

Breastfeeding and Asthma in Young Children

Findings From a Population-Based Study

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Objective: To evaluate the association between breastfeeding and asthma in young Canadian children.

Methods: Baseline data from the National Longitudinal Survey of Children and Youth (a population-based study of child health and well-being) were used. A weighted sample of 331 100 (unweighted $n=2184$) children between the ages of 12 and 24 months, whose biological mother reported data on breastfeeding and asthma, were included. Outcomes included parental report of physician-diagnosed asthma and wheeze in the previous year. Breastfeeding was categorized by duration as follows: less than 2 months, 2 to 6 months, 7 to 9 months, and longer than 9 months. Logistic regression analyses were conducted with breastfeeding duration dichotomized at various cutoffs. Important potential confounders were considered in the adjusted analyses. Published statistical methods appropriate for the sampling strategy were used.

Results: The prevalence of asthma was 6.3%; and wheeze, 23.9%. Almost half of the children (44.0%) were breastfed for less than 2 months. After adjustment for smoking, low birth weight, low maternal education, and sex, a duration of breastfeeding for 9 months or less was found to be a risk factor for asthma (odds ratio, 2.39; 99% confidence interval, 0.95-6.03) and wheeze (odds ratio, 1.54; 99% confidence interval, 1.04-2.29). A dose-response effect was observed with breastfeeding duration.

Conclusions: A longer duration of breastfeeding appears to be protective against the development of asthma and wheeze in young children. More public health efforts should be directed toward increasing the initiation and duration of breastfeeding.

Arch Pediatr Adolesc Med. 2001;155:1261-1265

THE MORBIDITY of childhood asthma, when measured by health care use, is highest in the young, with children aged 1 to 4 years accounting for up to 50% of asthma emergency visits.¹ Studies² looking at hospital discharge data in Ontario, Canada, have shown that recent hospitalization rates for asthma have decreased in all age groups except for young children (4 years of age and younger). Although much progress has occurred in developing effective treatment regimens for the control of asthma,³ there is still no cure for asthma and little is known about how we can prevent this disease. In recent years, it has become evident that factors in early life may increase a child's susceptibility to developing asthma.⁴

Human breast milk is recognized to have many beneficial health effects.⁵ Because the etiology of asthma is multifactorial, with genetic predisposition, immunologic profile, and allergic sensitization playing major roles,⁶ it is biologically plausible

that breastfeeding may offer some protection against the occurrence of asthma by decreasing allergic sensitization and/or modulating the infant's immune system.⁷ From a public health point of view, even a small protective effect would be important to detect, because asthma is a highly prevalent chronic disease in children⁶ and breastfeeding rates are modifiable by postnatal support programs.⁸

Several recent birth cohort studies,⁹⁻¹³ evaluating the association between breastfeeding and asthma and/or other respiratory illnesses in children, have shown consistently protective effects, particularly with exclusive breastfeeding for more than 4 months. There has, however, been much controversy about the protective effect of breastfeeding against atopic diseases, particularly with asthma.¹⁴ This study evaluates the association between breastfeeding and asthma in young children, who experience significant morbidity with asthma,² in a Canadian population-based sample.

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PARTICIPANTS AND METHODS

Baseline data from the Canadian National Longitudinal Survey of Children and Youth cycle 1, collected in 1994 and 1995, were used in this study.¹⁵ The National Longitudinal Survey of Children and Youth is a prospective questionnaire designed to measure child development, health, and well-being. The total cycle 1 sample size consists of 22831 children from birth to the age of 11 years. A complex clustered sampling scheme was used to be representative of the Canadian childhood population. The clusters were designed to have sufficient sample sizes within large geographic areas and within 7 key age groupings, with an overemphasis on the youngest age groups (<2 years). Trained Statistics Canada, Ottawa, Ontario, surveyors went to households and administered standardized questionnaires to the person most knowledgeable about the child. The person most knowledgeable was the biological mother in 90% of the cases. The overall response rate to the survey was 86%, while response rates for health outcomes of children were 91% or more. Informed consent was obtained from the legal guardians and/or the child as appropriate. All children between the ages of 12 and 24 months, whose biological mother was the person most knowledgeable, were eligible for our study. Subjects missing breastfeeding or asthma data were excluded.

Asthma-related outcomes included parental report of wheeze within the previous year and physician diagnosis of asthma. The exposure variable of interest—duration of breastfeeding—was reported in 7 categories. Because a duration of less than 2 months is too short to expect any biological protective effect,¹⁴ the variable was recategorized into 4 levels for analysis: none or less than 2 months, 2 to 6 months, 7 to 9 months, and longer than 9 months. Breastfeeding was grouped as a binary variable, evaluating the influence of less than 2 months, 6 months or less, and 9 months or less of breastfeeding exposure. The exclusivity of breastfeeding and the introduction of solid foods were not measured in the survey.

Other exposures that were explored for possible confounding effects included prematurity (gestational age \leq 258 days), low birth weight (LBW) (<2500 g), postnatal household smoking (at least 1 spouse living in the child's home currently smoking), prenatal smoking (smoking at any time during the pregnancy), low maternal education (less than a high school graduate), low income (family income variable derived by Statistics Canada that accounts for household income and the number of people dependent on that income¹⁵; low income corresponds closely with poverty

levels in 1995¹⁶), day care (child is in a day care center—data were only available if the mother was in school or working, and missing data were coded as no day care), siblings (any residing in the household, including full, half, and step siblings), and parental asthma history (either the biological mother or the biological father had asthma ever diagnosed by a health professional). Data on parental history of asthma for the biological father were missing for 16% of the sample. These missing cases were recoded as negative for father's history of asthma in the combined parental asthma history variable. Recoding did not have a significant effect on any of the logistic modeling.

Statistics Canada's data publication guides were followed throughout all analyses¹⁵ and, thus, data were weighted up to the population level. Corrections for the effect of sampling design on variable estimates were produced using coefficients of variation derived by Statistics Canada.¹⁵ Demographic and other characteristics of the study population were tabulated to obtain a description of the population under study. Spearman rank correlations between covariates were examined. The Pearson χ^2 and unadjusted logistic regression were used to test the statistical significance of risk factors for asthma or wheeze and breastfeeding. All variables used in logistic regression modeling had coefficients of variation meeting Statistics Canada's quality standards. A sensitivity analysis was conducted to evaluate the influence of dichotomizing the breastfeeding duration exposure variable at different cutoff points. The effects of a breastfeeding duration of less than 2 months, 6 months or less, and 9 months or less were examined. Factors associated with asthma or wheeze and breastfeeding were considered confounders and, thus, put into multiple regression models to adjust for potential effects on the association between asthma or wheeze and breastfeeding exposure. Subjects missing data (<1% of the sample) were excluded from the multivariate analysis. Where covariates were highly correlated, only one was put into the adjusted model. Interactions with sex and parental asthma history were also explored.

The effect of a clustered sampling design cannot be fully adjusted for in our logistic regression analyses, as the clustering sample weights are not released by Statistics Canada for public use. We have used standardized individual sample weights (normalized with a mean of 1) to derive statistical estimates that preserve the original sample size of each group, and reduce the variance estimate bias effect.¹⁷ In addition, tests of significance for logistic regression were considered at $P < .01$ (instead of $P = .05$), to reduce variance estimate bias and partially correct for lack of sample design information.¹⁷

RESULTS

The 2184 subjects included in the study resulted in a sample size of 331 100 when weighted up to the population level. Restricting the analysis to those children whose biological mother completed the survey excluded 10% of the original sample. Another 1.7% of the subjects were excluded because of missing breastfeeding information. The characteristics of the children are shown in **Table 1**.

The prevalence of asthma was 6.3%; and wheeze, 23.9%. Almost half of the children (44.0%) were not breastfed or were breastfed for less than 2 months. An

unadjusted logistic regression analysis (**Table 2**) revealed that the duration of breastfeeding, male sex, parental asthma history, prenatal and postnatal smoking, prematurity, and LBW were all risk factors for asthma, and less strongly so for wheeze. The breastfeeding duration exhibited a dose-response effect in the unadjusted analysis. Low income and low maternal education were risk factors for asthma but not wheeze, and day care was a risk factor for wheeze but not asthma. Risk factors for not breastfeeding included prenatal and postnatal smoking, prematurity, LBW, low maternal education, and low income. Therefore, these potentially

Table 1. Characteristics of Canadian Children Aged 12 to 23 Months

Characteristic	No. (%) of Children (N = 331 100)*
Male sex	170 000 (51.3)
Breastfed, mo	
>9	56 000 (16.9)
7-9	39 400 (11.9)
2-6	89 900 (27.2)
0 or <2	145 800 (44.0)
Asthma	20 700 (6.3)
Wheeze	79 000 (23.9)
Parental asthma	
Mother asthmatic†	17 300 (5.2)
Father asthmatic†	13 100 (4.7)
Either parent asthmatic	26 200 (9.4)
Prenatal smoking	75 100 (22.9)
Postnatal household smoking	
No household smoking	181 300 (55.0)
Mother smokes	52 000 (15.8)
Spouse smokes	47 900 (14.6)
Both parents smoke	48 300 (14.7)
Low household income adequacy	70 900 (21.4)
Low maternal education	58 600 (17.7)
Prematurity	33 400 (10.1)
Low birth weight	20 600 (6.3)
Day care center‡	17 500 (5.3)
Siblings	
0	135 100 (40.8)
1	118 000 (35.6)
≥2	78 000 (23.6)

*The number of children is weighted, and values are rounded to the nearest 100; the unweighted n = 2184. Percentages are adjusted for missing data, and may not total 100 because of rounding.

†The coefficient of variation is between 16.6% and 33.3%, which is considered marginal by Statistics Canada, Ottawa, Ontario.

confounding variables were considered for inclusion in the adjusted model.

Based on an adjusted sensitivity analysis comparing results with less than 2 months vs 6 months or less vs 9 months or less of breastfeeding duration (**Table 3**), it appeared that breastfeeding only conferred a statistically significant (based on a level of $P < .01$, decided a priori) protective effect if done so for at least 9 months. Table 3 is also suggestive of a dose-response effect for breastfeeding duration. Future analyses were completed for breastfeeding exposure at the 9-month cutoff.

The final adjusted model for breastfeeding less than a full 9 months and asthma or wheeze is shown in **Table 4**. The adjusted odds ratio (OR) for breastfeeding was higher than the risk associated with smoking and asthma.

The inclusion of covariates was based in part on patterns of correlation. Prenatal and postnatal household smoking were strongly correlated ($r = 0.53$, $P < .001$). Because prenatal smoking had a stronger association with asthma or wheeze and breastfeeding, it was used in the adjusted model. Prematurity and LBW were also strongly correlated ($r = 0.51$, $P < .001$). Because LBW is inherently a more precise measure and had a stronger association with asthma or wheeze and breastfeeding, it was used in the final model. Low income and low maternal education were moderately correlated ($r = 0.36$, $P < .001$). Low maternal education had stronger associations with

Table 2. Unadjusted OR Estimates for Asthma and Wheeze in Children Aged 12 to 23 Months*

Characteristic	OR (99% CI)	
	Asthma	Wheeze
Breastfed, mo		
>9†	1.00	1.00
7-9	2.14 (0.68-6.73)	1.50 (0.89-2.53)‡
2-6	3.13 (1.18-8.25)§	1.86 (1.21-2.87)§
<2	3.35 (1.32-8.53)§	1.68 (1.12-2.53)§
Male sex	2.05 (1.26-3.32)§	1.46 (1.12-1.89)§
Parental asthma history	4.22 (2.32-7.66)§	2.96 (1.93-4.52)§
Parental smoking		
Prenatal	1.96 (1.21-3.17)§	1.59 (1.19-2.14)§
Postnatal	1.52 (0.96-2.40)‡	1.48 (1.14-1.92)§
Low household income adequacy	1.49 (0.90-2.48)‡	1.00 (0.73-1.37)
Low maternal education	3.11 (1.92-5.02)§	0.98 (0.70-1.38)
Prematurity	2.16 (1.19-3.93)§	1.53 (1.02-2.28)§
Low birth weight	3.80 (2.03-7.11)§	1.76 (1.08-2.85)§
Day care	1.48 (0.62-3.56)	2.48 (1.50-4.10)§
≥2 Siblings	1.18 (0.70-1.98)	0.77 (0.56-1.05)‡

*Based on n = 2144. OR indicates odds ratio; CI, confidence interval.

†Referent.

‡ $P < .05$, based on logistic regression using normalized weights.

§ $P < .001$, based on logistic regression using normalized weights.

||The coefficient of variation is marginal for reporting.

Table 3. Adjusted OR Estimates for Asthma and Wheeze by Various Thresholds of Breastfeeding Exposure*

Outcome Variable	Breastfeeding Duration, mo	% of Children	OR (99% CI)
Asthma	<2	44.0	1.11 (0.68-1.83)
	≤6	71.2	1.62 (0.86-3.08)†
	≤9	83.1	2.39 (0.95-6.03)†
Wheeze	<2	44.0	1.01 (0.77-1.33)
	≤6	71.2	1.34 (0.98-1.83)†
	≤9	83.1	1.54 (1.04-2.29)‡

*Based on n = 2144. The OR estimates are adjusted for sex, prenatal smoking, low maternal education, and low birth weight. Breastfeeding thresholds are not mutually exclusive of each other. OR indicates odds ratio; CI, confidence interval.

† $P < .05$, based on logistic regression using normalized weights.

‡ $P < .01$, based on logistic regression using normalized weights.

asthma and breastfeeding, and because adding low income did not change the breastfeeding effect, it was not included in the final model.

Day care, siblings, parental asthma history, and sex were not associated with breastfeeding. Because the main purpose of this study was to examine the association between breastfeeding and asthma, only those variables for which there was evidence of the potential for confounding were left in the final model, except sex. Although some investigators would point out that it is not necessary to include sex in the model because it is not a true confounder, sex has traditionally always been adjusted for in logistic models with health outcomes and is a known correlate of asthma; therefore, we kept it in the model. Exploratory analyses were performed to examine the influence of these nonconfounding variables on the adjusted model. Adding parental asthma history, day care, and sibling variables into

Table 4. Adjusted OR Estimates for Asthma and Wheeze in Children Aged 12 to 23 Months*

Variable	OR (99% CI)	
	Asthma	Wheeze
Breastfed, mo		
>9†	1.00	1.00
≤9	2.39 (0.95-6.03)‡	1.54 (1.04-2.29)§
Sex		
Female†	1.00	1.00
Male	2.23 (1.35-3.69)§	1.48 (1.14-1.94)§
Prenatal smoking		
No†	1.00	1.00
Yes	1.39 (0.83-2.34)	1.54 (1.13-2.10)§
Low maternal education		
High school graduation or higher†	1.00	1.00
Less than high school graduation	2.61 (1.57-4.36)§	0.84 (0.59-1.21)
Low birth weight (<2500 g)		
No†	1.00	1.00
Yes	3.57 (1.84-6.90)§	1.80 (1.10-2.94)§

*Based on n = 2144. OR indicates odds ratio; CI, confidence interval.

†Referent.

‡ $P < .05$, based on logistic regression using normalized weights.

§ $P < .01$, based on logistic regression using normalized weights.

the adjusted model did not change the OR estimates for breastfeeding significantly; thus, they were left out of the final model. No significant interactions between sex or parental asthma history and breastfeeding were found.

COMMENT

This study suggests that infant feeding practices may have an effect on the development of asthma or wheeze in children younger than 2 years. The effect of breastfeeding appears to be stronger with a longer duration (suggesting a dose-response effect). Although the association between the duration of breastfeeding and asthma does not quite reach our a priori conservatively defined statistical significance level of $P < .01$, it does show a clearly increasing protective effect with an increasing duration of breastfeeding. The association between breastfeeding for 9 months or less and wheeze does reach statistical significance at the $P < .01$ level, although it is weaker (OR, 2.39 vs 1.54 for asthma vs wheeze). This is not surprising, because the wheezing group will contain many children who have asthma or may develop asthma⁴ and has a larger group size to obtain statistical significance.

The relations found in this study are consistent with 5 other recent birth cohort studies that have looked at the association between asthma and/or wheeze in children and breastfeeding and also controlled for confounding influences. Oddy et al⁹ prospectively studied 2187 children from Western Australia, and after controlling for sex, gestational age, household smoking, and day care, they found that the introduction of milk other than breast milk before the age of 4 months was a risk factor at the age of 6 years for an asthma diagnosis by a physician (OR, 1.25; 95% confidence interval, 1.02-1.52) and for wheeze in the previous year (OR, 1.31; 95% confidence interval, 1.05-1.64).

They did not demonstrate a dose-response effect. Wilson et al¹⁰ examined 674 children from Dundee, Scotland, and after controlling for parental asthma, sex, and social class, they found that exclusive breastfeeding for at least 15 weeks resulted in decreased respiratory illness (defined as persistent cough, wheeze, or breathlessness) throughout childhood up to the age of 10 years. The association between breastfeeding and an asthma diagnosis was not statistically significant, but the influence was in the same direction as in our study. Tariq et al¹¹ also prospectively observed a birth cohort of 1218 children from the Isle of Wight, England, and found that formula feeding before the age of 3 months predisposed the child to asthma at the age of 4 years. Saarinen and Kajosaari¹² observed a smaller sample of 236 children from Finland and found persistence of a protective effect of breastfeeding against atopic outcomes, extending into adolescence. Finally, Wright et al¹³ prospectively observed 1246 healthy infants and found that breastfeeding was associated with lower rates of recurrent wheeze at the age of 6 years.

The magnitude of the breastfeeding effect at 6 months in our study (OR, 1.62; 99% confidence interval, 0.86-3.08) was consistent with that found in other studies⁹ and was as would be expected biologically (ie, an OR between 1.2 and 2.0).¹⁸ The magnitude at 9 months was surprisingly high (OR, 2.39; 99% confidence interval, 0.95-6.03); however, to our knowledge, other studies have not looked at the effect of breastfeeding this long. The protective effect of breastfeeding longer than 6 and 9 months was stronger than the effect of smoking on asthma (prenatally and postnatally) in the unadjusted and adjusted analyses. This was also shown in 2 previous studies.^{9,10}

Several studies have suggested that the influence of breastfeeding on atopic outcomes is modified in children of atopic mothers¹⁹ or in atopic children.^{13,20} We were not able to test these hypotheses in our study. A subanalysis in the group of children with parental asthma history could not be performed because of an inadequate sample size.

The high overall response rate for the survey (86%) and the random sampling procedure with clustering within geographic areas suggest that our sample is highly representative of the population and, thus, generalizable to young Canadian children. The prevalences of asthma and wheeze⁴ and breastfeeding²¹ are consistent with those reported in other North American studies, further validating the data. The risk factors for asthma and wheeze identified in this population are consistent with those reported previously for early childhood wheeze.⁴

One limitation of this study is that it is a secondary data analysis of a cross-sectional design using disease prevalence as the outcome. Mild or developing cases of asthma will be missed. There is also measurement error in the classification of disease and exposure because these are based on parental report. Wheezing is a heterogeneous disorder in childhood, with about half of the children who wheeze before the age of 3 years being only transient wheezers and half having persistent wheezing or asthma.⁴ With our state of knowledge, we are not able to predict which wheezers have asthma and which will outgrow their wheezing. Some of the children who have never wheezed by the age of 2 years may still develop

What This Study Adds

There has been increasing recognition that factors in early life influence the development of asthma. The relationship between breastfeeding and asthma has been controversial. To date, to our knowledge, no population-based studies have been conducted in this area; therefore, this study was designed to examine the association between breastfeeding and asthma in a North American population-based sample of young children.

This study shows that breastfeeding confers a protective effect against asthma and wheeze in the first 2 years of life, when the alveolar stage of lung development is ongoing. Furthermore, the association appears to be dose dependent, meaning that the longer a mother breastfeeds, the more protection is offered to the child. This study highlights the importance of promoting breastfeeding as a public health intervention, as increasing population-based breastfeeding rates may modify the prevalence of asthma in young children.

asthma. Therefore, even if asthma were strictly and prospectively defined, there would still be misclassification in this young age group. Recall bias on breastfeeding duration has been minimized by using only the biological mother's reporting of this variable and by limiting the reporting to children younger than 2 years.

The greatest limitation of this study is the lack of finer assessments of breastfeeding duration (ie, by months) and information on breastfeeding exclusivity. It is possible that breastfeeding exclusivity is more important than the duration of breastfeeding; however, because the 2 are obviously highly correlated,⁹ it may be possible that we found an effect with the duration simply because of the correlation with exclusivity. We cannot exclude the possibility that a shorter duration of exclusive breastfeeding is more important than simply a longer duration of breastfeeding.

This study examines asthma and wheeze only in children younger than 2 years. It is possible that the protective effect of breastfeeding may disappear with age, ie, it may only delay the onset of asthma. Even if this is the case, it is still an important protective effect, because most of the morbidity and health care costs associated with asthma are in preschool-aged children.² Also, delaying the onset of disease may potentially result in decreased asthma severity.²²

CONCLUSIONS

To our knowledge, this is the first national population-based study to support that breastfeeding confers a protective effect against asthma and wheeze in young children. This protective effect increases with a longer duration of breastfeeding. The exact cutoff point for protection from breastfeeding cannot be established from this study, but when considering all of the available evidence, it is likely a continuous effect that becomes meaningful at a population level after at least 4 to 6 months of breastfeeding. The effect of exclusivity of breastfeeding warrants further investigation. Regardless, this study supports the saying that "breast is best." Strengthening public health efforts to increase the rates and duration of breastfeeding may help

decrease asthma and wheeze prevalence and related morbidity in young children. Further population-based studies examining the effects of breastfeeding on asthma outcomes in older children should be conducted.

Accepted for publication May 16, 2001.

This study was supported by the Research Institute, The Hospital for Sick Children, Toronto, Ontario.

We thank David Ip, BSc, for his help with the statistical analysis; and Suzanne M. Cadarette, MSc, for her help in multiple steps of the study.

This analysis is based on Statistics Canada microdata tape National Longitudinal Survey of Children and Youth, which contains anonymous data collected in the 1994-1995 special survey. All computations on these microdata were prepared by the Research Institute, The Hospital for Sick Children, and the responsibility for the use and interpretation of these data is entirely that of the authors.

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