Breastfeeding is Associated with Reduced Childhood Hospitalization: Evidence from a Scottish Birth Cohort (1997-2009)

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Objective To evaluate the risk of childhood hospitalization associated with infant feeding patterns at 6-8 weeks of age in Scotland.

Study design A retrospective population level study based on the linkage of birth, death, maternity, infant health, child health surveillance, and admission records for children born as single births in Scotland between 1997 and 2009 (n = 502 948) followed up to March 2012. Descriptive analyses, Kaplan Meier tests, and Cox regression were used to quantify the association between the mode of infant feeding and risk of childhood hospitalization for respiratory, gastrointestinal, and urinary tract infections, and other common childhood ailments during the study period.

Results Within the first 6 months of life, there was a greater hazard ratio (HR) of hospitalization for common childhood illnesses among formula-fed infants (HR 1.40; 95% CI 1.35-1.45) and mixed-fed infants (HR 1.18; 95% CI 1.11-1.25) compared with infants exclusively breastfed after adjustment for parental, maternal, and infant health characteristics. Within the first year of life and beyond, a greater relative risk of hospitalization was observed among formula-fed infants for a range of individual illnesses reported in childhood including gastrointestinal, respiratory, and urinary tract infections, otitis media, fever, asthma, diabetes, and dental caries.

Conclusions Using linked administrative data, we found greater risks of hospitalization in early childhood for a range of common childhood illnesses among Scottish infants who were not exclusively breastfed at 6-8 weeks of age. *(J Pediatr 2015;166:620-5)*.

Breastfeeding enhances child health and development, with the potential to give every child a healthy start.[1,2] In developed countries however, there remains continued debate on the size of health benefit based on the available evidence, which has been limited by methodologic issues related to sample size, quality of data, or adjustment for confounding factors[3-6]; particularly socioeconomic factors associated with both the choice and duration of infant feeding and child health outcomes.[3,4]

As in the rest of the United Kingdom, increasing rates of childhood hospitalizations have been observed in Scotland, particularly for acute infections among infants.[7,8] These hospitalizations may contribute to substantial savings in the health service if breastfeeding rates increased marginally.[9] Current trends in Scotland, however, show relatively stable exclusive breastfeeding rates and an increasing proportion of mixed (formula and human milk) fed infants. Approximately one-half of infants born annually initiate exclusive breastfeeding, decreasing to 25% by the review at 6-8 weeks after birth.[10]

Based on linkage of administrative data for a population cohort of Scottish born infants, we describe patterns of hospitalization observed in early childhood in relation to the mode of infant feeding reported at 6-8 weeks after birth, adjusted for a range of socioeconomic factors. The analyses focus on hospitalization for a range of conditions in which breastfeeding has been shown to be protective[6,11-13] and, additionally, on conditions frequently reported in the cohort.

Methods

This was a retrospective cohort study of singleton births in Scotland between 1997 and 2009 using anonymized extracts of linked administrative data provided by the Information Services Division, National Health Service National Services Scotland. Approval for the project design and confidentiality of patient data was provided by the Privacy Advisory Committee of National Health Service

HR	Hazard ratio
PAF	Population-attributable fraction

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National Services Scotland, a body set up to ensure the appropriate use of patient identifiable information.[14] Further ethical permission was not required.

The records were linked in 2 phases via a combination of probabilistic matching techniques and the use of the Community Health Index, a unique identifier developed for health records in Scotland.[15] Phase 1 comprised linkage of births, deaths, migration, maternity, infant health, and child health surveillance review records,[16] which was extended in Phase 2 to include episodes of hospital admission from birth until March 2012. Thus, each child in the cohort could be followed up from birth for at least 2.25 years and up to 15 years (depending on their birth year).

Infants with a diagnosis of congenital anomaly, a condition originating in the perinatal period, with invalid infant feeding records, and of non-Scottish residents were excluded from analysis.

Outcome Variables

The main outcome examined was a primary discharge diagnosis for selected conditions from a review of literature, including gastrointestinal infections, lower and upper respiratory tract infections, otitis media, asthma, urinary tract infections, allergy, eczema, and diabetes, and conditions frequently reported in the cohort such as fever and dental caries (**Table I**; available at www.jpeds.com).

Definition of Infant Feeding

Infant feeding reported at the 6-8 weeks of age review, defined as the predominant mode of infant feeding on the day preceding data collection, was divided into 3 categories: "exclusive breastfeeding," "formula feeding," and "mixed-breast and formula feeding."

Statistical Analyses

Descriptive and univariate (Kaplan Meier curves) analyses were used to identify variables associated with hospital admission and infant feeding. Multivariate analyses (Cox regression analyses) were conducted to quantify the independent contribution of infant feeding at the 6-8 week review on hospitalization in childhood. The Cox models included only variables significantly associated with the health outcome from the univariate analyses. Each model was tested for proportionality over time, adjustments were made to ensure the best fit, and violations noted.

Adjustment was made for parental factors, delivery and infant health characteristics, and features of the health care system.[16] In addition, area deprivation derived using postcode at birth based on the Scottish Index of Multiple Deprivation (2006[17]) and maternal ethnic and religious background derived from the mother's given name (ie, OnoMAP[18]) were included in the analyses. Additional analysis was conducted to assess the risk of hospitalization for injuries (a condition not causally associated with breastfeeding), to test the adequacy of adjustment for socioeconomic and demographic confounders included in the linked dataset.

A series of models were applied over varying periods of follow-up (using STATA vs11; StataCorp LP, College Station, Texas) to estimate the risk of hospital admission associated with infant feeding patterns: up to 6 months (that reflects the recommended duration of exclusive breastfeeding), 6-27 months (point of "equal" follow-up for all infants in the cohort), and up to 15 years (full-follow-up). An estimate of the time from birth to event (ie, first hospital admission) was derived from the merged datasets and a marker applied to infants who had a hospital admission. Those who had migrated or died before the end of the observation period (March 2012) were censored from follow-up at the point of migration/death. The variables were entered into the model iteratively ie, infant feeding at the 6- to 8-week review was entered first, followed by parental/background variables, then delivery and infant health variables. The model entry significance was 0.05. Population-attributable fractions (PAFs) were used to quantify the number of new cases that may have been avoided among formula fed children in each model using the formula: PAF = [(hazard ratio [HR] − 1)/HR] × proportion of the exposed population.

Results

Of the 502 948 singletons born between 1997 and 2009 included in the analysis, 63% were born by spontaneous/normal delivery, 8% had teenage mothers, 17% were born to single parents or parents living apart, 45% were born to first-time mothers, 22% had mothers who smoked, and 27% were residents in the most socioeconomically deprived areas at birth (**Table II**; available at www.jpeds.com). By the review at 6-8 weeks of age, 27% of infants were reported as exclusively breastfeeding, 9% as having mixed feeding, and 64% as formula-feeding.

During the study period, 137 905 (27%) of the infants had been hospitalized at least once for any of the selected conditions. At the first recorded hospital event, 31% were younger than 1 year, 29% were 1-2 years, 19% were 3-5 years, and 21% were aged 5 years or older. Most of the first hospital events were "emergency admissions" (75%), especially among infants <1 year of age at admission (98%).

Infants exclusively breastfed at the 6-8 week review were older at first admission (mean: 178 days; IQR: 74-275 days) and had a shorter length of stay (mean: 2.81 days; IQR: 1.0-3.5 days) compared with formula-fed infants (mean age: 164.6 days; IQR: 66-255 days and mean stay: 3.25 days; IQR: 1.0-4.0 days) and mixed-fed infants (mean age: 172.5 days; IQR: 70-263 days and mean stay: 3.08 days; IQR: 1-3 days). The crude rates of hospitalization were 21%, 24%, and 31% among exclusively breastfed, mixed fed, and formula-fed infants, respectively.

Multivariate Analyses

For any of the selected conditions, infants who were reported as formula and mixed fed at the 6-8 week review had a significantly greater relative risk of hospital admission, particularly within 6 months of birth (**Table III**; available at www.jpeds.com). There was also a greater relative risk of hospital admission among infants resident in more deprived areas (within 6 months of birth), of fathers with a semiroutine/routine occupation, of single parents/parents living apart, and among infants with siblings (within 6 months of birth). Preterm infants, those born by cesarean delivery, infants of low birth weight, and those admitted to a neonatal unit also had a relatively greater risk of hospital admission. Conversely, risk of infant admission decreased with increasing maternal age.

On the basis of adjusted PAF, 21% of hospital admissions within the first 6 months of birth might have been averted if formula fed infants had been exclusively breastfed until the 6-8 week review. The estimated PAFs were lower among older infants—10% for formula fed infants between 6 and 27 months and 13% during the full follow-up period.

Gastrointestinal, Respiratory, Urinary Tract Infections, Fevers, and Otitis Media

During the full follow-up period, the rates of hospital admissions for gastrointestinal, upper, and lower respiratory tract infections were 21%, 26%, and 25%, respectively. At the first admission event, more than two-thirds of the cohort admitted for gastrointestinal, lower, and upper respiratory tract infections was younger than 2 years. There was a lower prevalence of hospital admissions for urinary tract infections, fevers, and otitis media (3%, 3%, and 6%, respectively). Formula-fed infants had a greater rate of hospital admission for each of the infections studied.

The adjusted relative risk remained significantly greater among formula-fed infants for hospital admission for gastrointestinal, lower and upper respiratory infections, urinary tract infections, and otitis media, which occurred within 6 months of birth. Similarly, an increased risk of hospitalization was observed among these conditions and for fever at 6-27 months; the results for otitis media were not statistically significant (**Table IV**).

Within 6 months of birth, the proportion of hospitalizations that may have been averted among formula-fed infants, based on the PAF estimates, was 41% for otitis media, 27% for gastrointestinal infections, 22% for lower respiratory tract infections, and 16% for both upper respiratory and urinary tract infections.

Allergies, Eczema, and Asthma

During the study period, 4% of the cohort was hospitalized for asthma and 1% each for allergies and eczema. Infants aged less than 1 year made up 49% and 26% of the first-time admissions for eczema and allergies, respectively. More than one-half (58%) of the admissions for asthma occurred among children aged 3 years or older. Formula-fed infants had an increased (adjusted) relative risk of hospitalization for allergies within 6 months of birth. Similarly, an increased risk of hospital admission was observed for asthma among older infants (admitted aged 6-27 months).

In contrast, there was a relatively lower risk of hospital admission among formula-fed infants admitted for eczema within 6 months of birth and for allergies beyond 6 months (**Table IV**). Infant feeding was not significant in the models of hospitalization for eczema among older children.

Diabetes and Dental Caries

There were 1132 children in the study cohort (0.2%) hospitalized for diabetes during the study period. Approximately 1 in 10 (9%) of those hospitalized for diabetes were younger than 2 years of age at the first admission (1% aged <1 year) and 62% were ≥5 years of age.

During the full follow-up period, the relative risk of admission for diabetes was 1.28 (95% CI 1.09-1.49) among children who were formula fed at the 6-8 week review; there also was an increased HR for those aged 5 years or older at first admission (HR 1.39; 95% CI 1.13-1.71; not shown).

There were 38 650 children in the cohort admitted for dental caries during the study period (8% of the cohort), 95% of whom were aged 3 years or older at the first admission. During the full follow-up period, the adjusted models showed a 48% greater relative risk of admission for dental caries among formula-fed infants (HR 1.48; 95% CI 1.43-1.53). This result accounted for 27% of the hospitalizations for dental caries that might have been averted if formula-fed infants had been exclusively breastfed until the 6-8 week review, all other factors remaining constant (**Table IV**).

Injuries

Hospital admissions related to injuries were analyzed as a control group. There were 45 177 children admitted for injuries from the cohort during the study period. After adjustment for other factors, infant feeding was not a significant predictor of hospital admission (HR 1.00; 95% CI 0.98-1.02).

Discussion

This study of a representative sample of Scottish births (1997-2009) confirms evidence of the association between infant feeding choices (reported at 6-8 weeks) and childhood hospitalization and remained significant after adjustment for a range of socioeconomic factors. It also estimates the proportion of hospital admissions attributable to not breastfeeding exclusively, in the cohort, particularly hospitalizations within the first 6 months of life.

Respiratory and gastrointestinal infections comprised 79% of the selected causes of hospitalization (and 38% of all hospital admissions in the birth cohort); greater rates were reported among infants <1 year of age, consistent with the recently reported trends in pediatric admissions.[7,8]

After adjustment for parental and other factors, we found a greater risk of hospitalization among formula-fed infants as has been observed by others for each of the infections: gastrointestinal,[6,11-13,19-22] upper and lower respiratory tract

Table IV. Risk of hospitalization for selected conditions and feeding at the 6-8 wk review

Mode of infant feeding at the 6-8 wk review	Crude HR		Adjusted HR								
	All infants/ages		Infants aged ≤6 m			Infants aged 6-27 m			Full follow-up (all infants/ages)		
	HR	95% CI	HR	95% CI	PAF	HR	95% CI	PAF	HR	95% CI	PAF
Gastrointestinal infections											
Excl breastfed	1.00	Reference									
Mixed fed	1.18	(1.12-1.25)	***1.18***	***(1.03-1.34)***	***1%***	1.17	(1.08-1.26)	1%	1.13	(1.07-1.19)	1%
Formula fed	1.60	(1.55-1.65)	1.59	(1.47-1.73)	27%	1.34	(1.28-1.41)	17%	1.31	(1.26-1.35)	18%
Upper respiratory tract											
Excl breastfed	1.00	Reference	1.00	Reference		–	Reference	–	1.00	Reference	–
Mixed fed	1.19	(1.13-1.24)	**1.03**	**(0.89-1.20)**	–	1.13	(1.05-1.21)	1%	1.13	(1.08-1.18)	1%
Formula fed	1.44	(1.40-1.48)	1.28	(1.17-1.40)	16%	1.19	(1.14-1.25)	11%	1.21	(1.18-1.25)	9%
Lower respiratory tract infections											
Excl breastfed	1.00	Reference	1.00	Reference	–	1.00	Reference	–	1.00	Reference	–
Mixed fed	1.13	(1.08-1.18)	1.18	(1.07-1.30)	1%	1.09	(1.02-1.17)	1%	1.07	(1.02-1.12)	1%
Formula fed	1.39	(1.35-1.43)	1.50	(1.41-1.59)	22%	1.11	(1.06-1.16)	7%	1.14	(1.11-1.18)	9%
Urinary tract infections											
Excl breastfed	1.00	Reference	1.00	Reference	–	1.00	Reference	–	1.00	Reference	–
Mixed fed	**1.14**	**(1.00-1.30)**	**1.25**	**(0.99-1.59)**	–	**1.11**	**(0.89-1.38)**	–	**1.13**	**(0.99-1.30)**	–
Formula fed	1.42	(1.32-1.54)	1.46	(1.25-1.71)	16%	1.29	(1.13-1.46)	15%	1.35	(1.24-1.47)	14%
Otitis media											
Excl breastfed	1.00	reference	1.00	Reference	–	1.00	Reference	–	1.00	Reference	–
Mixed fed	**1.07**	**(0.98-1.17)**	**1.50**	**(0.65-3.48)**	–	**1.00**	**(0.83-1.18)**	–	**1.04**	**(0.95-1.14)**	–
Formula fed	1.11	(1.05-1.17)	2.13	(1.26-3.59)	41%	**1.00**	**(0.89-1.12)**	–	**1.03**	**(0.97-1.09)**	–
Asthma											
Excl breastfed	1.00	Reference	1.00	Reference		1.00	Reference	–	1.00	Reference	–
Mixed fed	1.11	(1.00-1.22)	**1.73**	**(0.41-7.29)**	–	**1.14**	**(0.93-1.40)**	–	**1.01**	**(0.91-1.12)**	–
Formula fed	1.25	(1.17-1.32)	**2.06**	**(0.77-5.46)**	–	1.15	(1.01-1.31)	10%	**0.98**	**(0.92-1.05)**	–
Allergies											
Excl breastfed	1.00	Reference	1.00	Reference	–	1.00	Reference	–	1.00	Reference	–
Mixed fed	0.76	(0.62-0.94)	**1.15**	**(0.94-1.42)**	–	**0.75**	**(0.53-1.04)**	–	0.63	(0.55-0.72)	–
Formula fed	0.55	(0.48-0.62)	1.20	(1.06-1.37)	6%	0.51	(0.41-0.64)	–	0.73	(0.59-0.91)	–
Eczema											
Excl breastfed	1.00	Reference	1.00	Reference	–	1.00	Reference		1.00	Reference	
Mixed feeding	**0.92**	**(0.74-1.16)**	**0.83**	**(0.58-1.20)**	–	**0.77**	**(0.52-1.13)**	–	**0.89**	**(0.77-1.02)**	–
Formula feeding	**1.06**	**(0.93-1.20)**	0.73	(0.57-0.92)	–	**0.89**	**(0.71-1.12)**	–	**0.81**	**(0.65-1.02)**	–
Diabetes											
Excl breastfed	1.00	Reference	1.00	Reference	–	1.00	Reference		1.00	Reference	
Mixed feeding	**1.18**	**(0.92-1.52)**		N/A (n = 4)	–	**1.39**	**(0.74-2.61)**	–	**1.22**	**(0.94-1.57)**	
Formula feeding	1.22	(1.05-1.42)			–	**0.79**	**(0.50-1.26)**	–	1.28	(1.09-1.49)	15%
Fever											
Excl breastfed	1.00	Reference	1.00	Reference	–	1.00	Reference	–	1.00	Reference	–
Mixed fed	1.15	(1.05-1.25)	**1.28**	**(0.99-1.65)**	–	1.15	(1.03-1.29)	1%	1.10	(1.00-1.20)	1%
Formula fed	1.36	(1.29-1.43)	**1.13**	**(0.95-1.35)**	–	1.26	(1.17-1.35)	14%	1.16	(1.10-1.23)	10%
Dental caries											
Excl breastfed	1.00	Reference	1.00	Reference	–	1.00	Reference		1.00	Reference	–
Mixed fed	1.34	(1.27-1.42)				**0.72**	**(0.46-1.11)**	–	1.15	(1.09-1.21)	1%
Formula fed	2.63	(2.55-2.72)		No cases	–	**1.02**	**(0.79-1.31)**	–	1.48	(1.43-1.53)	27%

Excl, exclusive; *ISD*, Information Services Division; *n/a*, not applicable.
(–) refers to variables excluded from the model. Variables in bold were not significant ($P > .05$) or violated the assumption of proportionality required by Cox regression analyses (bold and in italics).
Source: ISD Scotland linked data extract.

infections,[6,19-22] urinary tract infections,[12] otitis media,[12,13,23] fevers often associated with an underlying infection,[24,25] and, for other conditions such as asthma,[26-28] diabetes,[29,30] and dental caries.[31,32] These patterns could be attributed to the components of human milk, which provide immunologic protection[6,33] and delay exposure to environmental contaminants or pathogenic micro-organisms.[33]

Furthermore, compared with breastfed infants, mixed- and formula-fed infants were younger and stayed longer when admitted to hospital.[20,34] There also was a greater relative risk of hospital admission among infants with siblings, of fathers of a lower socioeconomic status, of single parent households,[34,35] preterm infants, and those born via cesarean delivery and of a small weight for gestational age.[36]

The relatively lower risk of hospitalization for eczema and allergies among formula-fed infants aged 6 months or older was contrary to the plausible mechanisms for its action[37] and the findings of some[13,26-28,38,39] but not all[40,41] studies. This "inverse" pattern may be associated with influences not measured in our study (eg, prenatal sensitization, family history,[42] parental knowledge and health seeking behavior,[43] vitamin D deficiency,[44] exposure to environmental contaminants, or the age that solid foods were introduced). It is also possible that the duration of breastfeeding, ie, measured at 6-8 weeks, was insufficient to detect a beneficial outcome.

In addition to the large sample size and wide coverage, this study, based on routinely collected data, had the advantage of a wide range of relevant variables, including area and individual-level socioeconomic characteristics. This made it possible to observe the influence of both individual and area-based socioeconomic factors in the analyses, which often confounds the complex relationship between infant feeding and child health. As expected, the risk of hospital admission significantly increased with greater deprivation. However, further analyses, stratifying the results by area deprivation (not shown) and controlling for other parental, maternal, and infant health characteristics, confirmed a greater risk of hospital admission among formula-fed compared with exclusively breastfed infants in both the least-deprived (HR 1.38 95% CI 1.33-1.42) and most-deprived areas (HR 1.46 95% CI 1.41-1.51), albeit with an effect modification that may be due to residual confounding. In addition, the modeling of hospitalizations for injuries—not causally associated with infant feeding—suggests that the adjustment for socioeconomic confounders was sufficient.

Although the coverage and completeness of variables using the routine datasets was relatively high, the study was limited to an extent by the availability of confounders on the linked dataset and uncertainty over the overall duration and the definition of infant feeding. An attempt was made to adjust for variation in the age at review, but it was not possible to account for the "exclusivity" or exact duration of feeding, and hence, to fully model the dose-response effect. Minimal violations to the assumption of proportionality noted in this study may relate to unmeasured covariates and their association with other covariates.[45]

Overall, it is likely that there is a underestimation of the association between formula feeding and hospitalization as not all ill health conditions observed in children result in hospitalization[46] and other studies include parent observation in the definition of disease,[11,19,22] which was not possible in this study. Furthermore, using the main diagnoses at hospital discharge (a probable marker of severity) along with the variation in coding practices between hospitals[21] may have moderated the observed associations of infant feeding on early child health.

Limitations in the data set preclude a full debate on causality and the protective effects of exclusive breastfeeding. Nevertheless, the strength of association between breastfeeding and reduced infant morbidity, which is consistent with other studies, provides convincing evidence of the benefits of breastfeeding on child health in the context of developed countries. This study also highlights the utility of administrative datasets and the need to enhance their quality for child health research in Scotland. ■

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References

1. Black RE, Allen LH, Bhutta ZA, Caulefiled LE, de Onis M, Ezzati M, et al. Maternal and child undernutrition, global and regional exposures and health consequences. Lancet 2008;371:243-60.
2. WHO Collaborative Study Team on the Role of Breastfeeding on the Prevention of Infant Mortality. Effect of breastfeeding on infant and child mortality due to infectious disease in less developed countries: a pooled analysis. Lancet 2000;355:451-5.
3. Quigley MA. Breastfeeding, causal effects and inequalities. Arch Dis Child 2013;98:654-5.
4. Brion MA. Assessing the impact of breastfeeding on child health: where conventional methods alone fall short for reliably establishing causal inference. Int J Epidemiol 2010;39:306-7.
5. Williams LA, Davies PSW, Boyd R, David M, Ware RS. A systematic review of infant feeding experience and hospitalisation in developed countries. Acta Paediatr 2014;103:131-8.
6. Ip S, Chung M, Rawan G, Chew P, Magula N, DeVine D, et al. Breastfeeding and maternal and infant health outcomes in developed countries. Evid Rep Technol Assess (Full Rep) 2007;1-186.
7. Gill PJ, Goldacre MJ, Mant D, Heneghan C, Thomson A, Seagroatt V, et al. Increase in emergency admissions to hospital for children under 15 in England 1999-2010: national database analysis. Arch Dis Child 2013;98:328-34.
8. Wood R, Blair M, Wilson P. Trends in emergency hospital admissions in children: observations from Scotland. Arch Dis Child 2013;98:1024-5.
9. Renfrew MJ, Pokhrel S, Quigley M, McCormick F, Fox-Rushby J, Dodds R, et al. Preventing disease and saving resources: the potential contribution of increasing breastfeeding in the UK. UNICEF; 2012, http://www.unicef.org.uk/Documents/Baby_Friendly/Research/Preventing_disease_saving_resources.pdf. Accessed August, 2014.
10. ISD Scotland. Infant feeding. http://www.isdscotland.org/Health%2DTopics/Child%2DHealth/Infant%2DFeeding/. Accessed August, 2013.
11. Oddy WH, Sly PD, de Klerk NH, Landau LI, Kendall GE, Holt PG, et al. Breastfeeding and respiratory morbidity in infancy: a birth cohort study. Arch Dis Child 2003;88:224-8.
12. Paricio Talayero JM, Lizán-Garca M, Puime AO, Muncharaz MJB, Soto BB, Sánchez-Palomares M, et al. Full breastfeeding and hospitalisation as a result of infections in the first year of life. Pediatrics 2006;118:e93-9.
13. Eidelman AI, Schanier RJ, Johnston M, Landers S, Noble L, Szucs K, et al. Breastfeeding and the use of human milk. Pediatrics 2012;129:e827-41.
14. National Privacy Advisory Committee. http://www.nhsnss.org/pages/corporate/privacy_advisory_committee.php. Accessed August, 2013.
15. Fleming M, Kirby B, Penny KI. Record linkage in Scotland and its application to health research. J Clin Nurs 2012;21:2711-21.
16. Ajetunmobi O, Whyte F, Chalmers J, Fleming M, Stockton D, Wood R. Informing the early years' agenda in Scotland: understanding infant feeding patterns using linked datasets. J Epidemiol Community Health 2014;68:83-92.
17. Scottish Government. Scottish Index of Multiple Deprivation. http://www.scotland.gov.uk/Topics/Statistics/SIMD. Accessed August, 2013.
18. Mateos P, Longley P, Webber R. The cultural, ethnic and linguistic classification of populations and neighbourhoods using personal names. London: University College London, Centre for Advanced Spatial Analysis; 2007. CASA Working Paper 116.
19. Howie PW, Forsyth JS, Ogston SA, Clark S, Florey CD. Protective effect of breastfeeding against infection. BMJ 1990;300:11-6.
20. Duijts L, Ramadhani MK, Moll HA. Breastfeeding protects against infectious diseases during infancy in industrialized countries. A systematic review. Matern Child Nutr 2009;5:199-210.
21. Yorita KL, Holman RC, Sejvar JJ, Steiner CA, Schonberger LB. Infectious disease hospitalizations amongst infants in the United States. Pediatrics 2008;121:244-52.
22. Quigley MA, Kelly YJ, Sacker A. Breastfeeding and hospitalisation for diarrhoeal and respiratory infections in the United Kingdom Millennium Cohort Study. Pediatrics 2007;119:e837-42.

23. Ladomenou F, Kafatos A, Tselentis Y, Galanakis E. Predisposing factors for acute otitis media in infancy. J Infect 2010;61:49-53.
24. Pisacane A, Continisio P, Palma O, Cataldo S, De Michele F, Vario U. Breastfeeding and the risk of fever after immunisation. Pediatrics 2010;125:e1448-52.
25. Zhu Q, Li Y, Han Q. Prolonged exclusive breastfeeding, autumn birth and increased gestational age area associated with lower risk of fever in children with hand, foot and mouth disease. Eur J Clin Microbiol Infect Dis 2012;31:2197-202.
26. Kull I, Wickman M, Lilja G, Nordvall SL, Pershagen G. Breastfeeding and allergic diseases in infants—a prospective cohort study. Arch Dis Child 2002;87:478-81.
27. Karmus W, Davis S, Chen Q, Kuehr J, Kruse H. Atopic manifestations, breastfeeding protection and adverse effect of DDE. Pediat Perinat Epidemiol 2003;17:212-20.
28. Oddy WH, Holt PG, Sly PD, Read AW, Landau LI, Stanley FJ, et al. Association between breastfeeding and asthma in 6 year old children: findings from a prospective birth cohort. BMJ 1999;319:815-9.
29. Cardwell CR, Stene LC, Ludvigsson J. Breastfeeding and the childhood onset Type 1 Diabetes: a pooled analysis of individual participant data from 43 observational studies. Diabetes Care 2012;35:2215-25.
30. Patelarou E, Girvalaki C, Brokalaki H, Patelarou A, Androulaki Z, Vardavas C. Current evidence on the association of breastfeeding, infant formula and cow's milk introduction with type 1 diabetes mellitus: a systematic review. Nutr Rev 2012;70:509-19.
31. Tiano AVP, Moimaz S, Saliba NA. Dental caries prevalence in children up to 36 months attending daycare centres in municipalities with different water fluoride content. J Appl Oral Sci 2009;17:39-44.
32. Nairnar SMH, Mohammed S. Role of infant feeding practices on the dental health of children. Clin Pediatr 2004;43:129-33.
33. Gribble KD. Mechanisms behind breastmilk's protection against and artificial baby milk facilitation of diarrhoeal illness. Breastfeed Rev 2011;19:19-26.
34. Ladomenou F, Moschandreas J, Kafatos A, Tselentis Y, Galanakis E. Protective effect of exclusive breastfeeding against infections during infancy: a prospective study. Arch Dis Child 2010;95:1004-8.
35. Tarrant M, Kwok MK, Lam TH, Leung GM, Schooling CM. Breastfeeding and childhood hospitalizations for infection. Epidemiology 2010;21:847-54.
36. Boyle EM, Poulsen G, Field DJ. Effects of gestational age at birth on health outcomes at 3 and 5 years of age: population based cohort study. BMJ 2012;344:e896.
37. Misak Z. Infant nutrition and allergy. Proc Nutr Soc 2011;70:465-71.
38. Matheson MC, Erbas B, Balasuriya A, Jenkins MA, Wharton CL, Tang ML, et al. Breast-feeding and atopic disease: a cohort study from childhood to middle age. J Allergy Clin Immunol 2007;120:1051-7.
39. Rosenbacher D, Weyerman M, Beerman C, Bremar H. Breastfeeding, soluble CD14 concentration in breast milk and risk of atopic dermatitis and asthma in early childhood: birth cohort study. Clin Exp Allergy 2005;35:1014-21.
40. Yang YW, Tsai CL, Lu CY. Exclusive breastfeeding and incident atopic dermatitis in childhood: a systematic review and meta-analysis of prospective cohort studies. Br J Dermatol 2009;161:373-83.
41. Risch A. Breastfeeding and atopic dermatitis. Pediatrics 2012;130:e461-2.
42. Lucas A, Brooke OG, Morley R, Cole TJ, Bamford MF. Early diet of preterm infants and development of allergic or atopic disease: randomised prospective study. BMJ 1990;300:837-40.
43. Williams HC, Strachan DP, Hay RJ. Childhood eczema: disease of the advantaged. Br Med J 1994;304:1132-5.
44. Subbarao P, Mandhane PJ, Sears MR. Asthma, epidemiology, etiology and risk factors. CMAJ 2009;180:e181-90.
45. Keele L. Proportionally difficult: testing for nonproportional hazards in Cox models. Political Analysis 2010;18:189-205.
46. Gilchirst I, Rosenberg K. Hospital admission in the first year of life. Health Bull 1986;44:29-36.

Appendix

Additional members of the Glasgow Centre for Population Health Breastfeeding Project Steering Group include: James Egan, BA, Mres (Glasgow Centre for Population Health), Judith Tait, Bcom (Information Services Division, National Health Services National Services Scotland), Kate Woodman, BA, PhD (National Health Services Health Scotland), and Helen Yewdall, BA, MPhil, RGN, RHV (Scottish Government).

Table I. ICD-10 codes for selected outcomes

Ill health condition	ICD-10 codes (main diagnoses)
Gastrointestinal infections	A02, A03, A04, A05, A06, A08, A09X, K529, K521, K522, K528, P783, R11X, P920
Upper respiratory tract infections	J00X, J01, J02, J03, J04, J05, J06, J101, J111
Lower respiratory tract infections	J10, J11, J12, J13X, J14X, J15, J16, J17, J18, J20, J22X, R062, J100, J110, J40X, J41, J42X, R05X
Urinary tract infections	N390, N30, N34
Otitis media	H65, H66, H67
Asthma	J45, J46X
Allergy	T784, T781, T887, J301, J302, J303, J304, J450, L23, K522, T780, T782, T783, T886
Eczema	L20, L21, L22X, L23, L24, L25, L26X, L27, L28, L29, L30
Diabetes	E10, E11, E12, E14, E14, P702
Fever	R560, R509
Dental caries	K029

ICD-10, International Classification of Diseases, 10th revision.

Table II. Cohort characteristics and rates of infant feeding and hospital admission

	Cohort		Infant feeding at 6-8 wk (rates)			
	N	%	Excl breastfeeding, %	Mixed feeding, %	Formula feeding, %	Rate of admission, %
Maternal age, y						
Less than 20	40 127	8	6	3	90	36
20-24	91 135	18	14	6	81	33
25-29	133 101	26	25	9	66	28
30-34	147 436	29	36	11	54	24
35-39	76 617	15	39	12	49	23
40+ years	13 870	3	41	13	47	22
Area deprivation						
SIMD A Least deprived quintile	87 674	17	45	12	42	21
SIMD B	86 574	17	38	11	51	24
SIMD C	87 358	17	29	9	62	26
SIMD D	104 587	21	21	8	72	29
SIMD E most deprived quintile	136 751	27	13	6	81	33
Mother's country of birth						
British	462 627	92	25	8	67	28
Non-British	40 305	8	49	19	32	20
Mother's socioeconomic status						
Higher manger/professional	139 430	28	47	12	41	22
Intermediate	115 032	23	26	9	65	26
Semiroutine/routine	142 718	28	15	6	79	31
Student	8963	2	23	10	67	26
Other/unknown	96 805	19	19	7	74	32
Father's socioeconomic status						
Higher manger/professional	146 605	29	45	12	43	22
Intermediate	83 850	17	32	10	58	25
Semiroutine/routine	220 571	44	17	7	76	31
Student	5358	1	36	13	50	22
Other/unknown	46 564	9	11	5	83	35
Marital status						
Married	272 231	54	37	11	52	24
Cohabiting	146 831	29	19	7	73	29
Single/parents living apart	83 886	17	9	4	87	35
Parity						
No siblings/first child	224 370	45	26	9	64	27
One sibling	164 987	33	28	8	63	27
2 or more (to 16 siblings)	94 812	19	27	8	65	29
Other/unknown	18 779	4	31	10	60	25
Maternal smoking						
Nonsmoker	356 865	71	33	10	57	25
Smoker	110 512	22	9	5	86	35
Other/unknown	35 571	7	28	8	64	29
Neonatal admission						
Not admitted	434 819	86	28	9	63	27
Admitted for up to 48 h	15 742	3	23	8	70	33
Admitted for more than 48 h	20 403	4	19	9	72	37
Other/unknown	31 984	6	29	10	61	28
Mode of delivery						
Normal/spontaneous	318 442	63	28	8	64	28
Instrumental	60 025	12	29	10	61	26
Breech births	1037	0.2	22	9	69	33
Cesarean, elective	42 160	8	26	10	65	28
Cesarean, emergency	65 963	13	25	10	65	28
Other/unknown	79	0.0	25	13	62	18
Maternal religious background						
Christian	477 941	95	27	8	65	28
Muslim	13 793	3	37	25	38	26
Buddhist	3120	1	41	19	40	19
Sikh	1346	0.3	50	24	26	18
Hindu	1397	0.3	29	19	52	22
Jewish	316	0.1	34	13	53	22
Other	5035	1	37	16	47	23

Excl, exclusive; *SIMD*, Scottish Index of Multiple Deprivation.

Table III. Risk of hospitalization for specific childhood conditions (1997-2009 birth cohort)*

Parental, maternity, and infant health variables	Follow-up period, HR (95% CI) 6 mo	6-27 mo	Full follow-up
Feeding at 6-8 wk			
Excl breastfeeding	1.00	1.00	1.00
Mixed feeding	1.18 (1.11-1.25)	***1.11 (1.07-1.15)***	1.11 (1.08-1.14)
Formula feeding	1.40 (1.35-1.45)	***1.18 (1.15-1.21)***	1.24 (1.22-1.26)
Sex			
Male	1.00	1.00	1.00
Female	–	0.80 (0.78-0.81)	0.84 (0.83-0.85)
Maternal age range, y			
Less than 20	1.00	1.00	1.00
20-24	0.87 (0.82-0.91)	**0.99 (0.95-1.03)**	0.97 (0.95-0.99)
25-29	0.69 (0.65-0.73)	0.94 (0.90-0.97)	0.90 (0.88-0.92)
30-34	0.60 (0.57-0.64)	0.87 (0.83-0.91)	0.84 (0.82-0.86)
35-39	0.53 (0.50-0.57)	0.83 (0.79-0.87)	0.81 (0.79-0.83)
40+	0.44 (0.40-0.49)	0.81 (0.76-0.88)	0.78 (0.75-0.82)
Area deprivation			
SIMD A_Least deprived quintile	1.00	1.00	1.00
SIMD B	**1.04 (0.99-1.10)**	1.05 (1.02-1.09)	1.09 (1.07-1.12)
SIMD C	1.08 (1.03-1.14)	**1.01 (0.98-1.05)**	1.11 (1.08-1.13)
SIMD D	1.11 (1.06-1.17)	1.07 (1.03-1.10)	1.17 (1.15-1.20)
SIMD E_Most deprived quintile	1.11 (1.06-1.17)	**1.02 (0.99-1.06)**	1.19 (1.17-1.22)
Mother's country of birth			
British birth	1.00	1.00	1.00
Non-British birth	–	0.87 (0.83-0.91)	0.87 (0.84-0.89)
Father's country of birth			
British birth	1.00	1.00	1.00
Non-British birth	–	0.93 (0.88-0.97)	0.92 (0.89-0.94)
Other unknown	–	**1.05 (0.98-1.12)**	**1.02 (0.98-1.06)**
Mother's socioeconomic status			
Higher managerial/professional	1.00	1.00	1.00
Intermediate	**0.95 (0.91-0.99)**	**0.99 (0.96-1.02)**	1.02 (1.01-1.04)
Routine/semiroutine	**1.01 (0.97-1.05)**	**0.97 (0.94-1.00)**	1.09 (1.07-1.11)
Students	**0.98 (0.88-1.08)**	**0.95 (0.88-1.02)**	**0.99 (0.95-1.04)**
Not stated	1.08 (1.03-1.13)	0.93 (0.90-0.96)	1.09 (1.07-1.11)
Father's socioeconomic status			
Higher managerial/professional	1.00	1.00	1.00
Intermediate	1.05 (1.00-1.10)	**1.01 (0.98-1.04)**	1.07 (1.05-1.09)
Routine/semiroutine	1.08 (1.04-1.12)	1.06 (1.04-1.09)	1.17 (1.15-1.19)
Students	**0.99 (0.87-1.14)**	**0.94 (0.85-1.04)**	**0.94 (0.88-1.01)**
Not stated	1.16 (1.09-1.23)	**1.01 (0.95-1.08)**	1.12 (1.08-1.16)
Marital status			
Married	1.00	1.00	1.00
Cohabiting	**1.02 (0.99-1.06)**	1.04 (1.01-1.06)	1.04 (1.02-1.06)
Single/living apart	1.14 (1.09-1.19)	1.08 (1.04-1.12)	1.13 (1.11-1.15)
Maternal smoking status			
Nonsmoker	1.00	1.00	1.00
Smoker	–	1.05 (1.02-1.08)	1.11 (1.09-1.12)
Other unknown	–	0.87 (0.84-0.90)	**0.99 (0.96-1.01)**
Parity			
First birth	1.00	1.00	1.00
One sibling	1.46 (1.41-1.51)	**0.98 (0.96-1.01)**	1.04 (1.03-1.06)
2-16	1.70 (1.63-1.77)	**1.01 (0.98-1.04)**	1.10 (1.08-1.12)
Other unknown	1.47 (1.27-1.69)	1.13 (1.01-1.25)	1.10 (1.03-1.17)
Mode of delivery			
Normal/spontaneous delivery	1.00	1.00	1.00
Instrumental	**0.95 (0.91-0.99)**	**1.01 (0.97-1.04)**	**1.00 (0.98-1.02)**
Breech births	**0.90 (0.70-1.16)**	**1.18 (0.99-1.42)**	**1.04 (0.93-1.17)**
Cesarean emergency	1.24 (1.18-1.30)	1.18 (1.14-1.23)	1.14 (1.12-1.17)
Cesarean elective	1.06 (1.01-1.10)	1.10 (1.07-1.14)	1.06 (1.04-1.08)
Other unknown	**0.29 (0.04-2.06)**	**0.72 (0.30-1.74)**	**0.67 (0.38-1.18)**
Maternal religious background			
Christian	1.00	1.00	1.00
Muslim	–	**1.06 (0.99-1.14)**	1.18 (1.13-1.23)
Buddhist	–	0.82 (0.70-0.97)	**0.97 (0.88-1.07)**
Hindu	–	**0.92 (0.73-1.16)**	**0.92 (0.80-1.07)**
Sikh	–	**0.87 (0.70-1.08)**	**0.88 (0.78-1.00)**
Jewish	–	**0.92 (0.62-1.38)**	**0.84 (0.65-1.09)**
Other	–	0.85 (0.76-0.95)	**0.94 (0.88-1.00)**

(*continued*)

Table III. Continued

Parental, maternity, and infant health variables	Follow-up period, HR (95% CI) 6 mo	6-27 mo	Full follow-up
Weight/gestational age			
Normal weight/gestational age	1.00	1.00	1.00
Small for gestational age	–	1.06 (1.01-1.12)	1.05 (1.01-1.08)
Birth weight			
Greater than 2500 g	1.00	1.00	1.00
Less than 2500 g	1.16 (1.09-1.24)	1.10 (1.04-1.16)	1.08 (1.04-1.11)
Estimated gestation			
Normal	1.00	1.00	1.00
Preterm	1.45 (1.37-1.55)	1.30 (1.24-1.37)	1.19 (1.15-1.23)
Postterm	**0.72 (0.44-1.20)**	**0.88 (0.64-1.23)**	**0.99 (0.82-1.19)**
Neonatal admission			
Not admitted	1.00	1.00	1.00
Admitted to 48 h	1.18 (1.11-1.27)	1.12 (1.07-1.18)	1.14 (1.11-1.17)
Admitted >48 h	1.33 (1.25-1.42)	1.13 (1.08-1.19)	1.17 (1.14-1.21)
Other unknown	1.13 (1.05-1.21)	1.09 (1.03-1.14)	1.12 (1.09-1.16)
Baby friendly			
Not accredited	1.00	1.00	1.00
Fully accredited	–	0.68 (0.66-0.69)	–
Length of postnatal stay, d			
<2	1.00	1.00	1.00
3-5	0.96 (0.93-0.99)	0.94 (0.92-0.96)	0.97 (0.96-0.98)
6-20	**1.02 (0.96-1.09)**	**0.99 (0.94-1.04)**	**0.99 (0.96-1.02)**
Other unknown	**0.80 (0.59-1.08)**	**1.08 (0.90-1.30)**	**0.94 (0.83-1.08)**
Month of birth			
July-September	1.00	1.00	1.00
January-March	–	–	0.96 (0.94-0.97)
April-June	–	–	0.97 (0.95-0.98)
October-December	–	–	**1.01 (0.99-1.02)**

ISD, Information Services Division.
(–) refers to variables excluded from the model, variables in bold were not significant ($P > .05$) or violated the test of proportionality required for Cox analysis (bold and in italics).
Adjusted for infant feeding, area deprivation, infant sex, maternal age range, area deprivation, mother's country of birth, father's country of birth, mother's socioeconomic status, father's socio-economic status, marital status, maternal smoking status, parity, mode of delivery, maternal religious background, weight for gestational age, birth weight, estimated gestation, neonatal admission indicator, birth in baby friendly facility, maternal postnatal stay in hospital, month of birth.
*Selected conditions outlined in Table I.
Source: ISD Scotland linked data extract.