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Increasing Breastfeeding Rates to Reduce Infant Illness at the Community Level

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ABSTRACT. ***Objective.*** **Although breastfeeding is associated with lower rates of a variety of infant illnesses, skeptics have suggested that much of the association is attributable to confounding, even after appropriate statistical adjustment. This article utilizes a novel design to investigate changes in infant illness at the community level after a successful breastfeeding promotion program.**

Methods. **In this population-based cohort study, the medical records of all infants born in one Navajo community the year before a breastfeeding promotion program (n = 977) and the year during the intervention (n = 858) were reviewed. Outcomes assessed include changes after the intervention in: proportion breastfeeding and/or breastfeeding exclusively; incidence of common infant illnesses in the first year of life; and feeding-group specific incidence of illness.**

Results. **The proportion of women breastfeeding exclusively for any period of time increased from 16.4% to 54.6% after the intervention. The percent of children having pneumonia and gastroenteritis declined 32.2% and 14.6%, respectively, after the intervention. Feeding-group specific rates of these illnesses were unchanged, indicating that the decline observed was attributable to the increased proportion of infants breastfeeding. In contrast, rates of croup and bronchiolitis increased after the intervention among those fed formula from birth, suggesting a viral epidemic which was limited to those never exclusively breastfed. Finally, sepsis declined in both formula-fed and breastfed infants after the intervention, suggesting that other factors affected this illness outcome after the intervention.**

Conclusions. **Increasing the proportion of exclusively breastfed infants seems to be an effective means of reducing infant illness at the community level. The experimental design suggests that the increased incidence of illness among minimally breastfed infants is causally related to lack of breast milk, rather than being attributable to confounding.** ***Pediatrics*** **1998;101:837–844;** ***breastfeeding, infection, infant illness, causality, health promotion, respiratory tract infections, gastroenteritis.***

ABBREVIATION. IHS, Indian Health Service.

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Breastfeeding has been associated with lower rates of a variety of infant illnesses[1] including wheezing lower respiratory tract illnesses,[2] pneumonia,[3] upper respiratory tract illnesses,[4] otitis media,[5,6] gastroenteritis,[4,7] meningitis,[8] and necrotizing enterocolitis.[9] It is widely believed that breastfeeding is causally associated with these lower rates, either because breast milk contains elements which might provide both specific and nonspecific protection against illness[10] or because it is more hygienic, particularly in areas with poor sanitation.[11] Skeptics, however, assert that the association of breastfeeding with lower rates of illness may be attributable to confounding, that women who breastfeed differ from mothers who formula-feed in ways which might alter their infant's risk for illness.[12] Although more recent studies adjust statistically for confounding, it is difficult to control for unmeasured and/or subtle differences between the two groups.

Mata et al[13,14] had previously demonstrated that neonatal mortality and morbidity attributable to diarrhea, sepsis, bronchopneumonia, and meningitis declined after breastfeeding promotion in Costa Rica. However, data were not collected on rates of mild illnesses not requiring hospitalization, and the overall association between feeding practices and illness outcomes was not shown. Most importantly, other improvements in infant health occurred simultaneously in Costa Rica, making it difficult to assess what proportion of improved survival and morbidity was attributable specifically to the breastfeeding intervention.

This analysis investigates further the nature of this relationship by evaluating changes in infant illness at the population level after a breastfeeding promotion program. We proposed that if feeding practices were causally associated with infant illness, rates of a particular illness would be higher in formula-fed infants at both times, and rates of illness would be lower for the cohort born after the intervention compared with the cohort born before the intervention, reflecting the increase in proportion of infants who were breastfed (Fig 1). Further, feeding-group specific rates of illness should not change after the intervention, because the risk of illness was unaltered within feeding groups. If, however, other events occurred which impacted the rate of illness more globally, such as the introduction of a new sanitation system or a viral epidemic, rates of illness would change significantly

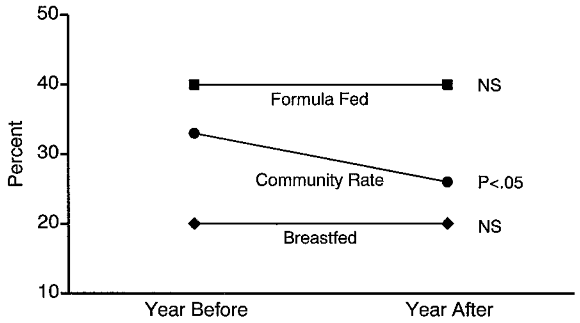

Fig 1. Hypothesized incidence of illness at the community level, and for formula-fed and breastfed infants, before and after an intervention, if change in rates is attributable to the intervention.

after the intervention within feeding groups as well as between cohorts.

METHODS

The first phase of this research, begun in 1988, assessed the determinants of infant feeding practices on the Navajo reservation. The research combined qualitative methods, such as ethnographic interviews and participant observation, with survey interviews on a sample of 250 women at three sites, to identify factors associated with infant feeding practices, results of which are published elsewhere.[15–17] After this phase of the project, a culturally appropriate breastfeeding promotion program, designed specifically to address the obstacles to breastfeeding identified in the preceding research, was implemented at Shiprock, New Mexico, one of the research sites.[18] The objective of the program was to enable Navajo mothers to postpone the introduction of formula for at least 1 month. The program consisted of three components: a community intervention which entailed public service announcements, a video, a billboard, and infant t-shirts given through the Women, Infants, and Children Supplemental Nutrition Program (WIC); an intervention in the health care system; and education of families about breastfeeding. The promotion program began on September 24, 1991 with a 3-day health care providers conference on lactation management, and continued for 1 year. The subsequent analysis assesses the feeding practices and the illnesses experienced for two groups of infants: those born before and those born after the intervention.

Data Collection

Evaluation of the impact of the breastfeeding promotion program on infant illness was based on a medical record search for all infants born at the Indian Health Service (IHS) hospital from June 1, 1990 to May 30, 1991 (the year before the intervention) and those born between September 24, 1991 to September 24, 1992 (the year of the intervention). Infants born in the 4-month period between those dates were excluded from consideration because preparations for the promotion were underway, which might have had some impact on feeding practices. A total of 1835 live-born infants, virtually all of whom were Navajo, were delivered in these years, 977 before and 858 after the intervention. There was no change in the number or type of health care providers between the two study periods, with care being provided by the same group of 4 pediatricians, 4 obstetricians, 16 family practitioners, and 4 nurse midwives.

Data were obtained for each child at each encounter with the health care system, including clinic visits, hospitalizations, emergency room visits, or home visits, each of which was identified by date. For illness visits, data were obtained on diagnosis made and medications prescribed; in addition, fever and whether or not the infant coughed, wheezed, had diarrhea and/or vomited was recorded. No particular effort was made by the providers to standardize diagnostic criteria, such as number of stools necessary to qualify as diarrhea. Diagnoses were recorded both by name and by unique numeric code, with a new number assigned to each new diagnosis. For well-child and follow-up visits, information was recorded on immunizations, length, and weight. Data regarding feeding status was recorded whenever it appeared in the medical record. Such information was routinely requested on forms used at each well-child visit; it is not known, however, if providers probed for information on exclusiveness of breastfeeding. Data regarding immunizations and feeding were also available from occasional home visits made by public health nurses, although these comprised a very small proportion (<1%) of the 29 768 visits for which data were obtained. All demographic information provided in the chart such as maternal age and parity, and data regarding the delivery (gestational age, birth weight, anesthesia, Apgar scores, type of delivery) were collected.

Information from the chart was entered directly into laptop computers using Knowledgeman software (Micro Data Base System, Inc, West Lafayette, IN). Researchers worked in pairs to alternately locate and read the information from the chart, enter it into the computer, and verify accuracy. Charts were read backwards, from the visit closest to 1.5 years toward birth, so researchers were blind to the child's feeding status when they recorded illness information; feeding information was the first data recorded for only 2.6% of records. Researchers were not involved in providing care for the infants. Data entry for both years occurred concurrently. Additional data were noted in a text file for each infant, which was reviewed for information that might alter classification of feeding status or illness outcome. Only illnesses occurring within 365 days of birth are considered here, because the evidence of a protective effect of breastfeeding is strongest for this period.

Although all the infants included in the study were born in Shiprock, there is substantial seasonal and annual mobility among Navajo families and medical care may be obtained from any IHS facility on the reservation. To minimize the concern that lack of illness data might reflect lack of follow-up rather than good health, infants who were seen infrequently (fewer than six times) or who had minimal data (<3 notations) regarding feeding were considered likely to be receiving care elsewhere. These children (n = 682) were eligible for additional follow-up at 18 other IHS clinics where the family had some tie to the community, such as having grandparents residing in or parents originating from the community. Visits were made to seven such communities at which 46% of the 682 children had ties, during which additional data regarding feeding status and/or illness visits were obtained for 92 children. Infants having more than the minimum recorded visits were assumed to be receiving care at the Shiprock facility, and no attempts were made to obtain medical record data from other clinics. Information regarding admission to other hospitals was recorded in the medical record housed at Shiprock, but information regarding illnesses for which no care was received or for which treatment was received from clinics other than those visited, was not available.

Data Analysis

Information was obtained on whether the child was ever breastfed, the age at which formula was first given, and the age at which breast milk was last known to be given. Children were classified into one of the following categories: never breastfed, breastfed but also formula fed from birth (early formula), exclusively breastfed for any period of time (postponed formula), and exclusively breastfed (never formula fed). Duration of breastfeeding was defined as the age at the last visit at which the child was reported to be breastfeeding. For example, an infant who was breastfed at 4 months but not at 6 months, was considered to have breastfed to 4 months. A small percentage of records (5.5%) contained inconsistent data; ie, infants were said to start breastfeeding after one or more visits during which they were reported to be fed formula only. Such infants were considered to still be breastfeeding only if there were two subsequent notations to that effect. Data regarding feeding status were entirely lacking for 6 children, leaving 1829 children with sufficient data for analysis.

Illnesses were classified with reference to the diagnosis made at the time of the acute visit. The following diagnostic categories (and the diagnoses as recorded in the chart) were considered in this analysis: otitis media (left or bilateral otitis media, otitis) for which medication was prescribed; recurrent otitis media (three or more episodes of otitis media which were ≥30 days apart); gastroenteritis (gastroenteritis, colitis/enteritis, acute or viral gastroenteritis); bronchiolitis; pneumonia (pneumonia, pneumonitis, bronchopneumonia); croup (croup, laryngotracheitis); bronchitis; nasopharyngitis (nasopharyngitis, viral upper respiratory infection, or colds); and sepsis (bacteremia, sepsis, or septicemia) with hospitalization. No additional criteria were applied to standardize use of diagnostic terms between providers (such as the requirement that pneumonia be verified with a chest radiograph) except as noted above. In the case of sepsis, for example, the percent with positive cultures is unknown. These diagnostic categories include the most frequent reasons for consultation for illness in this population, for which an association with feeding status has been established. In addition, trauma (including contusions, lacerations, burns, motor vehicle accidents, and abrasions) was assessed because we would expect to find neither a relation with feeding nor a significant change in the incidence of trauma for the cohort after the intervention. Finally, occurrence of one or more visits in which a fever of >100.4°F was recorded was assessed as a gloss for any visit for an infectious illness.

The percent of infants in each feeding category being diagnosed with each illness at any time in the first year of life was assessed before and after the intervention. If more than one diagnosis was made for a particular visit, each illness was considered separately (eg, a child diagnosed simultaneously with bronchiolitis and otitis media would be considered as an incident case in both categories). The relative risk of developing a particular illness was calculated for those who never received formula compared with never-breastfed infants. Incidence of each illness in the first year of life was compared for the cohorts born the year before and the year of the intervention. Finally, changes in feeding-group specific rates between cohorts were assessed to identify outcomes potentially affected by other factors. Feeding-group specific comparisons were repeated separately, including only breastfed infants, thereby removing from the analysis any children who were too sick to have breastfed, and later, including only those who were never breastfed, thereby adjusting for the increases in breastfeeding after the intervention. Statistical significance was determined for comparison of incidence figures using the χ^2 distribution, and for differences between means, by *t* tests.

The project was approved by Internal Review Boards at the University of Arizona, the Navajo Area Indian Health Service, and Navajo Community College. Publication of the results was approved by the tribe through the Navajo Nation Health Research Review Board.

RESULTS

Characteristics and Feeding Practices of Mothers Delivering Before and After the Intervention

Women who delivered after the intervention were older and more likely to have multiple pregnancies, to have planned this pregnancy and to have delivered vaginally, and were less likely to receive anesthesia than those delivering before the intervention (Table 1). Despite these differences, the infants born before and after the intervention did not differ in gender, birth weight, Apgar scores at 1 and 5 minutes, presence of congenital anomalies, or gestational age. Infants born after the intervention had more encounters with the health care system in the first year of life. They were seen for significantly more well-child visits (mean, 3.0 ± 1.5 vs 3.2 ± 1.3; $P < .05$) and were vaccinated more frequently (3.5 ± 2.1 times vs 2.9 ± 1.4; $P < .0001$) than children born before the intervention. No mother had an infant in both cohorts.

TABLE 1. Comparison of Subjects Delivering Before and After the Intervention*

Characteristic	Before	After
N	972	857
Maternal age (y)	25.7 (±5.9)	26.3 (±6.0)†
Pregnancies (mean #)	3.0 (±1.9)	3.2 (±1.9)†
Planned pregnancy (%)	50.1	60.1‡
Anesthesia for delivery (%)	37.3	28.7§
Cesarean section rate (%)	14.2	10.5†

* No significant differences existed in parity, frequency of prenatal visits or use of Women, Infants, and Children Supplemental Nutrition (WIC) program.
† $P < .05$
‡ $P < .001$.
§ $P < .01$.

Breastfeeding rates improved significantly after the intervention. The proportion of infants fed formula from birth declined by almost one half from 83.6% before the intervention to 45.4% after the intervention ($P < .0004$; Table 2). The percent of women who ever breastfed increased from 71.1% to 81.1% ($P < .001$), mean age at introducing formula increased from 11.7 (standard deviation, ±53.1) to 48.5 days (standard deviation, ±102.9; $P < .001$) and, among ever breastfeeders, the mean duration of breastfeeding increased from 100.6 (standard deviation, ±125.8) to 131.6 days (standard deviation, ±147.5; $P < .001$) after the intervention. Infants born after the intervention had more data points regarding feeding (6.2 ± 2.4 vs 5.6 ± 2.4 before; $P < .001$), but there were no differences between the groups in the proportion of records with inconsistent feeding data.

Women delivering before the intervention were significantly more likely to have a cesarean section (14.2% vs 10.5%; $P < .01$), to use anesthesia during the delivery (37.3% vs 28.7%; $P < .0005$), to have an unplanned pregnancy (60.1% vs 50.1%; $P < .0001$), and to be younger (mean age, 25.7 ± 5.9 years vs 26.3 ± 6.0 years; $P < .02$). With the exception of age, these factors were also associated with formula feeding. Mothers who postponed or never gave formula were less likely to have used anesthesia (27.5% vs 36.7%; $P < .002$), to have delivered by cesarean section (6.3% vs 15.7%; $P < .001$), and to have an unplanned pregnancy (38.7% vs 48.6%; $P < .001$). No data were available regarding years of maternal education; however, our earlier research showed no relation of feeding practices with maternal education among the Navajo.[15]

Feeding Practices and Illness Outcomes in the First Year of Life

Table 3 displays the percent of children who were seen for specific illnesses in relation to feeding practices. There was an inverse relationship between amount of breastfeeding and the incidence of most illnesses, including otitis media, gastroenteritis, bronchiolitis, pneumonia, croup, nasopharyngitis, and sepsis, as well as fevers of >100.4°F. Although there was an apparent inverse dose response between amount of breast milk received and rate of illnesses such as croup, for most outcomes the principal effect was among children who never received formula. These relations were similar for infants born both before and after the intervention, although they were not always significant. In contrast, neonatal jaundice was more common with increasing breastfeeding, and there was no consistent relation between incidence of trauma and feeding status.

TABLE 2. Infant Feeding Practices Before and After the Intervention

		Never Breastfed	Early Formula*	Postponed Formula†	Never Formula‡	P Value
Percent (N)	Before	28.9 (281)	54.7 (530)	12.8 (124)	3.8 (37)	.001
	After	18.9 (162)	26.5 (227)	45.4 (389)	9.2 (79)	
Mean duration of breastfeeding (days)‖	Before	—	90.4 (±120.7)	119.4 (±125.7)	183.7 (±159.4)	.0001§
	After	—	83.0 (±118.4)	145.1 (±149.4)	205.0 (±168.9)	.0001§

* Consists of children who received some breast milk but were also fed formula prior to discharge following the delivery.
† Consists of breastfed infants who received formula at some point, but starting after discharge from the hospital. Mean age at introducing formula in those who postponed formula was 88.3 (±120.8) days before and 97.0 (±128.5) days after the intervention.
‡ Consists of infants who were never reported to have received formula.
§ P value for difference between the three groups at each time, after excluding the never breastfed group.
‖ Mean duration of breastfeeding is taken from the last date at which infants were known to have been breastfed, up to the age of 1.5 years when the chart review was terminated. This method undoubtedly underestimates the duration of breastfeeding since some infants breastfed beyond 1.5 years, particularly among the group which was never given formula.

TABLE 3. Incidence of Illness (%) in the First Year of Life by Feeding and Intervention Status, and Relative Risk (Confidence Intervals) for Illness if Never Given Formula

Illness		Never Breastfed	Early Formula	Postponed Formula	Never Formula	Relative Risk (CI)*
Otitis media	Before†	75.4	73.6	79.8	56.8	0.75 (0.56–1.00)
	After‡	75.9	70.9	73.3	53.2	0.70 (0.56–0.88)
Gastroenteritis	Before§	44.8	40.0	47.6	18.9	0.42 (0.21–0.83)
	After§	36.4	40.1	37.5	19.0	0.52 (0.32–0.86)
Bronchiolitis	Before	21.4	16.4	21.8	10.8	0.51 (0.20–1.31)
	After†	25.9	23.3	20.1	10.1	0.39 (0.19–0.79)
Pneumonia	Before	12.1	12.8	10.5	2.7	0.22 (0.03–1.58)
	After	8.6	11.0	9.3	2.5	0.29 (0.06–1.26)
Croup	Before	1.8	2.8	1.6	0.0	—
	After	6.2	5.3	2.6	1.3	0.21 (0.03–1.58)
Bronchitis	Before	3.6	6.4	6.5	2.7	0.75 (0.10–5.76)
	After	2.5	3.1	3.9	1.3	0.51 (0.06–4.51)
Nasopharyngitis	Before‡	64.4	67.0	71.8	37.8	0.59 (0.39–0.90)
	After†	66.0	69.2	68.1	50.6	0.77 (0.60–0.98)
Sepsis	Before	3.6	3.4	4.0	2.7	0.76 (0.10–5.76)
	After	1.2	0.9	0.3	0.0	—
Ever fever >100.4F°	Before†	77.2	75.7	81.5	56.8	0.74 (0.35–0.98)
	After‡	80.2	81.1	79.4	51.9	0.65 (0.52–0.81)
Jaundice	Before‡	1.1	5.7	10.5	8.1	7.59 (1.59–36.26)
	After†	1.2	4.4	7.2	3.8	3.08 (0.52–18.04)
Trauma	Before	8.2	7.7	10.5	8.1	0.99 (0.31–3.14)
	After	6.2	10.1	12.3	6.3	1.02 (0.36–2.90)

* Relative risks show risk of illness for children who were never given formula compared with those who were never breastfed in each cohort.
† P values for overall $\chi^2 < .05$.
‡ P values for overall $\chi^2 < .001$.
§ P values for overall $\chi^2 < .01$.

TABLE 4. Cumulative Incidence of Illness, and Change in Incidence, for Cohorts Born Before and After the Intervention

Illness	Before	After	Percent Change*	P Value
Sepsis	3.5%	0.6%	−190.0	.00005
Bronchitis	5.5%	3.2%	−71.9	.02
Pneumonia	11.9%	9.0%	−32.2	.04
Gastroenteritis	41.6%	36.3%	−14.6	.02
Trauma	8.2%	10.0%	+18.0	NS
Bronchiolitis	18.3%	21.1%	+13.3	NS
Croup	2.3%	3.9%	+41.0	.05

* Calculated as 1 − (rate before/rate after) × 100.

Change in Community Incidence of Illness After the Intervention

Table 4 compares incidence of illness before and after the intervention. Rates of sepsis, bronchitis, pneumonia, and gastroenteritis declined significantly after the intervention, whereas rates of croup were significantly higher. Despite the strong relationship between increasing breastfeeding and bronchiolitis, rates of this illness were not significantly lower after the intervention. No significant change occurred after the intervention in incidence of otitis media (74.3% vs 71.3%), nasopharyngitis (65.7% vs 66.4%), jaundice (5.0% vs 5.0%), or fever of >100.4°F (76.1% vs 77.5%); the decline in recurrent otitis media (30.7% to 27.4%) was of borderline significance ($P <$ .13). Rates of trauma were also unchanged during this time.

To assess changes in feeding-group specific rates for the seven outcomes considered in Table 4, never-breastfed children and early formula users were combined into a formula from birth group (n = 1200), whereas those exclusively breastfed for some period of time were classified as mostly breastfed (n = 629). Three patterns of change in rates of illness were evident within feeding groups (Fig 2). There was no significant change in feeding-group specific rates of either pneumonia or gastroenteritis (group A

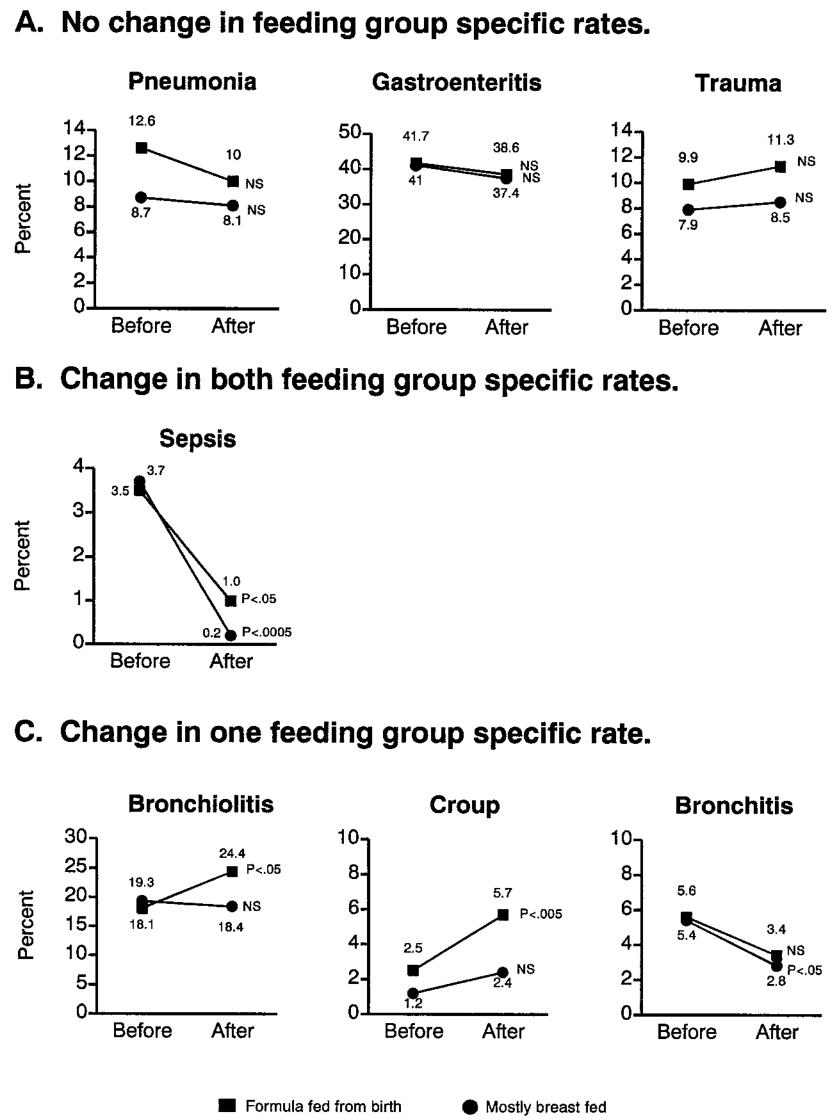

Fig 2. Feeding-group specific rates of illness, before and after the intervention.

in Fig 2) for the cohorts born before and after the intervention, suggesting that the decline in incidence rates of these outcomes after the intervention was because of the increase in community rates of breastfeeding. The nonsignificant apparent ($P < .20$) decline in pneumonia after the intervention among those formula fed from birth entirely disappeared when comparisons were limited to infants who received some breast milk (12.8 to 11.0%; $P = .49$), thereby adjusting for the larger proportion of children who breastfed after the intervention.

In contrast, rates of sepsis (group B in Fig 2) declined after the intervention for both the formula from birth (3.5% to 1.0%; $P < .05$) and mostly-breastfed (3.7% to 0.2%; $P < .001$) groups, indicating that although breastfeeding may have contributed to the decline, factors independent of change in feeding practices were also involved.

Rates of two outcomes increased after the intervention in the formula from birth group but not for mostly-breastfed infants (group C in Fig 2). Bronchiolitis in the formula from birth group increased from 18.1% to 24.1% ($P < .01$) whereas croup increased from 2.5% to 5.7% ($P < .005$), suggesting that a viral epidemic occurred the year after the intervention. If feeding patterns had remained the same and illness occurred at postintervention levels, community incidence of bronchiolitis and croup would have been even higher after the intervention (23.1% and 5.0%, respectively), an increase of 10% to 30% greater than observed rates. This increase would have occurred exclusively in the group of infants fed formula from birth. Again, results were unchanged when comparisons were limited to infants who received some breast milk, thereby excluding infants who were too sick at birth to breastfeed.

Finally, bronchitis declined significantly after the intervention but only in the mostly-breastfed group (5.4% to 2.8%; $P < .05$). However, this decline most likely reflects the increase in milk received, because it was not significant for either the group which postponed formula use (6.5% to 3.9%; $P = .22$) or the never formula-fed group (2.7% to 1.3%; $P = .58$).

The effect of the breastfeeding promotion on incidence rates of illness could not be attributed to confounders for which data were available. As noted above, there was change in three characteristics of the cohort giving birth the year after the intervention which was associated with increased breastfeeding: both anesthesia use and cesarean section rates declined, and the percent planning this pregnancy increased. Pregnancy planning was not associated with any illness outcome, so this variable could not be a confounder. Both having a vaginal delivery and using anesthesia were associated with significantly higher incidence of pneumonia; they showed no relation with any of the other illness outcomes considered. Because pneumonia declined after the intervention, these variables could not be confounders.

DISCUSSION

This cohort study has shown that rates of infant illness can be reduced through successful promotion of breastfeeding. Incidence of gastrointestinal and respiratory illness in the first year of life was significantly lower in this community after a dramatic increase in exclusive breastfeeding. Feeding-group specific rates of most of these illnesses remained constant before and after the intervention, suggesting that the decline in illness after the promotion reflects the greater proportion of women breastfeeding rather than other changes which might affect infant morbidity in general.

The breastfeeding promotion program was extremely successful,[18] with the proportion of women who breastfed exclusively for some period of time increasing from 16.4% before the intervention to 54.6% after the intervention. These increases in breastfeeding were associated with significant declines in several illness outcomes after the intervention. Incidence of pneumonia and bronchitis was reduced by 32% to 72% for the cohort of infants born after the intervention, whereas incidence of gastroenteritis declined by approximately 15%. There was no significant change in incidence of any of these outcomes when groups with comparable feeding histories were compared. Interestingly, rates of gastroenteritis were somewhat lower in most feeding categories after the intervention, which might be explained by increased resistance attributable to the high proportion of children presumably protected by breastfeeding (herd immunity), by increases in duration of breastfeeding, or by a possible excess of some gastrointestinal organism in the preintervention period. Nevertheless, the decline in gastroenteritis is within the range predicted by Feachem and Koblinsky[19] in their efforts to estimate the impact of breastfeeding promotion on illness rates.

It was initially surprising that bronchiolitis and croup also did not decline after the intervention, given the strong association between breastfeeding and wheezing lower respiratory tract infections[2] and the significant inverse relationship between amount of breastfeeding and these illnesses shown for this population. Although no state or county data were available regarding isolations of respiratory syncytial virus, the percentage of positive specimens nationally was substantially higher in the winter of 1991 to 1992 compared with 1990 to 1991,[20] suggesting that there was an epidemic of this virus in the postintervention year. Consistent with studies which show a specific protective effect against respiratory syncytial virus,[21–23] excess morbidity because of croup and bronchiolitis was limited to infants who received formula from birth. In fact, infants who were never given formula had one-half the incidence of lower respiratory tract illness of those receiving formula. If the promotion had succeeded in getting more women to never use formula, declines might have been observed in all these illnesses after the intervention.

Unlike respiratory and gastrointestinal illness, sepsis declined after the intervention among both those mostly breastfed and those fed formula from birth. Routine administration of the Hib vaccine began in Shiprock in late 1990, and *Haemophilus influenzae* infection declined significantly throughout the next 3 years.[24] Nevertheless, breastfeeding may have contributed to the decline in sepsis, given the lower rates in the mostly-breastfed group, at substantial savings to the health care system relative to the vaccine. It is important to note that jaundice, the one adverse outcome which was associated with increased breastfeeding, is associated with inadequate breastfeeding rather than breastfeeding per se.[25] The fact that rates of jaundice declined (although not significantly) in all groups of breastfed infants after the intervention indicates that education of health care providers regarding lactation physiology can substantially reduce jaundice through improved medical treatment.

If the inverse association of breastfeeding with illness shown here were an artifact of differences between mothers who choose to breastfeed and those who do not, increasing breastfeeding rates would dilute the effect because women who would normally feed formula have become breastfeeders. In fact, the reverse is true: rates of illness seemed lower in the mostly-breastfed group after the intervention. This apparent difference probably reflects the fact that the amount of breast milk received by infants in this group increased after the intervention, and that feeding information was reported more consistently by physicians after the intervention, resulting in less misclassification.

Several unique characteristics of this setting made it possible to define the effect of increasing breastfeeding on infant illness more precisely than is usually possible. First, IHS provides health care services free of charge to Native Americans who do not have private insurance, thereby minimizing both financial barriers and ascertainment bias, as well as assuring that the vast majority of the population was seen within a single health care system. Because there is only one IHS hospital in the Shiprock area, the entire population of infants born the year before and the year after the intervention (excepting 6 infants with no feeding data) could be assessed avoiding selection bias. Access to medical records made it possible to determine feeding specific rates of illness, thereby allowing consideration of other factors which might affect incidence of illness. Finally, the breastfeeding promotion program was extremely successful, as the result of extensive research into the determinants of infant feeding practices in this population and utilization of culturally appropriate messages.

The use of medical records, although permitting assessment at the population level, has distinct limitations. First, little information is available regarding potential confounders and illness data are available only for illnesses for which care was obtained. Although differences between mothers in the two cohorts should have increased the infants risk of illness after the intervention (when, for example, mean parity was higher), it is impossible to assess the potential impact of unmeasured differences, such as years of maternal education. A second limitation inherent in the evaluation is that the providers making diagnoses were, for the most part, aware of and participating in the activities designed to increase breastfeeding rates. In the current study, it is possible that the decline in illness observed after the intervention could be attributable to diagnostic bias because most providers would have known the feeding status of infants when making a diagnosis. Although this alternate explanation for the declines in infant morbidity cannot be entirely rejected, use of preventive health care services increased after the intervention making it more likely that a mild illness would be diagnosed in the second cohort.

Risks for illness in this population differ somewhat from other parts of the United States: many homes do not have indoor plumbing and are heated by a combination of wood or coal burning stoves, and most infants spend substantial amounts of time with other children. Although each of these factors might be expected to increase risks of illness, lower respiratory tract infection rates were virtually identical with those reported for a middle-class population in Tucson.[26] In addition, rates of gastrointestinal illness are very comparable to those reported for industrialized and/or middle-class settings.[4,7] In Dewey et al's[7] middle-class population in California, for example, more than 50% of infants had at least one episode of diarrhea; 25% to 30% of infants in a Scottish study sought care for gastroenteritis.[7] These similarities in incidence rates suggest that the declines in incidence observed after breastfeeding promotion in this population might be realized in other settings.

Several reviews published during the 1980s[12,27] questioned whether breastfeeding is causally associated with lower rates of illness, particularly in the industrialized world. Earlier studies were faulted for problems associated with recall bias, surveillance bias,[28] detection bias,[12] lack of adjustment for confounding, and the fact that illness may precipitate formula use, thus accounting for the association. This study collected data that was recorded prospectively in the medical record, and incidence of illness was assessed rather than hospitalization, thereby avoiding both recall problems and surveillance bias. If anything, detection of mild illnesses would be greater among the mostly breastfed because these infants were seen for more well child visits. No confounding was evident when factors associated both with breastfeeding and intervention status were assessed in relation to illness, effectively eliminating confounding as the reason for the decline in community illness rates. Finally, the feeding categories used here eliminate the cart versus horse concern for whether illness or formula use came first because they are based on feeding practices at birth, and exclusion of the never-breastfed group from certain comparisons eliminates possible confounding because of the fact that very sick newborns may be unable to nurse.

Because it is ethically impossible to randomly assign infants to feeding groups, this study provides the strongest experimental evidence to date which suggests that increases in breastfeeding are causally associated with declines in infant morbidity. With the inclusion these data, all of Bradford-Hill's[29] criteria for demonstrating cause have been demonstrated, including strength of association,[30,31] consistency,[1,32] specificity,[10,22,23,33] temporality,[7,13,34] dose response,[5,34] plausibility,[35,36] coherence,[37] and analogy.[38,39] Although occasional studies[40] find no significant protective effect of breastfeeding on infant illness, the bulk of evidence should be considered with reference to causation, because many factors may undermine the ability to demonstrate a particular criterion in a particular situation.[29] This body of evidence strongly supports the hypothesis that formula feeding increases the risk of infectious illness in infancy.

In conclusion, this study has shown that, at the community level, incidence of gastrointestinal and respiratory illness decline after effective promotion of breastfeeding. It supports a causal association, indicating that breast milk itself or the process of breastfeeding provides protection against infant illness. These findings suggest that increasing rates of breastfeeding, particularly among high-risk groups and in settings with low initial rates of breastfeeding, is an effective means of reducing infant illness at the community level. Finally, this study was successful in differentiating changes in morbidity because of the promotion from changes attributable to other factors, by using a model which may be applicable to other evaluations of the impact of health promotion programs on illness outcome.

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