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Full Breastfeeding Duration and Associated Decrease in Respiratory Tract Infection in US Children

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ABSTRACT

OBJECTIVE. The American Academy of Pediatrics recommends exclusive breastfeeding for an infant's first 6 months of life. When compared with exclusive breastfeeding for 4 months, greater protection against gastrointestinal infection, but not respiratory tract infection, has been demonstrated for the 6-month duration. The objective of this study was to ascertain if full breastfeeding of ≥ 6 months compared with 4 to < 6 months in the United States provides greater protection against respiratory tract infection.

METHODS. Secondary analysis of data from the National Health and Nutrition Examination Survey III, a nationally representative cross-sectional home survey conducted from 1988 to 1994, was performed. Data from 2277 children aged 6 to < 24 months, who were divided into 5 groups according to breastfeeding status, were compared. Children who required neonatal intensive care were excluded. SUDAAN software was used to account for the complex sampling design. Logistic regression adjusted for confounding factors. Outcome measures included adjusted odds of acquiring pneumonia, ≥ 3 episodes of cold/influenza, ≥ 3 episodes of otitis media (OM), or wheezing in the past year or acquiring first OM at < 12 months of age.

RESULTS. In unadjusted analyses, infants who were fully breastfed for 4 to < 6 months ($n = 223$) were at greater risk for pneumonia than those who were fully breastfed for ≥ 6 months ($n = 136$) (6.5% vs 1.6%). There were not statistically significant differences in ≥ 3 episodes of cold/influenza (45% vs 41%), wheezing (23% vs 24%), ≥ 3 episodes of OM (27% vs 20%), or first OM at < 12 months of age (49% vs 47%). Adjusting for demographic variables, childcare, and smoke exposure revealed statistically significant increased risk for both pneumonia (odds ratio [OR]: 4.27; 95% confidence interval [CI]: 1.27–14.35) and ≥ 3 episodes of OM (OR: 1.95; 95% CI: 1.06–3.59) in those who were fully breastfed for 4 to < 6 months compared with ≥ 6 months.

CONCLUSIONS. This nationally representative study documents increased risk of respiratory tract infection including pneumonia and recurrent OM in children who were fully breastfed for 4 vs 6 months. These findings support current recommendations that infants receive only breast milk for the first 6 months of life.

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Key Words

breastfeeding, benefits, respiratory infections, infant feeding, nutrition-infant

Abbreviations

WHO—World Health Organization
URI—upper respiratory infection
OM—otitis media
NHANES—National Health and Nutrition Examination Survey
ROM—recurrent otitis media
OM < 12 —otitis media at < 12 months of age
FullBF < 1 —fully breastfed for < 1 month
FullBF1–3—fully breastfed for 1 to < 4 months
FullBF4–5—fully breastfed for 4 to < 6 months
FullBF ≥ 6 —fully breastfed for ≥ 6 months
OR—odds ratio
CI—confidence interval
no BF—not breastfed

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BREASTFEEDING BENEFITS HAVE been demonstrated in multiple studies to be dose-responsive or, in other words, related to the amount of breast milk received.¹⁻⁵ For example, fully breastfed infants have been shown to have lower overall illness rates, whereas minimal breastfeeding has not been found to be protective.¹ Breastfeeding duration also affects child morbidity. A recent comprehensive review of the world literature to determine health benefits of exclusive breastfeeding for 6 months compared with exclusive breastfeeding for 3 to 4 months noted a decrease in the risk of gastrointestinal infection even in developed settings.² No study, however, has documented a decrease in the risk of respiratory infection with 6 compared with 4 months of exclusive breastfeeding. Currently, most national and international authorities, including the American Academy of Pediatrics,⁶ American Academy of Family Physicians,⁷ World Health Organization (WHO),⁸ and United Nations Children's Fund,⁹ recommend 6 months of exclusive breastfeeding.

In 2001, the WHO changed their recommendations from 4 to 6 months of exclusive breastfeeding, in part, on the basis of a study in Belarus that noted decreased gastrointestinal morbidity with 6 months of exclusive breastfeeding,¹⁰ combined with the estimate that up to 55% of infant deaths worldwide annually are from diarrheal disease, acute respiratory infections, and other infectious diseases that are attributed to inappropriate feeding practices.^{5,11} At that time, the WHO noted a paucity of evidence regarding both benefits and risks of 4 vs 6 months of exclusive breastfeeding and called for more research.⁸ This study was undertaken to investigate whether the longer duration of exclusive breastfeeding provides children additional protection against acute respiratory illnesses in a developed country such as the United States. Specifically, the objective of this study was to evaluate whether 4 to <6 months compared with ≥ 6 months of full (exclusive or almost exclusive¹²) breastfeeding is an independent risk factor for respiratory tract disease, including pneumonia, wheezing, early otitis media (OM), and recurrent bouts of upper respiratory tract infections (URIs) and OM in a nationally representative sample of children.

METHODS

Secondary analysis of data from the third National Health and Nutrition Examination Survey (NHANES III),¹³ a population-based cross-sectional survey of US household residents aged ≥ 2 months that was conducted from 1988 to 1994, was performed. NHANES was designed to be nationally representative of the noninstitutionalized, civilian population. A household youth questionnaire collected information on children who were ≤ 16 years and was administered to a proxy respondent, usually the child's parent or guardian. For this study, data on respiratory tract infections were com-

pared for children aged 6 to <24 months ($N = 2277$) by breastfeeding status. The duration of full breastfeeding, defined in this study as receiving nothing other than breast milk on a daily basis, was the breastfeeding variable considered. Standard definitions of breastfeeding¹² divide full breastfeeding into 2 subcategories: exclusive (child has never received any food or liquid other than breast milk) and full almost exclusive (child has received occasional but does not receive other foods/liquids on a regular or daily basis). We chose full breastfeeding because it more accurately represents the period of time during which breast milk is the overwhelming majority of the diet.

The reported number of episodes of pneumonia, colds or influenza, and wheezing or whistling in the past 12 months was used to identify respiratory tract infections. In addition, the number of and age at first ear infection or earache were used as indicators of OM. The percentage of children with pneumonia, ≥ 3 episodes of cold or "influenza" (recurrent URI), ≥ 3 episodes of OM (recurrent OM [ROM]), or wheezing in the past 12 months or experiencing the first episode of OM before 12 months of age (OM<12) were compared for 5 groups: formula fed only ($n = 1149$) or full breastfeeding for <1 month (FullBF<1; $n = 426$), 1 to <4 months (FullBF1-3; $n = 343$), 4 to <6 months (FullBF4-5; $n = 223$), and ≥ 6 months (FullBF ≥ 6 ; $n = 136$). Children with a history of admission to the NICU were excluded. Identical analyses were performed for children who were 6 to <72 months of age ($N = 6548$). The sample sizes of the 5 groups with this greater age range are as follows: formula fed only ($n = 3464$), FullBF<1 ($n = 1101$), FullBF1-3 ($n = 902$), FullBF4-5 ($n = 561$), and FullBF ≥ 6 ($n = 520$).

Taylor linearization using SUDAAN software accounted for stratum and primary sampling units in the complex sampling design of the NHANES.¹⁴ Logistic regression was used to adjust for potentially confounding demographic and lifestyle variables. Variables that were assessed for inclusion in this analysis include age, birth weight, gender, race/ethnicity (white, black, Mexican American, or other), poverty index (family income divided by the federal poverty level), household composition (1 vs 2 parents and family size [used as a surrogate for number of siblings]), childcare ≥ 10 hours/week, head-of-household education, and exposure to cigarette smoke (none, postnatal only, prenatal only, or both prenatal and postnatal). For the outcome of wheezing, a history of parental atopy (asthma or hay fever) was also included. Variables were included in the regression model if they have been previously demonstrated to affect respiratory tract infections (smoke exposure) or because they were associated in the bivariate analysis at a significance level of $P \leq .10$ with the respiratory outcome under analysis. Analyses were performed controlling for smoke exposure in 2 manners: (1) 1 variable with 4 levels of smoke exposure as noted above (both

exposures, only prenatal, only household, and neither exposure) and (2) as 2 distinct variables (prenatal and household exposure).

Unless otherwise stated, results are given using FullBF \geq 6 as the referent. Adjusted odds ratios (ORs) with 95% confidence intervals (CIs) are reported for all demographic and lifestyle variables included in the model for a specific respiratory outcome. Reported *P* values are 2-sided; *P* < .05 was considered statistically significant.

RESULTS

Median durations of full breastfeeding in the 4 breastfed groups were 7 days (FullBF<1), 61 days (FullBF1-3), 122 days (FullBF4-5), and 182 days (FullBF \geq 6). Demographic characteristics of the 5 groups of children aged 6 to <24 months are shown in Table 1. There were minimal differences in age and gender among the groups, but children in the FullBF \geq 6 group had greater mean birth weight compared with the other groups. In accordance with usual breastfeeding patterns in the United States,^{15,16} infants who were not breastfed (no BF) were of lower socioeconomic status, lived in households with less educated adults, were more likely to be black and less likely to be white, and were less likely to live in 2-parent households than those in the FullBF \geq 6 group. Infants in the no-BF group were also more likely to experience passive smoke exposure. Similarly, children in the FullBF<1 group were less likely to be white, more likely to be Mexican American, and more likely to live in

less-educated and single-parent households than those in the FullBF \geq 6 group. Other than birth weight as noted above, there were no statistically significant differences between the FullBF1-3, FullBF4-5, and FullBF \geq 6 groups in any of the variables evaluated.

In unadjusted analyses, infants in the FullBF \geq 6 group were at less risk for having had pneumonia in the past year than those in the FullBF4-6 group (1.6% vs 6.5%; *P* = .017). Additionally, the FullBF1-3 group was more likely to have had the first episode of OM before 1 year of age (61.7% vs 47.2%; *P* = .026) and to have had ROM during the past year than the FullBF \geq 6 group (32.5% vs 20.4%; *P* = .016). Differences between the FullBF \geq 6 and FullBF4-5 groups for other outcomes, incidence of recurrent URI (40.8% vs 45.3%), wheezing (24.4% vs 22.6%), ROM (20.4% vs 27.3%), and first episode of OM before 1 year of age (47.2% vs 49.3%), did not reach statistical significance.

Adjusting for demographic and lifestyle variables that are associated with respiratory outcomes demonstrated that infants in the FullBF4-5 group had significantly increased odds of both pneumonia (OR: 4.27; 95% CI: 1.27–14.35) and ROM (OR: 1.95; 95% CI: 1.06–3.59) compared with those in the FullBF \geq 6 group. Children in the no-BF and FullBF1-3 groups were also at significantly greater risk for ROM compared with those in the FullBF \geq 6 group. Additionally, those in the FullBF1-3 group were at significantly increased risk for having the first episode of OM at <1 year compared with the referent group but not compared with the FullBF4-5 group.

TABLE 1 Demographic Characteristics of Children in the NHANES III Aged 6 to <24 Months According to Breastfeeding Status

	No BF (n = 1149)	FullBF<1 (n = 426)	FullBF1-3 (n = 343)	FullBF4-5 (n = 223)	FullBF \geq 6 (n = 136)
Age, %					
6 to <12 mo	35	37	33	35	24
12 to <24 mo	65	63	67	65	76
Gender, %					
Male	51	54	51	50	48
Female	49	46	49	50	52
Race/ethnicity, %					
White	54.7 ^a	61.5 ^a	76.6	77.4	79.3
Black	26.5 ^a	9.3	7.3	7.2	7.8
Mexican American	8.2	16.4 ^a	9.4	6.2	7.2
Other	10.7	12.9	6.7	9.2	5.7
Two-parent household, %	70.6 ^a	84.1 ^a	90.2	88.9	92.6
Child care \geq 10 h/wk	13.7	11.1	22.4	9.3	17.7
Smoke exposure, %					
Prenatal and postnatal	26.7 ^a	12.0	13.0	9.8	6.6
Prenatal only	4.5	3.4	3.3	1.3	2.8
Postnatal only	22.8	11.7	14.4	12.2	14.0
None	46.0 ^a	72.9	69.3	76.6	76.6
Birth weight, mean (SE), kg	3.33 (0.02) ^a	3.42 (0.03) ^a	3.51 (0.03) ^a	3.51 (0.04) ^a	3.64 (0.06)
Poverty index, mean (SE)	1.7 (0.1) ^a	2.5 (0.2)	2.9 (0.2)	2.8 (0.2)	2.8 (0.2)
Head-of-household education, mean (SE), y	11.4 (0.2) ^a	12.6 (0.2) ^a	13.5 (0.2)	13.6 (0.4)	14.1 (0.5)
Family size, mean (SE)	4.4 (0.1)	4.3 (0.1)	4.0 (0.1)	4.1 (0.1)	4.2 (0.1)

^a Statistically significant results.

There were no other statistically significant differences; specifically, risks in the FullBF \geq 6 group were not statistically different for recurrent URI or wheezing compared with any of the other groups. Although failing to reach statistical significance, for each respiratory outcome the adjusted OR is >1.0 for children in the no-BF, FullBF1-3, or FullBF4-5 groups, with the exception of wheezing in those in the FullBF4-5 group.

Adjusted ORs for each variable in the model, including breastfeeding status, are shown in Table 2. It is notable that children in day care were at increased risk and black children were at decreased risk for both OM outcomes and wheezing. Smoke exposure was associated with recurrent URI, ROM, and wheezing. Repeat multivariate analysis with prenatal and household smoke exposure treated independently did not substantively change any of the other associations (data not shown).

Analyses of data from children aged 6 to <72 months of age revealed that for each respiratory outcome other than recurrent URI, the adjusted OR is >1.0 for children in the no-BF, FullBF1-3, or FullBF4-5 groups when adjusting for the same covariates as in the younger age range. As before, the increased risks did not reach statistical significance in most cases. Specifically, there was not a significant decrease in the odds of respiratory tract infections or wheezing within the past year or of acquiring

the first episode of OM at <12 months of age for children in the FullBF \geq 6 group compared with the FullBF4-6 group. Children in the FullBF \geq 6 group were at lower risk of experiencing the first episode of OM before 1 year compared with each of the other breastfeeding groups (no BF, FullBF <1 , and FullBF1-3). However, the risk of acquiring OM in the first year was not decreased in the FullBF4-5 group compared with the FullBF1-3 or no-BF groups. Similarly, the risk for wheezing for those in the FullBF <1 group was greater than the risk for those in the FullBF \geq 6 group (OR: 1.66; 95% CI: 1.05–2.62) but not greater than those in the FullBF1-3 or FullBF4-5 groups. Adjusted ORs for respiratory outcomes according to breastfeeding status in the wider age range are depicted in Table 3.

DISCUSSION

This study documents that full breastfeeding for ≥ 6 months provides greater protection against respiratory tract infection than does full breastfeeding for >4 but <6 months. This protection is independent of other factors that are known to be associated with rates of respiratory illness, including age, smoke exposure, day care, race/ethnicity, family size, education, and socioeconomic status.

Our findings are most convincing for the outcome of ROM in children between the ages of 6 and 24 months,

TABLE 2 Adjusted ORs (95% CIs) for Respiratory Tract Infections in Past Year of Children in the NHANES III Aged 6 to <24 Months

	Pneumonia (n = 2190)	Recurrent URI (n = 2010)	OM <12 (n = 1993)	ROM (n = 1963)	Wheeze (n = 1950)
No BF	2.02 (0.64–6.34)	1.41 (0.74–2.70)	1.57 (0.91,2.71)	2.30 (1.12–4.71) ^a	1.05 (0.60,1.81)
FullBF <1	1.34 (0.39–4.62)	1.49 (0.76–2.92)	1.44 (0.81,2.57)	1.80 (0.88–3.64)	1.41 (0.78,2.57)
FullBF1-3	1.97 (0.53–7.27)	1.34 (0.67–2.69)	1.87 (1.07,3.26) ^a	2.07 (1.12–3.79) ^a	1.07 (0.54,2.12)
FullBF4-5	4.27 (1.27–14.35) ^a	1.53 (0.63–3.68)	1.25 (0.69,2.27)	1.95 (1.06–3.59) ^a	0.98 (0.49,1.96)
FullBF ≥ 6	Referent	Referent	Referent	Referent	Referent
Ethnicity					
White	Referent	Referent	Referent	Referent	Referent
Black	1.09 (0.58–2.03)	0.82 (0.57–1.18)	0.67 (0.052,0.86) ^a	0.55 (0.33–0.91) ^a	0.59 (0.37–0.92) ^a
Mexican American	1.63 (0.86–3.06)	0.89 (0.59–1.34)	0.82 (0.57,1.17)	0.81 (0.53–1.23)	1.37 (0.92–2.04)
Other	0.35 (0.08–1.55)	0.87 (0.54–1.38)	0.68 (0.46,1.02)	0.74 (0.039–1.40)	0.81 (0.43–1.50)
Day care ≥ 10 h/wk	NA	1.48 (0.99–2.22)	2.04 (1.37,3.04) ^a	1.64 (1.11–2.42) ^a	2.93 (2.08–4.14) ^a
Head-of-household education	NA	1.02 (0.96–1.08)	1.02 (0.96,1.08)	1.02 (0.95–1.08)	0.97 (0.92–1.02)
Poverty index	NA	1.14 (1.04–1.26) ^a	1.04 (0.94,1.16)	1.04 (0.93–1.16)	0.89 (0.76–1.05)
Family size	NA	1.02 (0.96–1.09)	NA	0.99 (0.90–1.11)	NA
Smoke exposure					
Prenatal + postnatal	1.10 (0.56–2.14)	0.91 (0.62–1.34)	1.07 (0.73,1.56)	1.48 (1.01–2.16) ^a	1.99 (1.36–2.92) ^a
Prenatal only	2.26 (0.75–6.83)	2.02 (1.10–3.69) ^a	1.29 (0.74,2.27)	1.21 (0.59–2.48)	0.77 (0.35–1.08)
Postnatal only	1.83 (0.91–3.70)	0.82 (0.55–1.21)	0.84 (0.58,1.20)	0.76 (0.46–1.25)	1.07 (0.71–1.62)
None	Referent	Referent	Referent	Referent	Referent
Birth weight, g	0.99 (0.99–0.99) ^a	NA	NA	1.00 (1.00–1.00) ^a	0.99 (0.99–1.00)
Age					
6 to <12 mo	NA	Referent	NA	Referent	NA
12 to <24 mo	NA	2.37 (1.97–2.85) ^a	NA	3.69 (2.82,4.84) ^a	NA
Two-parent household	0.78 (0.44–1.41)	NA	NA	NA	0.67 (0.46,0.98) ^a
Gender, male	NA	1.14 (0.88–1.48)	NA	NA	NA
Parent asthma/hay fever	NA	NA	NA	NA	0.87 (0.66–1.15)

Adjusted for all variables except those indicated by NA (not included in regression model for the corresponding outcome).

^a Statistically significant results.

TABLE 3 Adjusted ORs (95% CIs) of Respiratory Tract Infections in Past Year For Children in the NHANES III Aged 6 to <72 Months

	Pneumonia	Recurrent URI	OM<12	ROM	Wheeze
No BF	2.12 (0.84–5.32)	0.93 (0.68–1.27)	1.40 (1.05–1.87) ^a	1.15 (0.79–1.67)	1.19 (0.80–1.80)
FullBF<1	1.76 (0.48–6.48)	1.33 (0.87–2.03)	1.62 (1.18–2.24) ^a	1.04 (0.73–1.48)	1.66 (1.05–2.62) ^a
FullBF1-3	1.42 (0.43–4.74)	1.20 (0.79–1.93)	1.48 (1.04–2.12) ^a	1.30 (0.86–1.96)	1.30 (0.80–2.10)
FullBF4-5	2.47 (0.94–6.48)	1.23 (0.79–1.93)	1.15 (0.78–1.70) ^b	1.02 (0.65–1.61)	1.58 (0.89–2.80)
FullBF≥6	Referent	Referent	Referent	Referent	Referent

Adjusted for the same variables as listed in Table 2.

^a Statistically significant results.

^b Not significantly different from referent group or any other breastfeeding group.

in whom the odds of having ≥ 3 episodes were doubled if full breastfeeding was stopped between 4 and 6 months compared with at ≥ 6 months. A dose-response effect is noted wherein the risks were higher yet in those who were fully breastfed for 1 to <4 months or not breastfed at all. Protection was also found in this age group against pneumonia, in whom the odds of experiencing pneumonia were more than fourfold lower if full breastfeeding was continued through 6 months. The latter evidence is less convincing, however, because the adjusted OR for acquiring pneumonia did not reach statistical significance in those who were fully breastfed for <4 months. The inability to detect a clear dose-response curve for this outcome may relate to the relative rarity of pneumonia as an outcome in comparison to outcomes such as OM and URI. It also may be a result of unrecognized differences between the FullBF4-5 and FullBF ≥ 6 groups and those who were fully breastfed for shorter durations or not breastfed that were not captured in our adjusted analyses. The possibility that this finding is the result of multiple comparisons must be acknowledged.

In the wider age range of 6 months to 6 years, ≥ 6 months of full breastfeeding protected against acquiring OM in the first year of life compared with all groups of those who were fully breastfed for <4 months, whereas 4 to 6 months did not. This also suggests a dose-response effect. This study did not demonstrate continued greater protection against respiratory tract infections through 6 years of age. It is important in interpreting these analyses to remember that parents were asked to report respiratory illness in the past year only rather than the cumulative experience over the lifetime of the child. If effects resulting from breastfeeding wane after discontinuation, it may have been easier to demonstrate results in the younger cohort in whom breastfeeding was more likely to be concurrent or recent.

The mechanisms by which an increased breastfeeding dose may provide extended protection against respiratory infections are incompletely understood. In addition to passive protection, breast milk seems to affect the infant's systemic immune response via multiple avenues: maturational, antiinflammatory, immunomodulatory, and antimicrobial.¹⁷ Some immune effects that

could result in prolonged protection against respiratory infections include, for example, changes in immune phenotype after exposure to maternal milk, including increases in postvaccination interferon- γ levels¹⁸ and in natural killer cell numbers, which is consistent with age-related changes and suggests enhanced immune maturation.¹⁹ In addition, there is experimental evidence in animals that maternal milk lymphocytes cross the infant's intestinal wall and enter the circulation²⁰; it is postulated that these cells activate the infant's immune system. Antiinflammatory cytokines such as interleukin 10 and transforming growth factor β are also present in maternal milk and taken up by neonatal tissues, in which they are associated with a decrease in inflammatory immune responses²¹ and augmented secretory immunoglobulin A synthesis.^{22,23} These findings of altered infant immune responses associated with breastfeeding lend biological credence to the findings in our study, ie, that an increased breastfeeding dose between 4 and 6 months could result in a decrease in respiratory infections for many months or even years.

Our findings are consistent with numerous other studies,^{1-5,10,24-28} most of which have been performed in other countries and have adjusted for appropriate confounders. These studies describe a protective effect of breastfeeding dose and/or duration on the rates of both upper and lower respiratory tract illness. Study results are difficult to compare, because breastfeeding doses and durations used for comparisons differ widely between studies, as does the duration over which outcomes are measured. Results are even more difficult to generalize because the degree of industrialization and availability of resources within the study settings vary tremendously.

In the United States, the secondary analysis of data from the US National Maternal and Infant Health Survey by Raisler et al¹ found full, most, or "equal" breastfeeding ($\sim 50\%$ of feedings were breast milk), but not "less" breastfeeding, to decrease cough or wheeze, as well as OM in infants without siblings, compared with non-breastfeeders. Similarly, a longitudinal analysis of infant-feeding practices during the first 6 months in the United States noted that both not breastfeeding and "low mixed feeding" (defined as breastfeeds for <57% of all feeds) in the prior month were associated with an increased risk

of developing an ear infection (adjusted ORs of 1.7 and 1.6, respectively) in the following month. These findings suggest at least a short-term effect of both breastfeeding dose and duration.³ In a prospective study in Bangladesh, exclusive breastfeeding in the first few months of life compared with partial or no breastfeeding resulted in a 2.4-fold lower risk of death from acute respiratory infection.⁴ Similarly, data from Latin America indicate that for those at <4 months of life, partial breastfeeding carried a 2.9-fold (and no breastfeeding carried a 4.0-fold) increased risk of death from acute respiratory infection compared with exclusive breastfeeding.⁵ Thereafter, partial breastfeeding until 1 year of age still protected against respiratory infection compared with no breastfeeding by 2.1-fold. Not all studies, however, have demonstrated exclusive breastfeeding to provide greater protection than partial breastfeeding. For example, a case-control study in Brazil of children who were 1 to 12 months of age demonstrated that the adjusted odds of hospital admission for pneumonia were not statistically greater in partial breastfeeders compared with exclusive breastfeeders.²⁴ Possible reasons for this discrepancy include not differentiating between degrees of partial breastfeeding (ie, almost exclusive breastfeeders would have been included with token breastfeeders as partial breastfeeders); confounding by other variables, because controls were only matched to cases by age; and inadequate power. The adjusted OR for hospital admission for pneumonia in partial versus exclusive breastfeeders at 1 to 2.9 and 3 to 6 months of age were 2.9 and 3.4, respectively, but this substantial increase in odds was not statistically significant.

Breastfeeding duration has also been shown to have an effect, although no studies have specifically compared 4 to 6 months of exclusive or full breastfeeding. Studies in Norway²⁵ and Saudi Arabia²⁶ have noted lactation duration to correlate inversely with respiratory infections in the first 1 and 2 years of life, although these studies did not also consider exclusivity (or "dose") of breastfeeding, which may have confounded the results (eg, more exclusively breastfed infants may also breastfeed longer). In Mexico, the probability of having an acute respiratory infection during the first 4 months of life was associated with the duration of full breastfeeding between 1 and 4 months; the effect did not extend to 6 months in that study.²⁷ In Greenland, exclusive breastfeeding compared with no breastfeeding or having weaned was found in a prospective study to protect against lower respiratory tract infection in multivariate analysis.²⁸ The case-control study in Brazil noted above, which did not demonstrate a protective effect of dose, did demonstrate a protective effect of duration: exclusive breastfeeding between 1 and 12 months (evaluated in groups of those at <3, 3 to <6, and >6 months) resulted in a large decrease in the adjusted odds of hospital admission for pneumonia when compared with infants

who were already weaned.²⁴ Similarly, a prospective study in Chile noted pneumonia during the first 18 months of life to be associated in multivariate analysis with duration of breastfeeding.²⁹ As with breastfeeding dose, however, all studies that examined duration have not shown increased protection with increased duration. There were 2 small studies in Sweden that did not support an association between breastfeeding duration and respiratory illness, one with an outcome of ROM and another with the outcome of number of respiratory tract infections treated with antibiotics.^{30,31} The observational study of morbidity by exclusive breastfeeding duration in Belarus also failed to demonstrate increased protection against infectious respiratory outcomes with 6 months of exclusive breastfeeding when compared with 3 months of exclusive breastfeeding followed by partial breastfeeding at least through 6 months.¹⁰ It is unclear why our results differ from those found in Sweden and Belarus. Possibilities include differing uses of the health care system (and therefore subsequent diagnoses), race/ethnicity differences in susceptibility to OM (such as that seen with black compared with white infants in this country),³² and/or different patterns of pacifier use.

This study has several limitations. First, and perhaps foremost, is that the day care question in the NHANES III did not account for the number of children in attendance and furthermore only allowed a dichotomous response, simply <10 or ≥10 hours per week. This dichotomy may not adequately capture the relative increase in risk of acquiring respiratory tract infections at day care. We were unable to adjust for pacifier use, because this information was not available in the NHANES database; pacifier use has been noted to be associated with risk for OM.³³ Differing pacifier use between the groups of those who were fully breastfed for 4 to <6 vs ≥6 months, however, would not explain the nearly twofold increase in risk of ROM seen in our study. The NHANES also relies on parental report of infections over the last year, which is likely to be inaccurate in some instances. It seems unlikely, however, that recall bias would differ by breastfeeding status. Using family size as a surrogate for number of siblings also may be a source of error. Finally, it is very limiting that the history of respiratory tract infection only within the past year is available. As previously noted, this would lead to an underestimate of the cumulative effect of breastfeeding on respiratory illness in both age groups. Accordingly, our findings should not be interpreted as proof that extended full breastfeeding is not protective beyond 2 years of age. This study's major strengths include a relatively large, nationally representative sample size with the ability to adjust for factors known to affect the incidence of respiratory tract infections in childhood.

The magnitude of the increased likelihood of experiencing ROM if full breastfeeding was stopped after 4 vs after 6 months (OR: 1.95) is even greater than the in-

creased odds seen with smoke exposure (OR: 1.48) or day care ≥ 10 vs < 10 hours weekly (OR: 1.64). This substantial difference in morbidity supports the current national and international recommendations that infants be exclusively breastfed for 6 months. Heretofore, the main difference in morbidity that has been reported between 3 vs 6 months of exclusive breastfeeding is a decrease in diarrheal disease.¹⁰ There are no previous reports that detailed specific differences in respiratory morbidity between 4 and 6 months of exclusive or full breastfeeding, despite the fact that the question of whether to introduce solids at 4 vs 6 months is a matter of considerable public health debate.

CONCLUSIONS

This analysis is the first to document decreased risk for respiratory tract infection, particularly ROM, in children who are fully breastfed for 6 vs 4 months. Our findings add to growing evidence that breastfeeding benefits are dose- and duration-responsive and support current recommendations that infants receive only breast milk during the first 6 months of life.

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