Breastfeeding and the Risk of Postneonatal Death in the United States

Aimin Chen, MD, PhD; and Walter J. Rogan, MD

ABSTRACT. Objective. Breastfed infants in the United States have lower rates of morbidity, especially from infectious disease, but there are few contemporary studies in the developed world of the effect of breastfeeding on postneonatal mortality. We evaluated the effect of breastfeeding on postneonatal mortality in United States using 1988 National Maternal and Infant Health Survey (NMIHS) data.

Methods. Nationally representative samples of 1204 infants who died between 28 days and 1 year from causes other than congenital anomaly or malignant tumor (cases of postneonatal death) and 7740 children who were still alive at 1 year (controls) were included. We calculated overall and cause-specific odds ratios for ever/never breastfeeding among all children, conducted race and birth weight–specific analyses, and looked for duration–response effects.

Results. Overall, children who were ever breastfed had 0.79 (95% confidence interval [CI]: 0.67–0.93) times the risk of never breastfed children for dying in the postneonatal period. Longer breastfeeding was associated with lower risk. Odds ratios by cause of death varied from 0.59 (95% CI: 0.38–0.94) for injuries to 0.84 (95% CI: 0.67–1.05) for sudden infant death syndrome.

Conclusions. Breastfeeding is associated with a reduction in risk for postneonatal death. This large data set allowed robust estimates and control of confounding, but the effects of breast milk and breastfeeding cannot be separated completely from other characteristics of the mother and child. Assuming causality, however, promoting breastfeeding has the potential to save or delay ~720 postneonatal deaths in the United States each year. Pediatrics 2004;113:e435–e439. URL: http://www.pediatrics.org/cgi/content/full/113/5/e435; breastfeeding, infant mortality, cause of death, risk, logistic models.

ABBREVIATIONS. SIDS, sudden infant death syndrome; NMIHS, National Maternal and Infant Health Survey; OR, odds ratio; CI, confidence interval.

In developing countries, breastfeeding protects against diarrhea and respiratory diseases, important causes of infant death. In contemporary developed countries, however, where infectious diseases account for a smaller portion of infant mortality, what effect, if any, breastfeeding has on mortality is not clear. There is a large literature on the benefits to the child and the mother of breastfeed-

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Received for publication Sep 8, 2003; accepted Dec 22, 2003.

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http://www.pediatrics.org/cgi/content/full/113/5/e435

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most such deaths are attributable to preterm birth or congenital anomalies; we also excluded deaths from congenital anomaly or malignancy occurring in the postneonatal period.

METHODS

Subjects

The 1988 NMIHS is a nationally representative stratified systematic sample of 9953 women who had live births, 3309 who had late fetal deaths (28 weeks' gestation or more, including term stillborn and 539 who had infant deaths (liveborn child who died by 1 year of age) in 1988.22 These live births and infant deaths were from 48 states (none from Montana or South Dakota), the District of Columbia, and New York City. Black infants were oversampled in all 3 components of the NMIHS, and very low birth weight (<1500 g) and moderately low birth weight (1500–2499 g) infants were oversampled in the live birth component. Vital events to unmarried mothers in Arizona, Kansas, and North Dakota were excluded. Only live births and infant deaths are included in our analysis. The final sample for analysis, containing 1204 postneonatal deaths (cases) and 7740 live births (still alive and ≥1 year old at survey; controls), is shown in Fig 1.

Mothers answered a mailed questionnaire on characteristics of the parents, previous and subsequent pregnancies, prenatal care and health habits, and the infant’s health. Information from the birth certificate and death certificate was also included in the data set. Women whose infant died before 1 month or did not live with her at any time after birth were not asked the breastfeeding questions. The answer “yes” or “no” to the question, “Did you ever breastfeed this infant?” was defined as “ever breastfed” or “never breastfed” in the analysis. The duration of breastfeeding is from the answer to the question, “How old was your infant when you stopped breastfeeding?”

Causes of postneonatal death (International Classification of Diseases, Ninth Revision) were obtained from death certificates. For some analyses, we divided the deaths into 4 categories: infections, injuries, SIDS, and others (Table 1).

Statistics

We used logistic regression to calculate the odds ratio (OR) of ever having breastfed to never having breastfed for postneonatal death. We first considered all postneonatal deaths as cases and the live births as controls. We then duplicated the analysis using cases from each of 4 cause-of-death categories, whereas the controls remained unchanged. Race and birth weight are so strongly related to breastfeeding that we did analyses separately by race and birth weight category. Covariates included mother’s age, education, smoking during pregnancy, and participation in the federal nutritional support program for Women, Infants, and Children; and infant’s gender, race, birth weight, congenital malformation, reported at birth, live birth order, and single or multiple birth. The race- and birth weight–specific analyses did not include race or birth weight terms. We also did proportional hazard models to calculate the hazard ratio for ever breastfeeding in cases only to determine whether breastfeeding delayed death even among infants who died.

We were interested in determining whether prolonged breastfeeding had greater effects. Because these are case-control data, however, we cannot simply put breastfeeding duration in the logistic model, because the opportunity for the case infants to breastfeed extends only to their age at death, whereas the controls can breastfeed for up to 1 year. So, unless the case infants died very late in the infancy (clearly not true in this study), their opportunity for prolonged breastfeeding was significantly compromised. We addressed this problem by doing an analysis using the model described above but limiting the case group to those who had survived 3 months or more and using 3 months of breastfeeding versus <3 months or none in place of the ever/never breastfed variable. This equalizes the opportunity to breastfeed at 3 months in the cases and controls, at a cost of reduced sample size among the cases. We then can compare the OR of ever breastfeeding with the OR of breastfeeding for 3 months or more. We used SAS 8.2 (SAS, Inc, Cary, NC) for preliminary tabula-

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**TABLE 1.** Causes of Postneonatal Death in the 1988 NMIHS (Excluding Malignancy and Congenital Anomalies)

<table>
<thead>
<tr>
<th>Postneonatal Death Causes and ICD-9 Codes</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infections (n = 255)</td>
<td></td>
</tr>
<tr>
<td>001–139 Infectious and parasitic diseases</td>
<td>47</td>
</tr>
<tr>
<td>240–279 Endocrine, nutritional, and metabolic diseases and immunity disorders</td>
<td>1</td>
</tr>
<tr>
<td>320–389 Meningitis and other diseases of the nervous system and sense organs</td>
<td>56</td>
</tr>
<tr>
<td>460–519 Diseases of the respiratory system</td>
<td>124</td>
</tr>
<tr>
<td>520–579 Diseases of the digestive system</td>
<td>27</td>
</tr>
<tr>
<td>Injuries (n = 126)</td>
<td></td>
</tr>
<tr>
<td>E800–E999 Injury and poisoning</td>
<td>126</td>
</tr>
<tr>
<td>SIDS (n = 591)</td>
<td></td>
</tr>
<tr>
<td>798.0 Sudden infant death syndrome</td>
<td>591</td>
</tr>
<tr>
<td>Others and unknown (n = 232)</td>
<td></td>
</tr>
<tr>
<td>280–289 Diseases of the blood and blood-forming organs</td>
<td>3</td>
</tr>
<tr>
<td>760–779 Certain conditions originating in the perinatal period</td>
<td>30</td>
</tr>
<tr>
<td>780–797, 798.1–799 Symptoms, signs, and all other ill-defined conditions</td>
<td>87</td>
</tr>
<tr>
<td>Unknown</td>
<td>112</td>
</tr>
</tbody>
</table>

ICD-9 indicates International Classification of Diseases, Ninth Revision.

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Fig 1. Samples for analysis from the 1988 National Maternal and Infant Survey. Of 499 subjects without breastfeeding information in infant death group, 323 answered “No” to the question, “Was the baby at home with mother at any time after delivery?”, 78 had no available answer, and another 48 answered “Yes” but did not provide information regarding breastfeeding. Of 198 subjects without breastfeeding information in the live birth group, 100 answered “No” to the question, 37 had no available answer, and another 61 answered “Yes” but did not provide information regarding breastfeeding. N/A denotes not available.
RESULTS

As seen in Table 2, after adjustment with SUDAAN, cases and controls differ on all covariates of interest. Mothers of the children who died are younger, are less educated, and smoke more often during pregnancy. The children who died had a higher birth order and were more often male, black, and of low birth weight. There remained an excess of children with congenital anomalies among the cases, although children who died by 28 days or who died of their congenital anomaly or a malignant tumor were excluded. Age at death is shown in Fig 2. Most children who died did so before they had completed 4 months of life.

After adjustment for sampling strategy with SUDAAN, 53% of control infants were ever breastfed, compared with 38% of cases. Logistic regression models showed an OR of 0.79 (95% CI: 0.67–0.93) for ever breastfed (Table 3). Race-specific analyses gave similar estimates for the OR, although the proportion ever breastfed was much lower in black infants. For the low birth weight infants, the OR of ever breastfed was 0.97 (95% CI: 0.64–1.47). The estimates from logistic models changed only slightly by category of cause of death (Table 3). The overall risk estimate changes little even when we include deaths as a result of an underlying congenital anomaly (n = 212) or malignant tumor (n = 10); the OR for overall postneonatal death was 0.74 (95% CI: 0.63–0.87). Among cases only, a proportional hazard model showed that the risk of death at any specific time was marginally lower in the ever breastfed infants (hazard ratio: 0.91; 95% CI: 0.79–1.06).

In addition to the covariates adjusted in the models, we examined possible confounding from cesarean section. We found no difference in SUDAAN adjusted proportion of cesarean section between cases (20.2%) and controls (18.3%). Cesarean section did not affect the percentage of ever breastfeeding in either cases or controls and had no effect on the estimate of the strength of the effect of breastfeeding when it was included in the models. For duration of breastfeeding, comparing cases who survived 3 months (n = 691 in original sample and n = 5363 after adjustment with SUDAAN) and all controls, 3 months or more of breastfeeding showed an OR of 0.62 (95% CI: 0.46–0.82), less (ie, more protective) than the OR for ever/never breastfed (0.79; 95% CI: 0.67–0.93).

DISCUSSION

Breastfed children have a decreased risk of postneonatal death in the United States, although infectious diseases, those most plausibly prevented by...
Forste analysis (1988 and 1995). An estimate adjusting for race, birth weight, and breastfeeding. We examined the 1995 National Survey of Family Growth data, which formed half of the basis of the study, and the oversampling among black infants allows reasonably precise and robust estimates for them specifically. We found that breastfeeding represents a package of skills, abilities, and emotional attachments that mark families whose children were ever breastfed live marginally longer. This is a very large data set, representative of the US population, albeit in 1988. Because postneonatal mortality in the United States has declined from 3.6/1000 in 1986 to 2.3/1000 in 2000, a prospective study now would need to enroll >60 000 newborns and follow them for 1 year to approach the power and precision of these data. Familiar confounders can be accounted for in the analysis, and the oversampling among black infants and premature infants allows reasonably precise and robust estimates for them specifically. We see a more modest benefit than Forste; who observed a remarkably strong protective OR of 0.2 in a model with only race, birth weight, and breastfeeding. We examined the 1995 National Survey of Family Growth data, which formed half of the basis of the Forste analysis (1988 and 1995). An estimate adjusting for most covariables used in our study gives an OR of ~0.7 for breastfeeding and all-cause postneonatal mortality, comparable to our estimate in this study. Carpenter did not give an OR for his UK study, but it is possible to estimate an OR of 0.4 from the published data. Because Carpenter used a set of causes of death (what he termed “preventable death”) that are not readily extractable from International Classification of Diseases, Ninth Revision coded death certificates and deaths out to 2 years of age, we cannot compare our estimate directly with his.

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Is it plausible that breastfeeding protects not only against infectious disease mortality, through familiar immune enhancing mechanisms, but also against SIDS, accidental death, and others? Although a satisfactory mechanism has not yet been proposed, the protection from SIDS has been seen in several studies and is under investigation. For accidental death, Carpenter also observed lower risk, and although the association may represent something as simple as reverse causality, produced by the motivation or enthusiasm that marks a healthier child who can breastfeed or by specific characteristics of the child’s illness, such as cleft palate and breathlessness during sucking, that prevent breastfeeding might produce an artificial benefit of breastfeeding. Eliminating deaths in the first month and deaths from congenital anomaly or malignant tumor, where infants who are unable to breastfeed are concentrated, and using the initial feeding method to categorize feeding should diminish but perhaps not eliminate this problem. However, excluding these deaths also excludes the chance to examine whether breastfeeding has any effects on these deaths, especially those who are not fatally ill at birth. In a prospective study, it might be possible to include neonatal deaths if careful attention were paid to the reason that a child was breastfed or not. We do not have such data; however, we can eliminate from the analysis any child, case or control, who was admitted to the neonatal intensive care unit. This yields a similar but less precisely estimated OR of 0.83 (95% CI: 0.67–1.03). The NMIHS data are from cases and controls and depend on interviews done after the child had survived.
duced or not. There thus is opportunity for recall bias, if women report their feeding methods differently depending on whether the child survived. To produce the results that we see would require substantial underreporting of breastfeeding by mothers of children who died, which does not seem likely. For the analysis of duration, the case control data do not allow direct estimation of a duration effect, because the cases and controls have different opportunities to breastfeed for longer periods. When we limit the analysis to cases who survived at least 3 months and look at the effect of 3 months or more of breastfeeding, however, we see an increase in the protective effect, consistent with the idea that longer breastfeeding is more protective.

If more US mothers can be persuaded to breastfeed and indeed it is breastfeeding that accounts for the benefits, then the United States might improve its poor ranking among industrialized countries for postneonatal death. In 1986, 2 years before these data were collected, the United States ranked 16th (3.6/1000) in postneonatal death, well below Finland (first; 1.8/1000) and Sweden (second; 2.0/1000). The US breastfeeding prevalence in 1986 was 57% at birth and 22% at 6 months, whereas in Finland and Sweden, the prevalence at 6 months then was still ~60% and 50%, respectively. Although the United States still trails the Nordic countries both in breastfeeding and in postneonatal mortality, the US rate of postneonatal death has fallen steadily between the late 1980s and now, and breastfeeding has increased. In 2001, 70% of mothers left the hospital breastfeeding, and 33% were still breastfeeding at 6 months. If we assume that the risk structure has not changed as the overall rates have fallen, then the overall postneonatal mortality rate, a weighted average of the rate among those who were breastfed and those who were not, consists of 70% of children who are breastfed when they leave the hospital and who have a rate of 2.1 per 1000, and 30% of children who are not breastfed and have a rate of 2.7. If all children were breastfed, then it should prevent 1.8 postneonatal deaths per 10,000 live births. Because there are ~4 million births per year, 720 postneonatal deaths might be prevented or delayed each year at little cost.

ACKNOWLEDGMENTS

We thank the National Center for Health Statistics at the Centers for Disease Control and Prevention for providing the 1988 NHIS data set for this analysis. We also thank Dr. Haibo Zhou at University of North Carolina at Chapel Hill for comments on statistical analysis and Drs. Allen J. Wilcox and David M. Umbach at the National Institute of Environmental Health Sciences for comments on an earlier version of the manuscript.

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DOI: 10.1542/peds.113.5.e435

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