out of 325). Although the concordance was almost universal, such evaluation does not seem valid because medical care probably was more likely to be demanded for severe than for mild cases. Women who are breast-feeding may be more likely to detect any episode of illness because of their recognized mother-child attachment. This might result in a detection bias leading to an underestimation of the protective effects of breast-feeding.

The effects of breast-feeding on the prevalence of ARI have been addressed by Brown et al. (1989), who demonstrated fewer days ill with ARI in breast-fed than in formula-fed infants. However, the reported lower percentage of days ill may reflect a lower number of episodes instead of a shorter duration. Our study provides evidence for a lower prevalence of ARI as well as a shorter duration of individual episodes in breast-fed infants, by examining the percentage of days ill and the mean duration of individual episodes.

In this study, none of the participant mothers smoked cigarettes. Smoking habits of the fathers were not investigated. Smoking is highly prevalent in the male population of Mexico City. However, in this area of the city, most working males are away from their homes for 12 h/d or longer because of the lengthy commuting time to their work.

The effect of family size was analyzed using both the number of siblings and the presence of crowding, because each of those two variables affects the morbidity of acute infections differently. These variables functioned as effect modifiers. For instance, the protective effect of duration of full breast-feeding on incidence of ARI was present only for those infants who had siblings, and the association of duration of breast-feeding with the number of days ill with ARI was present only when crowding was removed from the analysis; crowding was not significantly associated by itself.

The mean birth weight, by feeding practice categories, was not different among groups, allowing us to assume that nutritional status was comparable at base line. Hence, any difference in the morbidity rates cannot be attributed to a nutritionally impaired immune response of the children (Chandra 1989). Thus, differences in morbidity might be attributed to the feeding mode. The prescription of antibiotics was infrequent (12% of all events) and unrelated in the analyses to the percentage of days ill.

Babies shifting from one feeding mode category to the other caused the formula-fed group to be a mixture of those who were formula-fed since birth and those with a previous history of breast-feeding. Thus, the risk rates for the formula-fed group were probably underestimated, especially in the later months of follow-up.

For the purpose of this study, the definition of ARI included symptoms and signs of both upper and lower respiratory tract infection, but episodes of lower respiratory tract infections were not detected. Consequently, our results refer to upper respiratory illnesses. The nature of the protective mechanisms against respiratory infections are not as well understood as the mechanisms protecting against diarrhea. There is growing evidence that some bioactive components in human milk protect against respiratory infections. Such is the case for a specific secretory immunoglobulin (sIgA) against syncytial viruses resulting from the bronchomammary pathway (Fishaut et al. 1981) and for an α_2-macroglobulin-like substance that inhibits influenza and parainfluenza viruses (Ryan-Poirier and Kawaoka 1993). Some milk oligosaccharides may inhibit the attachment of *Steptococcus pneumoniae* and *Haemophilus influenzae* to host cell surface receptors (Andersson et al. 1986). Lactoferrin may inhibit the growth of gram-positive and gram-negative bacteria by limiting iron availability (Sanchez et al. 1992), by interfering with virus receptor-mediated binding to target cells (Van Berkel et al. 1995), by modulating complement activation (Ferenec and Viljoen 1995), and stimulating natural killer cells (Bezault et al. 1994). Therefore, there is enough evidence to support the belief that respiratory infections in breast-fed infants are less severe than in their formula-fed counterparts.

The protective effect of breast-feeding against diarrhea reported by others was also confirmed in our study. The lowering effect of breast-feeding on the percentage of days ill with diarrhea has been previously reported by Brown et al. (1989), but the finding here of reduced duration of individual episodes may be novel.

A unique form of detection bias resulting in overdiagnosis of the occurrence of diarrhea can occur because stools of very young breast-fed infants are typically much looser and more frequent than those of nonbreast-fed infants (Bauchner et al. 1986). To avoid such a bias, the outcome event definition was as recommended by the World Health Organization (WHO 1984). In addition, we compared the number of bowel movements per day occurring during a given episode to the number of daily bowel movements registered by the mother.

The feeding mode categories in the present study were based on the type of milk consumed regardless of whether water, other liquids, or solid food was introduced. Nonexclusive forms of breast-feeding (i.e., inclusion of other liquids or food) increase the risk of diarrhea (Brown et al.1989). That means that the protection breast milk brings against acute infections may have been underestimated in our study. However, introduction of solid foods in this study was not associated with the appearance of an episode of diarrhea, probably because introduction of liquid or solid food and the daily energy intake were evenly distributed among groups. Popkin et al. (1990) found no differential protection between exclusive and full breast-feeding in a large longitudinal study on almost 3000 infants from both rural and urban areas of the Phillipines.

In conclusion, we present evidence of a protective effect of breast-feeding against acute respiratory infections and diarrhea, which reduced the incidence, percentage of days ill and duration of individual episodes in breast-fed infants. Causal inferences between feeding practices and the risk of ARI and diarrhea cannot be made with our design, because ethical limitations did not permit the random assignment of breast- or formula-feeding to infants. However, the consistency of our results with those of others, the effect of breast-feeding intensity, and the dose-response effect of breast-feeding on the incidence and prevalence of ARI and diarrhea, strongly suggest that such a relationship is plausible.

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