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ARTICLE

Breastfeeding and Hospitalization for Diarrheal and Respiratory Infection in the United Kingdom Millennium Cohort Study

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ABSTRACT

OBJECTIVE. The objective of this study was to measure the effect of breastfeeding on hospitalization for diarrheal and lower respiratory tract infections in the first 8 months after birth in contemporary United Kingdom.

METHODS. The study was a population-based survey (sweep 1 of the United Kingdom Millennium Cohort Study). Data on infant feeding, infant health, and a range of confounding factors were available for 15 890 healthy, singleton, term infants who were born in 2000–2002. The main outcome measures were parental report of hospitalization for diarrhea and lower respiratory tract infection in the first 8 months after birth.

RESULTS. Seventy percent of infants were breastfed (ever), 34% received breast milk for at least 4 months, and 1.2% were exclusively breastfed for at least 6 months. By 8 months of age, 12% of infants had been hospitalized (1.1% for diarrhea and 3.2% for lower respiratory tract infection). Data analyzed by month of age, with adjustment for confounders, show that exclusive breastfeeding, compared with not breastfeeding, protects against hospitalization for diarrhea and lower respiratory tract infection. The effect of partial breastfeeding is weaker. Population-attributable fractions suggest that an estimated 53% of diarrhea hospitalizations could have been prevented each month by exclusive breastfeeding and 31% by partial breastfeeding. Similarly, 27% of lower respiratory tract infection hospitalizations could have been prevented each month by exclusive breastfeeding and 25% by partial breastfeeding. The protective effect of breastfeeding for these outcomes wears off soon after breastfeeding cessation.

CONCLUSIONS. Breastfeeding, particularly when exclusive and prolonged, protects against severe morbidity in contemporary United Kingdom. A population-level increase in exclusive, prolonged breastfeeding would be of considerable potential benefit for public health.

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Key Words
breastfeeding, hospitalization, diarrhea, respiratory infection

Abbreviations
CI— confidence interval
LRTI—lower respiratory tract infection
OR— odds ratio
PAF—population-attributable fraction

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THE WORLD HEALTH Organization recommends that all infants be exclusively breastfed for 6 months.[1] In developing countries, exclusive breastfeeding has a large protective effect on infant mortality and severe morbidity.[2,3] However, the public health importance of breastfeeding in healthy, term infants in developed countries rarely has been quantified. Few studies have assessed the effect of breastfeeding on hospitalization rates in such settings.

Hospitalization is a marker of disease severity that is associated with large and measurable costs.[4] One United Kingdom study conducted in the 1980s[5] observed significantly less hospitalization for diarrheal disease in infants who were breastfed for ≥13 weeks compared with those who never were breastfed. A meta-analysis estimated a significant reduction in risk for hospitalization for respiratory disease in healthy, term infants in developed countries associated with exclusive breastfeeding for ≥4 months compared with no breastfeeding (unadjusted risk ratio: 0.28; 95% confidence interval [CI]: 0.14–0.54).[6] However, there was limited adjustment for confounders in the meta-analysis, with adjustment only for smoking in 1 model and socioeconomic status in another model. Moreover, some of the studies that were included in the meta-analysis did not analyze the timing of the outcome in relation to breastfeeding exposure. Therefore, some infants were classified according to their breastfeeding duration rather than whether the outcome occurred during breastfeeding (which would measure the effect of current breastfeeding) or after breastfeeding cessation (which would measure the effect of past breastfeeding). It is plausible that the effect of past breastfeeding is weaker than the effect of current breastfeeding, and combining the 2 effects may distort the interpretation of the effect of both current and past breastfeeding.

The present study aimed to measure the effect of breastfeeding on hospitalization for diarrheal and lower respiratory tract infections (LRTI) in 15 980 infants who were born in the United Kingdom in 2000–2002. To our knowledge, this is the largest study of the effect of breastfeeding on hospitalization in a developed country and is much larger even than the meta-analysis of 4525 infants from 7 studies.[6] The effects of partial and exclusive current breastfeeding on hospitalization in the same month were estimated. In addition, the effect of past breastfeeding was investigated by analysis of the association between months since breastfeeding cessation and hospitalization. Adjustment was made for a range of potential confounders.

METHODS

Millennium Cohort Study

The Millennium Cohort Study is a nationally representative longitudinal study of 18 819 infants who were born in the United Kingdom.[7] A random 2-stage sample of all infants who were born in England and Wales between September 2000 and August 2001 and in Scotland and Northern Ireland between November 2000 and January 2002 and were alive and living in the United Kingdom at 9 months of age were drawn from Child Benefit registers. Child Benefit claims in the United Kingdom cover virtually all children except those who are ineligible as a result of recent or temporary immigrant status. Stratified sampling by electoral ward (defined geographic area), with over sampling of ethnic minority and disadvantaged areas, ensured adequate representation of such areas. The interview response rate was 85%.[7]

Parents were interviewed for the first time (sweep 1) when most infants were aged 9 months, and detailed information was collected on a range of socioeconomic and health factors. The Millennium Cohort Study does not cover births in which the infant died within the first 9 to 10 months after birth, but these constituted <1% of all births.[8]

Exclusions

The analysis focused on the effects of breastfeeding in term, singleton infants who did not have major problems at birth. Hence, 2839 infants (15% of the original 18 819) were excluded for the following reasons: twins and higher order multiples (n = 522; 2.8%), singleton infants who were born at <37 completed weeks' gestation (n = 1290; 6.8%), singleton infants who were born at ≥37 weeks' gestation and were admitted to ICUs at birth (n = 975; 5.2%; the most common reasons were for breathing difficulties/delay in breathing, n = 353; jaundice that required hospital treatment, n = 154; and infection/suspected infection, n = 103), main respondent not natural mother (n = 50; 0.3%), consent withdrawn (n = 1; 0.005%), and infant's age missing (n = 1; 0.005%). The analysis was based on the remaining 15 980 infants.

Breastfeeding

Breastfeeding initiation was assessed by the question, "Did you ever try to breastfeed your infant?" Breastfeeding duration was estimated using the questions about the age of the infant when last given breast milk and when first given formula, other types of milk, and solids. Infant feeding was categorized per month into the following groups, which refer to the previous month: (1) not breastfed; (2) partially breastfed (received some breast milk but also received other milk and/or solids); (3) exclusively breastfed (received only breast milk and no other milk, solids, or fluids other than water).

Hospitalization for Diarrhea and LRTI

Hospitalized morbidity was assessed by the questions, "Has your infant ever been admitted to a hospital ward because of an illness or health problem?" and, "How

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many months old was your infant when admitted?" Among the possible reasons for admission that were listed on the questionnaire were "gastroenteritis" and "chest infection or pneumonia." In our analysis, diarrhea was defined as "gastroenteritis" ($n = 201$); this did not include "other persistent or severe diarrhea" ($n = 14$), "other severe or persistent vomiting" ($n = 43$), "other reflux or other vomiting" ($n = 73$) or "other gastrointestinal abnormalities" ($n = 7$). LRTI was defined as "chest infection or pneumonia" ($n = 552$) and did not include those with a diagnosis of "wheezing or asthma" ($n = 139$).

Statistical Methods

All analysis was restricted to the first 8 months after birth, for which all but 1 infant had complete follow-up. The data for each infant were analyzed per month of age to incorporate time-changing variables. Hence, variables at each month of age indicated whether the infant had been admitted to the hospital for diarrhea or LRTI during that month, whether they had been exclusively/partially breastfed during that month, and, for ever breastfed infants, how many months since they had last received breast milk (coded as 0 in those currently breastfed, 1 when they had not received breast milk for 1 month, etc). All analyses allowed for the clustered (by ward and infant), stratified sample using the "survey commands" in Stata 9 (Stata Corp, College Station, TX). All SEs presented are adjusted for clustering using Taylor linearization for variance estimation.

The prevalence of cause-specific hospital admissions per month was estimated according to infant feeding practice in the same month. Odds ratios (ORs) were estimated using logistic regression. The ORs were adjusted initially for the following variables: birth weight, gestation, mode of delivery, infant's age in months, infant's gender, maternal age in years, whether the infant was first-born, maternal (current) smoking, maternal occupation (coded using the United Kingdom National Statistics Socio-economic Class), maternal education, maternal marital status, and whether the infant lives in rented accommodation. In final models, adjustment was made for variables that were significantly ($P < .05$) associated with the outcome after adjustment for other variables in the model. Population-attributable fractions (PAFs) for hospitalization that was associated with not breastfeeding were estimated as (proportion of cases exposed) × (OR − 1)/OR, where OR is for not breastfeeding compared with exclusive/partial breastfeeding.

RESULTS

The age at interview of the 15 980 infants ranged between 6 ($n = 1$) and 12 ($n = 5$) months (mean and median: 9 months). Forty-two percent of infants were first-born, and 19% were delivered by cesarean section (Table 1). Eighty-nine percent of their mothers described their ethnicity as "white," and 28% were current smokers. Seventy percent of infants were ever breastfed, with 34% and 24% receiving breast milk for at least 4 and 6 months, respectively (Table 1). Only 1.2% of infants were exclusively breastfed for at least 6 months.

TABLE 1 Breastfeeding, Hospital Admissions, and Other Characteristics in the First 8 Months After Birth

Parameter	MCS ($N = 15\,890$), % (95% CI)
Perinatal and infant characteristics	
Female	49.4 (48.5–50.3)
First-born	42.4 (41.3–43.6)
Delivered by cesarean section	19.1 (18.3–19.9)
Gestation, mean, wk	40.0 (40.0–40.1)
Birth weight, mean, kg	3.45 (3.44–3.46)
Family history of asthma	25.5 (24.5–26.5)
Maternal and household characteristics	
Age at delivery, mean, y	28.9 (28.6–29.1)
Lone parent	13.7 (12.7–14.7)
White ethnicity	89.1 (86.9–91.0)
Managerial/professional occupation	30.8 (28.9–32.9)
Semiroutine/routine occupation	33.7 (32.0–35.5)
More educated (National Vocational Qualification 4/5)	33.8 (31.6–36.0)
Annual household income less than £10 400	21.4 (20.0–22.8)
Annual household income more than £52 100	7.2 (5.8–8.8)
Smoker at interview	28.2 (26.9–29.6)
Infant feeding	
Ever breastfed	70.5 (68.7–72.2)
Any breast milk at 4 mo	34.2 (32.1–36.3)
Any breast milk at 6 mo	24.8 (23.2–26.5)
Any breast milk at 8 mo	17.5 (16.2–18.8)
Exclusively breastfed at 4 mo	17.5 (16.2–18.8)
Exclusively breastfed at 6 mo	1.2 (1.02–1.44)
Outcomes	
Any hospital admission in the first 8 mo	11.8 (11.1–12.6)
Estimated rate for the first 12 mo[a]	17.7
Hospital admission for diarrhea in the first 8 mo	1.1 (0.9–1.3)
Estimated rate for the first 12 mo[a]	1.6
Hospital admission for LRTI in the first 8 mo	3.2 (2.8–3.5)
Estimated rate for the first 12 mo[a]	4.8
Hospital admission for LRTI/wheeze	3.8 (3.4–4.2)
Estimated rate for the first 12 mo[a]	5.7

All percentages are weighted to allow for the stratified sample, and CIs allow for clustering. MCS indicates Millennium Cohort Study.

[a] Annual rate estimated by multiplying rate in first 8 months by 12/8.

In the first 8 months after birth, 12% of infants had at least 1 hospital admission. The most common causes of hospital admission were LRTI (3.2%), diarrhea (1.1%), asthma/wheezing (0.9%), and other high temperature acute viral infection (not respiratory or meningitis; 0.8%). Approximately 2% of infants had >1 hospital admission. Among those who were hospitalized for diarrhea ($n = 185$) and LRTI ($n = 539$), the proportions with at least 1 other hospital admission were 24% and 21%, respectively. Of the 714 infants who were hospitalized for diarrhea or LRTI, 10 (1.4%) were hospitalized for both infections. Those who were hospitalized for diarrhea were more likely to be hospitalized for LRTI than those who were not hospitalized for diarrhea, but

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the effect was not statistically significant (OR: 1.63; 95% CI: 0.70–3.81; $P = .26$). Therefore, neither infection was considered as a potential confounder for the other infection.

Infant data for the first 8 months were split into 127 798 infant-months. The monthly risk for hospitalization at ages 0 to 8 months was 0.15% for diarrhea and 0.42% for LRTI (Table 2). These risks, when multiplied by 8, are slightly higher than those in Table 1 because they include multiple hospital admissions per infant. Compared with infants who were not breastfed, those who were exclusively breastfed had a large and statistically significant reduction in risk for hospitalization for diarrhea (adjusted OR: 0.37; 95% CI: 0.18–0.78) and LRTI (adjusted OR: 0.66; 95% CI: 0.47–0.92). The effect of partial breastfeeding was weaker and not statistically significant. The PAFs suggest that 53% of diarrhea hospitalizations could have been prevented each month by exclusive breastfeeding and 31% by partial breastfeeding. Similarly, 27% of LRTI hospitalizations could have been prevented each month by exclusive breastfeeding and 25% by partial breastfeeding.

Table 3 shows the association between breastfeeding cessation and hospitalization for diarrhea and LRTI. Here, no distinction was made between exclusive and partial breastfeeding to keep the model relatively simple; otherwise, the effect of breastfeeding cessation would need to be estimated separately according to the months of continued partial breastfeeding, which may range from 0 to 7. Clearly, breastfeeding cessation is strongly correlated with infant's age; for example, having stopped breastfeeding for 4 months may be assessed only in infants who were aged ≥5 months. However, the ORs in Table 3 are adjusted for infant's age.

There is a statistically significant increasing linear trend in the effect of breastfeeding cessation for both outcomes in older and younger infants, suggesting that the protective effect of breastfeeding wears off over time. There was evidence of a stronger increasing trend at age 1 to 4 months compared with 5 to 7 months (interaction $P = .084$ for diarrhea and $P = .031$ for LRTI); therefore, the results are presented stratified by age group. In both age groups, the trend is stronger for diarrhea than for LRTI, although the estimates for diarrhea are adjusted for fewer confounders. For diarrhea, the protective effect of breastfeeding does not seem to persist beyond the first month, after which there is a steady increase in risk over time since cessation; on average, there is a doubling of risk for every month that elapses after breastfeeding cessation (adjusted OR: 1.98; 95% CI: 1.32–2.96) in those aged 1 to 4 months and a 28% increase in risk in those aged 5 to 7 months (adjusted OR: 1.28; 95% CI: 1.01–1.61). For LRTI, the protective effect of breastfeeding weakens as soon as breastfeeding stops.

DISCUSSION

Approximately 12% of healthy, singleton, term infants who were born in contemporary United Kingdom have been hospitalized at least once by the time they are 8 months of age; 1.1% of infants have been hospitalized for diarrhea and 3.2% for LRTI. Exclusive breastfeeding protects against hospitalization for diarrhea and LRTI. It is estimated that 53% of diarrhea hospitalizations could have been prevented each month if all infants were exclusively breastfed, and 31% could have been prevented if all were partially breastfed. Similarly, 27% of LRTI hospitalizations could have been prevented each month by exclusive breastfeeding and 25% by partial breastfeeding. However, the protective effect of breastfeeding for both outcomes wears off soon after breastfeeding cessation.

Our study used parental reporting for both hospitalization and breastfeeding. The recall of neither of these variables has been validated in this study population, although maternal recall of mode of delivery and birth weight have been shown to be highly reliable in this

TABLE 2 Association Between Breastfeeding and Hospital Admission per Month in the First 8 Months After Birth

Infant Feeding	Monthly Prevalence, % (*n*/*N*)	Crude OR (95% CI)	Adjusted OR (95% CI)[a]	PAF, %
Diarrhea				
Not breastfed	0.18 (158/86 648)	1.00	1.00	
Partially breastfed	0.08 (17/19 887)	0.46 (0.24–0.88)	0.63 (0.32–1.25)	31[b]
Exclusively breastfed	0.05 (11/20 352)	0.28 (0.14–0.58)	0.37 (0.18–0.78)	53[c]
LRTI				
Not breastfed	0.49 (429/86 648)	1.00	1.00	
Partially breastfed	0.25 (50/19 888)	0.50 (0.36–0.71)	0.69 (0.47–1.00)	25[d]
Exclusively breastfed	0.30 (60/20 352)	0.60 (0.44–0.81)	0.66 (0.47–0.92)	27[e]

All numbers and percentages are weighted to allow for the stratified sample, and CIs allow for clustering.

[a] For diarrhea, ORs are adjusted for month (ie, infant's age), mother's age at delivery, mode of delivery, and mother's education. For LRTI, ORs are adjusted for month (ie, infant's age), infant's gender, mother's age at delivery, mode of delivery, household income, whether the infant was first-born, mother's (current) smoking status, and family history of asthma.

[b] PAF = [(158/186) × 0.59/1.59] = 31%.

[c] PAF = [(158/186) × 1.70/2.70] = 53%.

[d] PAF = [(429/539) × 0.45/1.45] = 25%.

[e] PAF = [(429/539) × 0.52/1.52] = 27%.

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TABLE 3 **Association Between Months Since Breastfeeding Cessation and Hospitalization for Diarrhea and LRTI in the First 8 Months After Birth**

Parameter	Months Since Breastfeeding Cessation						Not Breastfed	Linear Trend per Month[b]
	0[a]	1	2	3	4–5	6–7		
Diarrhea in mo 1–4								
% (total)	0.07 (25 810)	0.09 (5757)	0.14 (4758)	0.23 (4074)	NA	NA	0.19 (23 047)	
OR (95% CI)[c]	1	0.94 (0.27–3.27)	2.04 (0.70–5.95)	2.37 (0.87–6.46)	NA	NA	2.31 (1.22–4.38)	1.98 (1.32–2.96)
Diarrhea in mo 5–7								
% (total)	0.07 (14 429)	0 (2648)	0.11 (3231)	0.15 (3166)	0.24 (12 394)	0.19 (8831)	0.21 (18 744)	
OR (95% CI)[c]	1	—	1.53 (0.35–6.80)	1.78 (0.49–6.39)	2.54 (0.97–6.68)	2.04 (0.66–6.36)	1.84 (0.74–4.59)	1.28 (1.01–1.61)
LRTI in mo 1–4								
% (total)	0.32 (25 810)	0.59 (5757)	0.64 (4758)	0.86 (4,-74)	NA	NA	0.58 (23 047)	
OR (95% CI)[c]	1	1.32 (0.78–2.23)	1.70 (0.96–3.03)	2.56 (1.36–4.83)	NA	NA	1.19 (0.85–1.67)	1.46 (1.19–1.80)
LRTI in mo 5–7								
% (total)	0.19 (14 429)	0.30 (2648)	0.24 (3231)	0.24 (3166)	0.36 (12 394)	0.33 (8831)	0.53 (18 744)	
OR (95% CI)[c]	1	1.79 (0.71–4.52)	1.41 (0.50–3.95)	1.36 (0.55–3.36)	1.62 (0.87–3.02)	1.70 (0.90–3.21)	2.13 (1.24–3.68)	1.12 (1.00–1.27)

All percentages are weighted to allow for the stratified sample, and CIs allow for clustering. NA indicates not applicable.

[a] Currently breastfed.

[b] Linear trend assessed excluding the "never breastfed" group.

[c] For diarrhea, ORs are adjusted for month (ie, infant's age), mother's age at delivery, mode of delivery, and mother's education. For LRTI, ORs are adjusted for month (ie, infant's age), infant's gender, mother's age at delivery, mode of delivery, household income, whether the infant was first-born, mother's (current) smoking status, and family history of asthma.

population.[9,10] Other studies have shown that maternal reporting of breastfeeding is reliable up to 3 years after the birth of the infant.[11,12] The breastfeeding rates in our study are slightly higher than those reported in the United Kingdom Infant Feeding Survey for the same time period,[13] perhaps because the infants who were excluded from our study (multiples, preterm infants, and those who were admitted to ICUs) were less likely to be breastfed. Validation studies[14–17] have found that parental recall of hospitalization in young children is extremely accurate, although we cannot rule out some misreporting of cause of admission. The hospitalization rate for diarrhea in our study (estimated as 1.6% in the first year after birth) is lower than that in a Scottish study (5.7%)[5] but similar to that in a Canadian study (1.1%).[18] We estimate a hospitalization rate for LRTI of 4.8% in the first year after birth, which is similar to rates that were observed in Scotland (4.9%),[5] Australia (5.2%),[16] and the United States (6.0%).[19] Moreover, the effects of breastfeeding in our study were similar when we included admissions for wheezing or asthma in the definition of LRTI (data not shown).

The main strength of our study is the large sample size that is representative of contemporary United Kingdom. Unlike many other studies that have measured the protective effect of breastfeeding, we assessed the effect of both current breastfeeding, using exposure and outcome data from the same month, and past breastfeeding, using outcome data that occurred in the months after breastfeeding cessation. We adjusted for a wide range of confounders. We focused on hospital admissions because they are likely to be reported accurately by parents, are an important measure of disease severity, and are associated with large and measurable costs.

Our finding of a protective effect of breastfeeding against diarrhea hospitalization is consistent with a study that was conducted in Scotland in the 1980s.[5] In a meta-analysis of 7 studies of hospitalization for respiratory disease, the unadjusted risk ratio for ≥4 months of breastfeeding compared with no breastfeeding was 0.28.[4] However, in the 4 studies that adjusted for socioeconomic status, the adjusted risk ratio was 0.53, which is similar to our adjusted OR of 0.66 for LRTI. It is interesting that our PAF estimates of 53% for diarrhea hospitalizations and 27% for LRTI hospitalizations are consistent with a recent study from Spain that estimated that exclusive breastfeeding for ≥4 months would have prevented 56.4% of nonperinatal, infection-related hospitalizations in children who were younger than 1 year.[20]

There is a large body of data describing how the immunologic properties of breast milk are likely to protect against infection in the infant.[21] In addition, infection may be attributable to contamination of bottles, teats, milk, and food in infants who are not exclusively breastfed. In our developed country setting, where rates of infection and poor hygiene are relatively low, the immune properties of "current" breast milk do not seem to persist after breastfeeding cessation. Alternatively, the immune properties may not persist at sufficient levels to protect against contamination.

CONCLUSIONS

Our findings confirm that breastfeeding, particularly when exclusive and prolonged, protects against severe morbidity in contemporary United Kingdom. In our study, only 1.2% of infants were exclusively breastfed for at least 6 months, and the protective effects of breastfeeding were large; a population-level increase in exclusive, prolonged breastfeeding would be of great public health benefit. Our results may be used to estimate the

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cost-effectiveness of breastfeeding interventions. Better information on the risks and benefits that are associated with infant feeding methods, including prolonged and exclusive breastfeeding, will enable parents to make an informed choice.

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