Breastfeeding has long been believed to protect against infection in infants, but protection against respiratory illnesses has not been consistently demonstrated in studies in developed countries. Between 1988 and 1992, the authors assessed the effect of breastfeeding on incidence and duration of respiratory illnesses during the first 6 months of life in a prospective study that actively tracked breastfeeding and respiratory illnesses. A cohort of 1,202 healthy infants, born in Albuquerque, New Mexico, between January 1, 1988 and June 30, 1990, from homes without smokers was enrolled. The daily occurrences of respiratory symptoms and breastfeeding status were reported by the mothers every 2 weeks. Illnesses were classified as lower respiratory illness (LRI) if wheezing or wet cough was reported; the remaining illnesses were classified as upper respiratory. The annualized incidence rates for LRI were 2.8, 2.6, and 2.1 during follow-up time with no, partial, or full breastfeeding, respectively, but the incidence rates for upper respiratory illness and lower respiratory illness combined were similar in the three categories. After adjustment for potential confounding factors, full breastfeeding was associated with a reduction in lower respiratory illness risk (odds ratio = 0.81, 95% confidence interval 0.68–0.96). Median duration of all respiratory illnesses was 5 days for the fully breastfed infants during the first 6 months of life compared with a median of 6 days for not breastfed and partially breastfed infants. Multivariate analysis confirmed that breastfeeding significantly reduced the duration of respiratory illness. This pattern of reduced incidence of LRI and shorter duration of all respiratory illnesses suggests that breastfeeding reduces the severity of infant respiratory illnesses during the first 6 months of life.


Breastfeeding has long been believed to protect against infection in nursing infants. Support for this belief can be found in the in vitro demonstration of specific and nonspecific antinfective substances in breast milk (1, 2) and in the findings of epidemiologic studies in developing countries (3–6). However, the apparent protection of breastfed infants in developing countries could reflect better overall nutrition for breastfed infants or reduced exposure to infectious agents rather than specific antiinfective substances in breast milk.

Protection against infection through breastfeeding, particularly for infections of the respiratory tract, has not been uniformly demonstrated in studies in developed countries (7–14). Differences in study designs and analytic approaches have complicated interpretation of the findings of the published studies. Bauchner et al. (15), in a 1986 review, faulted most of the epidemiologic studies and concluded that breastfeeding confers only a minimal protection against infectious illnesses in industrialized countries. Bias from confounding factors is of particular concern in the studies in developed countries, as women who breastfeed tend to have higher incomes and more education than do women who do not breastfeed (16, 17).

In a prospective study on the relation between indoor nitrogen dioxide exposure and respiratory illness (18), we followed more than 1,000 normal infants from birth through age 18 months with prospective surveillance for respiratory illness and breastfeeding status. Every 2 weeks, symptoms of respiratory ill-
nesses and breastfeeding were ascertained, and information on potential confounding factors was also collected; information on breastfeeding was compiled until the child stopped breastfeeding. Consequently, in the analysis, breastfeeding status was time dependent, and the effect of breastfeeding on the incidence and duration of each respiratory illness could be considered. This study is not affected by some of the methodological concerns that have limited interpretation of earlier studies. In this paper, we report findings on the relation between breastfeeding and incidence and duration of upper respiratory tract illnesses (URI) and lower respiratory tract illnesses (LRI) from birth through the first 6 months of life.

MATERIALS AND METHODS
Subject selection

Complete details of subject recruitment, data collection, and data analysis have been reported previously (18, 19). Briefly, the study subjects were recruited from among healthy, term infants born at all Albuquerque, New Mexico, hospitals between January 1, 1988, and June 30, 1990. Families were invited to participate in the study if the mother was at least age 18 years, spoke English, did not smoke, and had a telephone in the home. Families were excluded if there were any smokers in the home, if the parents planned to place the infant in full-time day care, or if the family planned to move from Albuquerque within the next 18 months.

Enrolled subjects were withdrawn from further follow-up if the infant was placed in day care for more than 20 hours a week, if any household member began to smoke, if the family failed to comply with study procedures, or if the family wished to discontinue participation.

Data collection

At an initial home visit, study interviewers obtained information on family composition, household income, sources of medical care for the index subject, ethnicity of the parents, and years of education completed by mother and father. Parents completed the standardized respiratory symptoms questionnaire of the American Thoracic Society (20), which includes questions on history of asthma, hay fever, and desensitization injections.

On enrollment, mothers were trained by a nurse to complete a daily calendar, on which they recorded signs and symptoms exhibited by the infant. Symptoms included runny nose, stuffy nose, fever, dry cough, wet cough, wheezing, difficulty breathing, loss of appetite, rash, and whether the mother thought the baby was sick. Every 2 weeks, up to age 18 months, an interviewer telephoned the mother to review the calendar diary for the subject's symptoms. During this call, the interviewer also determined whether the infant had attended day care during the previous week, and, if so, the number of hours and the number of children present. The interviewer also asked whether the infant was being breastfed, and, if so, whether breast milk was the only source of milk in the diet (full breastfeeding) or whether the infant received other milk in addition to breast milk (partial breastfeeding). Breastfeeding status was determined at each telephone interview until a previously breastfed infant no longer received any breast milk.

Illness events were defined, by using standard criteria (21), as the calendar diary report of at least 2 consecutive days of any of the following: runny or stuffy nose, wet cough, dry cough, wheeze, or trouble breathing. The illness event ended with 2 symptom-free days. Illness events were further classified as URI (2 or more consecutive days of runny or stuffy nose, dry cough, or trouble breathing) or LRI (2 or more consecutive days of any upper respiratory symptoms and either wet cough or wheezing or both for at least 1 day by calendar diary report). Duration was calculated for each illness. The comparability of this surveillance system in comparison with conventional clinical evaluation and diagnoses has been reported (22).

Data analysis

Although data were collected for 18 months, this analysis focused on the first 6 months of life, when breastfeeding is expected to have its greatest effect. The breastfeeding status of the infant was classified for each 2-week follow-up interval (see below) as fully breastfed, partially breastfed, or not breastfed. A parent was classified as having asthma on the basis of his or her self-report. Parents were classified as atopic on the basis of a questionnaire report of having had hay fever or desensitization injections. The high-risk season was the 4 months of each year of the study with the largest number of respiratory syncytial virus isolates.

Calculation of incidence rates

Incidence rates of the various types of illness were calculated as the ratio of the number of events to the number of days at risk, excluding days with illness in progress and days when the subject was not under surveillance (18). Days with an LRI in progress were excluded from the days at risk for URI. Rates are expressed on an annualized basis, reflecting 365 days at risk. This approach was used so that the rates could
be compared across categories. Confidence intervals for the rates were calculated by using an estimate of the standard error based on the Poisson distribution (23). Because of interdependence of the illness events, standard errors are likely to be underestimated and confidence intervals inappropriately narrow.

**Duration of illness**

Duration of illness was measured from the onset of symptoms to the last day of symptoms followed by 2 symptom-free days.

**Multivariate analysis**

Multivariate methods were used to control for potential confounding factors and to test for effect modification. In analyses of determinants of incident illnesses, the outcome variable was the occurrence of illness during 2-week, at-risk intervals. An at-risk interval was defined as a 2-week interval of follow-up time preceded by 2 days free of any respiratory tract illness. Breastfeeding status for each 2-week interval was classified on the basis of the surveillance call covering the first day of the interval.

**Variables**

The independent variables considered in the multivariate analysis included the fixed factors of birth order (firstborn, not firstborn), sex, ethnicity (Hispanic, non-Hispanic), parental asthma, parental atopy, household income (less than $10,000, $10,000-$40,000, greater than $40,000), and maternal education (12 years or less, 13–15 years, 16 years or more). Temporally varying factors were age (0–2 months, 3–4 months, 5–6 months), season as six 2-month groups, day-care attendance (none, 1–4 hours with no other children, 1–4 hours with 1–5 other children, 1–4 hours with 6 or more other children, 5 or more hours with no other children, 5 or more hours with 1–5 other children, 5 or more hours with 6 or more other children), and breastfeeding (none, partial, full). The classification of day-care attendance for the 2-week interval was based on the report for the week prior to the telephone call. Dependent variables included the occurrence of any respiratory illness, any URI, and any LRI.

Full details of the analytic strategy have been reported (18). The final analyses were performed by using the generalized estimating equation approach described by Zeger and Liang (24) that takes into account the correlation structure in estimating regression coefficients and their standard errors. We also used the generalized estimating equation approach to assess the effect of breastfeeding on illness duration after controlling for other factors. The logarithm of the duration minus 1 day was used as the dependent variable. Therefore, the antilogarithm of the model coefficient estimates the ratio of illness duration (less 1 day) for two categories, for example, fully breastfed compared with not breastfed.

All analyses were performed using the SAS software (25). The generalized estimating equations were applied using a SAS program supplied by Dr. Scott Zeger, The Johns Hopkins University, Baltimore, Maryland.

**RESULTS**

This analysis used data from 1,202 subjects followed for at least 1 month; of these, 1,051 were followed for at least 6 months. Through the first 6 months of life—the focus of these analyses—there were 13,711 2-week periods at-risk. As anticipated, breastfeeding varied by age, with a declining proportion of fully breastfed infants over the first 6 months of life (figure 1). Breastfeeding patterns also varied with household income, maternal education, and the child's ethnicity and birth-order (table 1). The extent of breastfeeding increased with the levels of maternal education and household income and was less for Hispanics and higher birth-order children. Infants whose parents had a history of atopy or asthma were more likely to be breastfed.

Of the 1,202 infants, 151 were not followed for the full first 6 months of life. In comparison with the 1,051 children followed for the full 6 months, those not followed were more likely to be Hispanic, to live in a household with a lower income, and to have a mother under age 25 years with a high school education or less.
During the first 6 months of life, the study subjects had 2,828 URI and 1,246 LRI, 976 (78 percent) with wet cough alone and 270 (22 percent) with wheezing. Only 11.3 percent of the participants did not have a URI during the first 6 months of life; 62.5 percent had at least one LRI, and 30.9 percent had more than one LRI. Across the first 6 months of life, the annualized incidence rates for LRI by breastfeeding status were 2.8 for not breastfed, 2.6 for partially breastfed, and 2.1 for fully breastfed infants. By age groups, fully breastfed infants had lower annualized rates of LRI during the first 4 months of life (table 2). The annualized incidence rates for URI were 5.8 for infants who were not breastfed and 6.5 for both partially breastfed and fully breastfed infants. Thus, the incidence rates for all respiratory illnesses combined were similar for the infants who were not breastfed and those who were fully breastfed. There was no effect of breastfeeding on illness occurrence in infants after 6 months of age.

We used the generalized estimating equation approach to estimate the effect of breastfeeding during the first 6 months on risks for all respiratory illnesses and for URI and LRIs alone. After adjustment for potential confounding factors, breastfeeding did not have a significant effect on the risk for total respiratory illness (table 3). However, full breastfeeding was associated with a significant reduction in risk of LRI. The odds ratios were comparable for LRIs with wet cough (odds ratio (OR) = 0.78, 95 percent confidence interval (CI) 0.65–0.93) and for LRIs with wheezing (OR = 0.84, 95 percent CI 0.56–1.26). The risk of URI was increased by breastfeeding, but the increase was not statistically significant.

We further examined the effect of breastfeeding on LRI incidence to determine whether the protective effect varied with plausible modifying factors (table 2).
Breastfeeding and Respiratory Illnesses

TABLE 3. Adjusted odds ratios* and 95% confidence intervals for incidence of respiratory illnesses in infants under age 6 months, Albuquerque, New Mexico, 1988–1992

<table>
<thead>
<tr>
<th>Illness type</th>
<th>Partial vs. no breastfeeding</th>
<th>Full vs. no breastfeeding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adjusted OR†</td>
<td>95% CI†</td>
</tr>
<tr>
<td>Upper</td>
<td>1.11</td>
<td>0.98–1.27</td>
</tr>
<tr>
<td>Lower</td>
<td>0.95</td>
<td>0.78–1.16</td>
</tr>
<tr>
<td>All</td>
<td>1.05</td>
<td>0.93–1.19</td>
</tr>
</tbody>
</table>

* Reference category is no breastfeeding. Odds ratios adjusted for birth order, sex, age, ethnicity, parental asthma and atopy history, household income, maternal education, and day care attendance.
† OR, odds ratio; CI, confidence interval.

4). We found consistent protection for full breastfeeding across strata of demographic factors, subject characteristics, parental history of asthma and atopy, and season. For partial breastfeeding, the odds ratios did not indicate strong evidence for protection. Incidence rates of LRI varied by season of the year. The odds ratios for full breastfeeding compared with no breastfeeding in the high-risk season (OR = 0.82, 95 percent CI 0.65–1.03) and in the low-risk season (OR = 0.76, 95 percent CI 0.61–0.96) demonstrated that breastfeeding had a similar protective effect against LRI in both. The effect of breastfeeding did vary by age, tending to be greater in the first 4 months of life (figure 2).

Because breastfeeding altered the distribution of illnesses between the categories of upper and lower respiratory illness, we compared the duration of all illnesses by breastfeeding status at the time of illness (figure 3). During the first 6 months of life, the median duration of illness was 5 days with full breastfeeding in comparison with medians of 6 days for infants who were not breastfed or partially breastfed; the corresponding means were 7.8 days for infants fully breastfed, 8.9 days for those who were partially breastfed, and 8.8 days for those who were not breastfed. We also used the generalized estimating equation approach to confirm the effect of breastfeeding on illness duration after controlling for other factors. After adjustment for potential confounding factors, full breast-

TABLE 4. Adjusted odds ratios* and 95% confidence intervals for incident LRI† stratified by characteristics of the infants, their mothers, and the households, Albuquerque, New Mexico, 1988–1992

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Partial vs. no breastfeeding</th>
<th>Full vs. no breastfeeding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adjusted OR†</td>
<td>95% CI†</td>
</tr>
<tr>
<td>Household income (dollars)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$10,000</td>
<td>0.77</td>
<td>0.41–1.44</td>
</tr>
<tr>
<td>$10,000–$39,000</td>
<td>1.00</td>
<td>0.79–1.26</td>
</tr>
<tr>
<td>≥$40,000</td>
<td>0.91</td>
<td>0.60–1.37</td>
</tr>
<tr>
<td>Infant's ethnicity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>1.27</td>
<td>0.92–1.75</td>
</tr>
<tr>
<td>non-Hispanic</td>
<td>0.80</td>
<td>0.63–1.01</td>
</tr>
<tr>
<td>Birth order</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Firstborn</td>
<td>0.95</td>
<td>0.66–1.35</td>
</tr>
<tr>
<td>Not firstborn</td>
<td>0.97</td>
<td>0.77–1.23</td>
</tr>
<tr>
<td>Infant's gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>0.78</td>
<td>0.58–1.06</td>
</tr>
<tr>
<td>Female</td>
<td>1.08</td>
<td>0.83–1.39</td>
</tr>
<tr>
<td>Maternal education (years)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤12</td>
<td>1.41</td>
<td>1.00–2.00</td>
</tr>
<tr>
<td>13–15</td>
<td>0.81</td>
<td>0.61–1.08</td>
</tr>
<tr>
<td>≥16</td>
<td>0.73</td>
<td>0.52–1.04</td>
</tr>
<tr>
<td>Parental history</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asthma</td>
<td>0.95</td>
<td>0.57–1.57</td>
</tr>
<tr>
<td>Atopy, no asthma</td>
<td>0.95</td>
<td>0.69–1.30</td>
</tr>
<tr>
<td>No asthma or atopy</td>
<td>0.93</td>
<td>0.70–1.24</td>
</tr>
</tbody>
</table>

* Reference category is no breastfeeding. Odds ratios adjusted for other factors, except the stratified variable. See table 3 for variables in the model.
† LRI, lower respiratory illness; OR, odds ratio; CI, confidence interval.

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feeding was associated with shorter duration of all respiratory illnesses combined during the first 6 months of age (OR = 0.90, 95 percent CI 0.83–0.98).

To determine whether there was protection of breastfed children beyond the time of actual breastfeeding, we compared the annualized incidence rates of LRI at ages 7–12 months among infants who had been fully breastfed during the first 6 months of life, regardless of breastfeeding during months 7–12, with that among infants of the same age not breastfed at all during the first 6 months; the rates were 3.1 and 2.8 per year, respectively. This finding gives no evidence of protection against LRI beyond the breastfeeding period itself.

DISCUSSION

Because the effects of breastfeeding can be evaluated only by observational methods, studies of the relation between breastfeeding and illnesses are subject to potential limitation by misclassification of exposure and outcome and by confounding. Bauchner et al. (15) listed four standards for evaluation of breastfeeding studies in relation to these limitations: avoidance of detection bias, definition of the outcome event (e.g., respiratory illnesses), definition of breastfeeding, and adjustment for potential confounding factors. In this study, we limited detection bias, i.e., information bias, through prospective, frequent, standardized surveillance of all subjects. We categorized breastfeeding according to specified criteria and ascertained the breastfeeding status of each participant on a 2-week basis. We assessed respiratory symptoms every day by using a symptom diary and categorized symptoms into illnesses and validated the agreement between calendar diary-defined illnesses and diagnoses made by clinicians (22). We gathered information on potential confounding factors and used multivariate statistical models to adjust for these factors. By restricting participants to infants from households without smokers, we eliminated the possibility of confounding by exposure to environmental tobacco smoke, also a cause of LRI (26).

Although our study met the standards offered by Bauchner et al. (15), the findings should not be extended to all infants because of the selection criteria for study participants. The infants who were excluded from our study, those living in homes with smokers or attending day care on a full-time basis, are now a majority of US infants. It is possible that our cohort was at lower risk than the infants excluded by these criteria and that the effect of breastfeeding would be different in infants at higher background risk.

We found that the overall incidence of respiratory illnesses, including URIs and LRIs, was not affected by breastfeeding (tables 2 and 3). However, breastfed infants had fewer illnesses classifiable as LRIs during the first 4 months of life (figure 2). LRIs were of shorter duration in breastfed infants, but the difference in duration was not statistically significant. The duration of all respiratory illnesses combined was significantly shorter in infants who were fully breastfed (figure 3). We interpret this pattern of reduced incidence of LRIs and shorter duration of all respiratory illnesses as evidence that breastfeeding reduces the severity of respiratory illnesses without lowering the incidence. Other studies of breastfeeding have focused on the incidence of illnesses and have used classification schemes that were not sufficiently precise to examine transfers from one diagnostic category to an-
other, as from URI and LRI. Other studies have not addressed the effect of breastfeeding on illness duration.

Our findings are consistent with others in regard to the reduction of LRI by breastfeeding and the age dependence of the effect of breastfeeding. In the Tucson Children's Respiratory Study, breastfeeding reduced the risk of all LRIs (27) and of respiratory syncytial virus-associated LRIs (28), primarily during the first 4 months of life, and breastfeeding was associated with a lower proportion of wheezing illnesses as well. The Tucson Study ascertained respiratory illnesses through contact with a health care provider, and consequently, the incident LRI cases would tend to be more severe than our study. In another prospective cohort study conducted in Scotland, infants breastfed during the first 13 weeks of life had a significantly lower incidence of LRI during the first 13 weeks of life and during weeks 40–52 (29). Most studies having sufficiently large numbers of infants showed protection against LRIs (27), particularly illnesses due to respiratory syncytial virus (9, 28).

Duncan et al. (30) found that infants who were fully breastfed for 4 months had half as many episodes of acute otitis media as did infants who were not breastfed. In a retrospective study of Pima Indian children, breastfeeding provided protection through age 8 months against having medical care for an URI or otitis media (31). We did not find an effect of breastfeeding on URIs at any age and did not ascertain otitis media in this study.

The consistency of our findings with those of these earlier reports suggests that the benefits of breastfeeding vary with age and do not extend beyond the first 6 months of life. This age pattern may reflect the relatively larger proportion of total dietary intake received as breast milk during the first months of life and the higher concentration of immunoglobulin A, the major component of local mucosal immunity, early in lactation (32).

We did not find persistent benefit beyond age 6 months for breastfed children or any indication that the reduced illness risk during the initial months of life was followed by either subsequent benefit or increased risk.

The weight of evidence from this and other studies is that infants less than 6 months old have fewer LRIs if they are fully breastfed than if they are not. For this reason, among others, promotion of breastfeeding is a worthwhile strategy for prevention of LRIs in young infants, the age group most likely to require hospitalization (33) and to suffer long-term consequences of such illnesses (34).

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The contents of this report do not reflect the views of the Health Effects Institute, nor do they reflect the policies of the Environmental Protection Agency, automobile manufacturers, or the Gas Research Institute.

REFERENCES


