

ORIGINAL ARTICLE

Reduced risk of physician-diagnosed asthma among children dwelling in a farming environment

WILLIAM K. MIDODZI,¹ BRIAN H. ROWE,² CARINA M. MAJAESIC³ AND AMBIKAIPAKAN SENTHILSELVAN¹

¹Department of Public Health Sciences, School of Public Health, and Departments of ²Emergency Medicine and ³Pediatrics, University of Alberta, Edmonton, Alberta, Canada

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Background and objective: Living in a farm environment has been reported to be associated with lower prevalence of asthma, based on the results of cross-sectional studies. The objective of this longitudinal study was to determine whether living in a farm environment is associated with lower incidence of asthma among children.

Methods: A total of 13 524 asthma-free children aged 0–11 years were drawn from the Cycle 1 (1994/1995) of the Canadian National Longitudinal Survey of Children and Youth (NLSCY). Subjects were categorized as dwelling in rural farming, rural non-farming and non-rural environments. Incidence of physician-diagnosed asthma was determined at Cycle 2 (1996/1997). Bootstrap logistic regression method was used to adjust for design effect in the NLSCY.

Results: The 2-year cumulative incidence of asthma was 2.3%, 5.3% and 5.7% among children living in farming, rural non-farming and non-rural environments, respectively. From the multivariate analysis with adjustment for important confounders, children from a farming environment had a reduced risk of asthma compared with children from rural non-farming environment with odds ratios (OR) of 0.22 (95% CI: 0.07–0.74) and 0.39 (95% CI: 0.24–0.65) for children with and without parental history of asthma, respectively. Children living in a non-rural environment with parental history of asthma had an increased risk of asthma incidence when compared with children living in rural non-farming environment (OR = 2.51, 95% CI: 1.56–4.05).

Conclusion: This longitudinal study expands on observational study results which suggest a reduced risk of developing asthma associated with living in a farming environment.

Key words: asthma, farming, NLSCY, rural, urban.

INTRODUCTION

Asthma is a common chronic condition among children and adults. Several cross-sectional studies have suggested that residing within a farm environment reduces the risk of allergic diseases among children^{1–4}

and adults⁵ while other cross-sectional studies have shown that early childhood exposure to a farm environment may reduce the risk of asthma and allergic sensitization during adulthood.^{6,7} Children living in farm environments had a lower risk of hay fever, allergic sensitization and/or asthma in studies conducted in Switzerland,¹ Austria,² Germany,³ New Zealand.⁴ In a cross-sectional study of a rural town in Canada, adolescents residing on a farm had a lower prevalence of asthma and atopy than non-farm adolescents.⁸ The 'hygiene hypothesis' has been proposed as a possible explanation for the lower proportions of asthma and allergy among rural and farming populations and for higher proportions among urban populations.^{9,10}

Despite knowledge of the associations observed in these studies, it was not possible to ascertain whether exposures preceded the development of asthma due to the cross-sectional nature of these studies. Accordingly, this prospective study has been conducted to

Correspondence: Ambikaipakan Senthilselvan, Department of Public Health Sciences, School of Public Health, University of Alberta, 13-106B Clinical Science Building, Edmonton, Alberta, Canada T6G 2G3. Email: sentil@ualberta.ca

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investigate the protective effect of living in farming environment on the incidence of asthma among children after adjusting for several independent confounding factors. The study sample was drawn from the National Longitudinal Survey of Children and Youth (NLSCY) conducted in Canada.¹¹ To the best of our knowledge, no prospective longitudinal study has yet been conducted to examine the relationship between developing childhood asthma and living in farm environments.

METHODS

Cohort and study design

The initial NLSCY was conducted by Statistics Canada in 1994/95 among 22 831 children of ages 0–11 years from the 10 provinces in Canada. The details of the NLSCY have been published elsewhere in the micro-data user's guide.¹¹ Trained interviewers administered the survey in person to the household member or person most knowledgeable (PMK) about the child (mother: 91.3%; father: 8.2%; non-parent: 0.5%). To reduce the survey burden to the PMK, a maximum of two children were randomly drawn from each household reducing the sample size to 16 903 children for the longitudinal follow up. Of these children, 15 648 were followed up in Cycle 2 (1996/1997) with a response rate of 91.5%. For the present analysis, all children who had a history of asthma and/or wheeze at Cycle 1 and whose parents failed to complete the question about physician-diagnosed asthma in Cycle 1 and/or Cycle 2 were excluded. These exclusions left 13 524 children from 9441 households for the analysis. At each cycle, the questionnaires sought information about children, parents and household characteristics. Statistics Canada gave consent for this study to be performed using confidential micro data from the NLSCY survey, and the study was approved by the Health Research Ethics Board at the University of Alberta, Edmonton, Canada.

Outcome and independent variables

In the NLSCY, the possible responses included asthma and other chronic conditions. In the present study, the PMK was asked the question 'Does this child have asthma that has been diagnosed by a Health Professional?' An affirmative response to this question at Cycle 2 was used to determine *incidence of asthma*. This question was followed by the question on wheeze and asthma attacks in the last 12 months.

The main independent variable was the neighbourhood environment of each household as reported at Cycle 1. The classifications were provided by trained interviewers from Statistics Canada conducting the NLSCY using the following close-ended question: 'Based on street level frontage, how would you characterize land use on this block/road?' Except for the responses 'primarily rural, farming' and 'primarily rural, residential', all other responses were grouped into a new category 'non-rural' which resulted in

three categories of the study variable, namely, 'primarily rural, farming', 'primarily rural, non-farming' and 'non-rural'. These three categories will be referred to as farming, rural non-farming and non-rural environments in this manuscript. Of the 9441 households which were considered in this analysis, 10.5% were from rural farming environment, 8.1% were from rural non-farming environment, and the remaining (81.4%) were from non-rural environment.

Several other baseline factors were selected based upon review of an extensive list of epidemiologic studies on known risk factors for asthma and wheeze.^{12–16} The factors considered in the study included age, gender, child's allergy, number of physician or paediatrician visits made in the past 12 months, health status, maternal age at birth, presence of older siblings, family history of asthma, immigrant parent, parental smoking, home needing repairs, socioeconomic status (SES) and geographic region. A dwelling unit was termed as needing repairs if there were major or minor repairs required at the time of the survey. A crowding index was derived from the number of persons per bedroom in the household. An index of SES was derived by Statistics Canada¹⁷ for each child based on parents' occupation, educational level and economic position. Information about country of birth and ethnicity of the children were collected in the survey but were not released to the researchers due to confidentiality concerns. A variable indicating whether mother was a migrant to Canada or not was used as a surrogate for ethnicity.

Statistical analysis

To account for the complex sampling design of the NLSCY, all statistical analyses were performed with SUDAAN callable procedures in SAS software.^{18,19} All survey responses used in the analysis were weighted using longitudinal weights provided by Statistics Canada at Cycle 2. Statistics Canada also provided 1000 bootstrap weights for each child to account for the complex study design which included selection of more than one child from the same household.²⁰ These bootstrap weights were used in all the statistical analyses including univariate and multivariate analyses. As all the children in the cohort had a 2-year follow up and the main objective was to determine the baseline predictors of asthma incidence after a 2-year follow up, logistic regression was used for the analysis instead of proportional hazards regression which is usually used for the analysis of cohort studies. The results from two analyses were very similar.

Initially, to determine the differences in the distribution of baseline risk factors between living environments as sources of potential confounders, bivariate tests of association were performed using chi-squared statistics for categorical variable, and analysis of variance (ANOVA) for continuous variables. In the main analysis, the dependent variable was the outcome of asthma (presence or absence) and logistic regression was used to assess the association between

the outcome and independent variables.²¹ The variables that were significant in the univariate analysis were considered for the multivariate analysis. Interaction terms were examined between factors in the multivariate model and significant interactions were included in the multivariate model.

RESULTS

The sample cohort of 13 524 children comprised 1461 (7.39%) children from a farming environment, 1109 (5.67%) children from a rural non-farming environment and 10 954 (86.94%) children from a non-rural environment.

Table 1 shows the distribution of baseline characteristics of the cohort according to the three living environments. The distribution of age and gender, prevalence of childhood allergy and parental smoking, and proportion of mothers with age less than 20 years at child's birth were similar among the three living environments. Children from a non-rural environment had significantly more visits to family physicians and paediatricians within the previous 12 months than their counterparts from a rural environment. The Ontario region had the highest proportion of children living in rural non-farming and non-rural environments whereas the Prairie region had the highest proportion of children living in a farming environment. The proportion of children from single parent families was almost twofold higher in the non-rural environment than in the other two environments. The children from non-rural environment had the highest mean SES index.

The overall 2-year cumulative incidence of asthma in Canadian children aged 0–11 years was 5.6%. Among the children with asthma at Cycle 2, 70.8% reported an episode of wheeze in the previous 12 months whereas only 8.9% of the children without asthma reported an episode of wheeze in the previous 12 months. The incidence of asthma was significantly lower in children living in a farming environment (2.3%) than those children living in rural non-farming (5.3%) and non-rural (5.7%) environments (Table 2). The difference in asthma incidence between rural non-farming and non-rural environments was not statistically significant. The incidence of asthma decreased with increase in age and was higher in men than in women.

The incidence rate was lower for children with a parental history of asthma than those without a parental history in farming and rural non-farming environments (Fig. 1). This pattern was reversed for children living in the non-rural environment with higher asthma incidence for children who had a family history of asthma than those who did not (Fig. 1). In the univariate analysis, children from a farming environment had a significantly reduced risk of asthma incidence compared with the children from rural non-farming environment (Table 2). The unadjusted odds ratios (OR) for the association between living environment and asthma incidence were 0.41 (95% CI: 0.24–0.70) and 1.08 (95% CI: 0.74–1.57) for children from farming and non-rural environments,

respectively. The protective effect of living in a farm environment on the incidence of asthma that was observed in univariate analysis was reinforced in the multivariate analysis, even after controlling for potential confounders (Table 2).

In subsequent analysis, the interaction between the living environment and each of the significant factors in the multivariate model were examined and only the interaction term between the living environment and parental asthma was statistically significant ($P = 0.04$). The interaction between living environment and geographical regions was statistically significant. Table 3 presents the results of the final multivariate logistic regression analysis which included significant factors and the interaction term between parental history of asthma and living environment. The protective effect of living in a farming environment for asthma incidence was seen in both children with and without a parental history of asthma (Table 3). The association between the farming environment and asthma incidence was lower when the children had a parental history of asthma (OR = 0.22; 95% CI: 0.07–0.74) than when they did not (OR = 0.39; 95% CI: 0.24–0.65). This pattern was reversed for children living in the non-rural environment. There was an increased risk of asthma incidence for children living in a non-rural environment in comparison to children living in rural non-farming environment with ORs of 2.51 (95% CI: 1.56–4.05) for children with a family history of asthma and 0.96 (95% CI: 0.65–1.43) for children without a family history of asthma (Table 3). In addition to the living environment, male gender, child's allergy, one or more visits to family physician, home needing repairs, residing in Atlantic region, higher SES and crowding index were significantly associated with incidence of asthma (Table 3).

The multivariate analysis was repeated with variables considered in Table 2 in age groups 0–1 years, 2–5 years and 6–11 years, respectively. The protective effect of living in farming environment for asthma incidence (in comparison to living in rural non-farming environment) observed for the whole sample was seen again in the stratified analysis with significant ORs in the age groups 0–1 years (OR = 0.34, 95% CI: 0.13–0.91), 2–5 years (OR = 0.20, 95% CI: 0.09–0.46); however, not for the ages of 6–11 years (OR = 0.73, 95% CI: 0.33–1.63).

DISCUSSION

In this Canada-wide population-based study, the 2-year cumulative incidence of asthma was lower in children living in a farming environment than those living in rural non-farming and non-rural environments. The protective effect of living in a farming environment for asthma incidence was observed in both children with and without a parental history of asthma. On the other hand, living in a non-rural area was a risk factor for asthma, but only in those children with a parental history of asthma.

In a study conducted in Northern Sweden during the same period as in this study, the 2-year cumulative incidence of asthma was 1.7% among children of ages

Table 1 Distribution of baseline characteristics of the cohort study by living environment^{†‡}

Characteristics	Total	Non-rural	Rural non-farming	Rural farming	P-value*
Participants, N	13 524 (100.0%)	10 954 (86.94%)	1 109 (5.67%)	1 461 (7.39%)	
Age, year groups (%)					
0–1	17.35	17.72	12.76	16.48	<0.008
2–5	34.38	34.39	34.80	33.86	
6–11	48.28	47.89	52.43	49.66	
Gender (%)					
Male	50.01	49.84	51.26	51.10	0.69
Female	49.99	50.16	48.74	48.90	
Child allergy (%)					
Yes	11.31	11.24	11.44	12.03	0.57
No	88.68	88.75	88.56	87.94	
Child's health status (%)					
Rated low	9.08	9.07	8.91	9.39	0.96
Rated high	90.92	90.93	91.09	90.61	
No. of paediatrician visits (%)					
None	74.20	72.38	86.63	86.14	<0.01
One or more	25.80	27.62	13.37	13.86	
No. of physician visits (%)					
None	30.47	30.54	30.06	29.84	0.22
One	37.91	37.26	44.41	40.57	
Two or more	31.63	32.20	25.53	29.69	
Mother's age at child's birth (%)					
Less than 20 years	3.21	3.23	3.62	2.68	0.55
Greater than 20 years	96.79	96.77	96.38	97.32	
Older sibling (%)					
1 or more	44.72	45.92	38.89	34.95	<0.001
None	55.26	54.06	61.11	65.4	
Parental history of asthma (%)					
Yes	7.50	7.59	8.54	5.81	0.02
No	92.50	92.41	91.46	94.19	
Single parent (%)					
Yes	15.22	16.36	8.52	6.3	<0.001
No	84.78	83.64	91.48	93.10	
Immigrant mother (%)					
Yes	17.52	19.18	6.94	6.04	<0.001
No	81.20	79.45	92.35	93.25	
Either parent smokes (%)					
Yes	34.40	34.16	36.11	35.95	0.001
No	56.75	56.44	58.44	59.13	
Home needing repairs (%)					
Yes	23.60	22.13	29.30	36.69	<0.001
No	76.40	77.87	70.70	63.31	
Geographic region (%)					
Atlantic	7.66	6.99	19.87	6.21	<0.001
Quebec	23.50	24.91	13.03	14.94	
Ontario	37.63	37.83	39.33	33.91	
British Columbia	12.60	12.85	14.27	8.24	
Prairies	18.61	17.42	13.52	36.69	
BMI (kg/m ²), mean (SD)	18.22 (0.07)	18.22 (0.08)	18.32 (0.18)	18.26 (0.16)	0.34
Socioeconomic index, mean (SD)	−0.07 (0.01)	−0.04 (0.01)	−0.18 (0.03)	−0.25 (0.03)	<0.001
Crowding index (no./room), mean (SD)	1.39 (0.01)	1.38 (0.02)	1.38 (0.02)	1.43 (0.03)	0.011

*P-values were obtained using 1000 bootstrap longitudinal weights at Cycle 2.

[†]Only children with complete information were included in the analysis.[‡]All data are weighted by normalized longitudinal weights at Cycle 2.

Table 2 Two-year cumulative asthma incidence, and odds ratios for baseline risk factors from univariate and multivariate analyses

Baseline factors	Incidence (%) [§]	Univariate analysis [†]		Multivariate analysis [‡]	
		Odds ratios (95% CI) [¶]	P-value	Odds ratios (95% CI) [¶]	P-value
Age (years)					
0–1	6.9	1.47 (1.10–1.97)	0.016	1.33 (0.89–2.00)	0.14
2–5	5.3	1.11 (0.83–1.47)	0.61	1.04 (0.81–1.33)	0.72
6–11	4.9	1.00		1.00	
Gender					
Male	6.5	1.49 (1.18–1.88)	0.001	1.54 (1.12–2.10)	0.012
Female	4.4	1.00		1.00	
Child allergies					
Yes	11.3	2.62 (1.91–3.60)	<0.001	2.35 (1.67–3.32)	<0.001
No	4.7	1.00		1.00	
Child's health status					
Rated low	7.6	1.52 (1.06–2.18)	0.02	1.23 (0.87–1.74)	0.21
Rated high	5.2	1.00		1.00	
No. of paediatrician visits					
One or more	5.87	1.12 (0.84–1.49)	0.429	1.15 (0.98–1.34)	0.07
None	5.26	1.00		1.00	
No. of physician visits					
Two or more	7.94	2.18 (1.16–2.95)	<0.001	1.84 (1.24–2.73)	0.007
One	4.63	1.23 (0.90–1.68)	0.201	1.24 (0.92–1.69)	0.139
None	3.80	1.00		1.00	
Mother's age at child's birth					
Less than 20 years	8.6	1.72 (1.04–2.85)	0.04	1.46 (0.60–3.54)	0.36
Greater than 20 years	5.3	1.00		1.00	
Older sibling					
1 or more	4.7	0.71 (0.56–0.91)	0.007	1.18 (0.87–1.61)	0.25
None	6.4	1.00		1.00	
Parental history of asthma					
Yes	11.4	2.52 (1.72–3.71)	<0.001	2.45 (1.65–3.62)	<0.001
No	4.8	1.00		1.00	
Immigrant mother					
Yes	4.9	0.87 (0.77–0.98)	0.04	1.08 (0.63–1.87)	0.75
No	5.5	1.00		1.00	
Either parent smoked					
Yes	6.3	1.21 (0.95–1.55)	0.12	1.13 (0.76–1.69)	0.50
No	5.2	1.00		1.00	
Home needing repairs					
Yes	6.6	1.32 (1.00–1.74)	0.05	1.41 (1.00–1.96)	0.05
No	5.1	1.00		1.00	
Geographic region					
Atlantic	7.8	1.59 (1.19–2.12)	0.002	1.63 (1.09–2.44)	0.022
Quebec	4.9	0.95 (0.65–1.39)	0.79	0.96 (0.61–1.52)	0.85
Ontario	6.0	1.17 (0.85–1.60)	0.34	1.14 (0.79–1.64)	0.44
British Columbia	3.6	0.71 (0.46–1.10)	0.12	0.67 (0.44–1.00)	0.04
Prairies	5.2	1.00		1.00	
Neighbourhood environment					
Non-rural	5.7	1.08 (0.74–1.57)	0.68	1.19 (0.83–1.70)	0.30
Farming	2.3	0.41 (0.24–0.70)	0.001	0.47 (0.35–0.64)	0.001
Rural non-farming	5.3	1.0		1.00	
BMI (kg/m ²) ^{††}	—	1.00 (0.98–1.02)	0.80	1.00 (0.99–1.02)	0.94
Socioeconomic status ^{††}	—	0.85 (0.73–0.98)	0.02	0.85 (0.71–1.01)	0.08
Crowding index [‡]	—	0.69 (0.52–0.93)	0.013	0.76 (0.53–1.07)	0.09

[†]In the univariate analysis, each variable was included one at a time in the model.

[‡]In the multivariate analysis, all the variables listed in the table were included in model.

[§]Rates were weighted by normalized longitudinal weights at Cycle 2.

[¶]95% confidence interval and P-value were estimated using 1000 bootstrap longitudinal weight at Cycle 2.

^{††}Cumulative incidence is not given for continuous variables.

Figure 1 Cumulative incidence of asthma by living environment and parental history of asthma in Canadian children of ages 0–11 years. The *P*-values were obtained from chi-squared tests using the bootstrap weights. (■) Presence of parental history of asthma, (▨) absence of parental history of asthma.

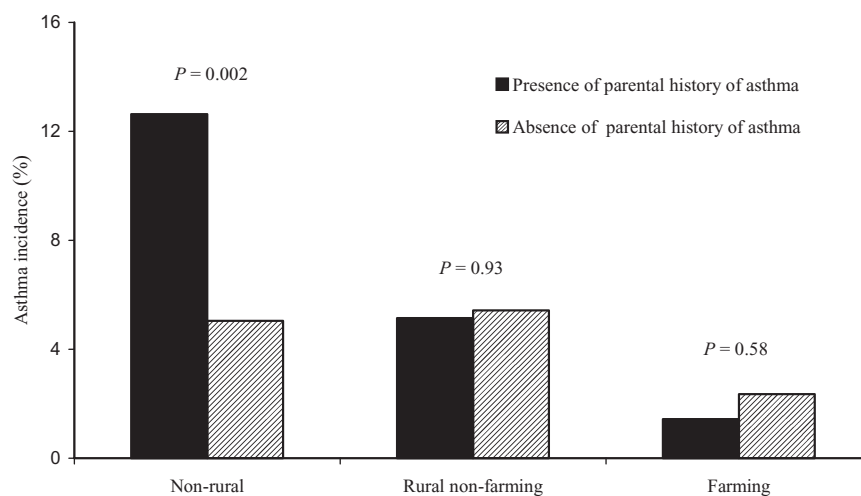


Table 3 Final model including significant factors and an interaction term^{†‡}

Risk factors	Odds ratios (95% CI) [‡]	<i>P</i> -value [‡]
Gender		
Male	1.48 (1.15–1.91)	0.002
Female	1.00	
Child's allergy		
Yes	2.41 (1.73–3.35)	<0.001
No	1.00	
No. of physician visits		
Two or more	2.11 (1.55–2.88)	<0.001
One	1.31 (0.93–1.84)	0.12
None	1.00	
Home needing repairs		
Yes	1.36 (1.02–1.82)	0.03
No	1.00	
Geographic region		
Atlantic	1.52 (1.13–2.04)	0.005
Quebec	1.05 (0.74–1.49)	0.80
Ontario	1.18 (0.85–1.63)	0.32
British Columbia	0.64 (0.42–1.03)	0.07
Prairies	1.00	
Environment and parental history of asthma [§]		
Presence of parental asthma		
Non-rural	2.51 (1.56–4.05)	<0.001
Rural farming	0.22 (0.07–0.74)	0.02
Rural non-farming	0.81 (0.21–3.16)	0.82
No parental asthma		
Non-rural	0.96 (0.65–1.43)	0.85
Rural farming	0.39 (0.24–0.65)	0.001
Rural non-farming	1.00	
Socioeconomic index	0.83 (0.72–0.96)	0.01
Crowding index	0.65 (0.48–0.89)	0.007

[†]Complete observations were available for 11 751 children.

[‡]95% CI and *P*-value were estimated using 1000 longitudinal bootstrap weights at Cycle.

[§]Rural non-farming and no parental asthma was the reference category for all odds ratios.

7 and 8 years,²² which was lower than that observed for the Canadian children in same age group (5.3%). Asthma prevalence has been reported to be higher in Western countries than in developing countries.²³ In several studies, this differential risk of asthma has been noted between the urban and the rural living environment, with a higher risk often reported for urban living.^{24–26} These observed differences among living environments and geographic regions suggests that exposure to environmental factors are critical to the development of asthma. In the present study, use of the rural non-farming environment as the reference has ruled out the possibility that the decreased risk of asthma incidence in the farming environment might have been due to the increased risk of asthma observed in urban environments.²⁵

The lower prevalence of asthma and/or other allergic diseases among farm dwellers has been reported in other cross-sectional studies conducted in Canada, Europe and New Zealand for children,^{1–4} adolescents⁸ as well as adults.^{5–7} Children whose parents had farming as their occupation had a reduced risk of sneezing attacks during pollen season and atopic sensitization in a cross-sectional study conducted in Switzerland.¹ Children living in a farm environment had a reduced risk of hay fever and asthma, and children who had regular contact with farm animals had a reduced risk of atopic sensitization in a cross-sectional study conducted in Austria.² In a cross-sectional survey conducted in Germany, the reduced risk for hay fever, asthma and wheeze was stronger for children whose parents were full-time farmers compared with children whose parents were part-time farmers.³ In a cross-sectional study of children aged 7–10 years conducted in New Zealand, current farm residence was associated with an increased risk of allergic symptoms whereas early life animal exposures were associated with a reduced risk of hay fever, skin-test positivity and asthma.⁴ In the present study, children of ages 0–1 years and 2–5 years had a stronger protective effect of living in a farm environment for asthma incidence than children in the older age group of 6–11 years. These differences in the strength

of protective effects between the age groups may be related to exposure to the farm environment including animals earlier in their life for the younger age-group children in comparison to the farm exposure later in life for the older age-group children.

The 'Hygiene Hypothesis' has often been cited as a possible explanation for the decreased risk of allergic diseases in farming and rural populations.^{9,10,27} According to this hypothesis, lack of early childhood exposure to infectious agents and oro-faecal pathogens results in insufficient production of T helper type 1 cells, which in turn, increases the production of T helper type 2 cells and results in increased risk of allergic diseases in children and adults.²⁸ In the present study, dwelling in a farming environment was associated with a lower incidence of asthma but not allergy. The lack of an objective measure to determine allergy in the present study might be a possible reason for the absence of association between farming environment and allergy. Skin-prick tests were used to determine allergy in the majority of studies reporting reduced risk of allergy among children with farm exposure.^{1,2,4}

In the present study, a significant interaction was observed between parental history of asthma and the living environments. The reasons for the observed difference between rural and non-rural environments in the effect of parental asthma on the incidence of asthma in children are not known and are open to speculation. One possible reason for these observed results might be a higher prevalence of occupational asthma among parents residing in the rural environment; their children are not at a higher risk genetically of developing asthma. This possibility seems unlikely as a review article concluded that the prevalence of occupational asthma was not higher among farmers in comparison to the general population.²⁹ Another possible explanation for these findings is that asthma among children living in a farm environment might be Th1 mediated rather than Th2 mediated, resulting in nonallergic asthma which might be not associated with parental asthma.³⁰

The present study is not without limitations. First, the cumulative incidence of asthma was based on a parental report of physician-diagnosed asthma in the interviewer-administered questionnaire. A high proportion of children with asthma also reported an episode of wheezing in the previous 12 months indicating the parental report of physician diagnosed asthma has acceptable validity. In addition, the parental report has been a commonly used method to determine asthma outcomes among children in other epidemiological studies. Second, interviewers had to make a subjective judgement to determine if the street level land usage in front of the living was farming or rural non-farming environment in rural areas. Finally, the families could have moved between the rural and urban areas within the 2 years of follow up. The information on the dwelling environment was not collected at the end of the follow-up in Cycle 2. However, based on the information on children's dwelling centres (urban metropolitan, non-urban metropolitan, rural) which was collected at both cycles 1 and 2, over 99% of the children remained in

the same dwelling centres during follow up. Notwithstanding these concerns, this study indicated that children living in a farming environment had a lower risk of developing asthma than children living in a rural non-farming environment. The study extends the results that have been previously reported for asthma prevalence in cross-sectional studies to asthma incidence in a longitudinal study.

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REFERENCES

- Braun-Fahrlander CH, Gassner M, Grize L, Nue U, Sennhauser FH *et al.* Prevalence of hay fever and allergic sensitization in farmer's children and their peers living in the same rural community. *Clin. Exp. Allergy* 1999; **29**: 28–34.
- Riedler J, Eder W, Oberfeld G, Schreuer M. Austrian children living on a farm have less hay fever, asthma and allergic sensitization. *Clin. Exp. Allergy* 2000; **30**: 194–200.
- Von Ehrenstein OS, Von Mutius E, Illi S, Baumann L, Bohm O *et al.* Reduced risk of hay fever and asthma among children of farmers. *Clin. Exp. Allergy* 2000; **30**: 187–93.
- Wickens K, Lane JM, Fitzharris P, Siebers R, Riley G *et al.* Farm residence and exposures and the risk of allergic diseases in New Zealand children. *Allergy* 2002; **57**: 1171–9.
- Eduard W, Omenaas E, Bakke PS, Douwes J, Heederik D. Atopic and non-atopic asthma in a farming and a general population. *Am. J. Ind. Med.* 2004; **46**: 396–9.
- Leynaert B, Neukirch C, Jarvis D, Chinn S, Burney P *et al.* Does living on a farm during childhood protect against asthma, allergic rhinitis, and atopy in adulthood? *Am. J. Respir. Crit. Care Med.* 2001; **164**: 1829–34.
- Kilpelainen M, Terho EO, Helenius H, Koskenvuo M. Childhood farm environment and asthma and sensitization in young adulthood. *Allergy* 2002; **57**: 1130–5.
- Ernst P, Cormier Y. Relative scarcity of asthma and atopy among rural adolescents raised on a farm. *Am. J. Respir. Crit. Care Med.* 2000; **161**: 1563–6.
- Braun-Fahrlander C. Environmental exposure to endotoxin and other microbial products and the decreased risk of childhood atopy: evaluating developments since April 2002. *Curr. Opin. Allergy Clin. Immunol.* 2003; **3**: 325–9.
- Sheikh A, Strachan DP. The hygiene theory: fact or fiction? *Curr. Opin. Otolaryngol. Head Neck Surg.* 2004; **12**: 232–6.

- 11 Statistics Canada. *National Longitudinal Survey of Children and Youth (NLSCY): Overview of Survey Instruments for 1994–1995 Data Collection Cycle 1*. Catalogue no. 89F007878XIE. Statistics Canada, Ottawa, February 1995. [Accessed 26 October 2006.] Available from URL: <http://www.statcan.ca/english/rdc/whatdata.htm>
- 12 King ME, Mannino DM, Holguin F. Risk factors for asthma incidence. A review of recent prospective evidence. *Panminerva Med.* 2004; **46**: 97–110.
- 13 Lwebuga-Mukasa JS, Oyana TJ, Wydro P. Risk factors for asthma prevalence and chronic respiratory illnesses among residents of different neighbourhoods in Buffalo, New York. *J. Epidemiol. Community Health* 2004; **58**: 951–7.
- 14 Aligne CA, Auinger P, Byrd RS, Weitzman M. Risk factors for pediatric asthma. Contributions of poverty, race, and urban residence. *Am. J. Respir. Crit. Care Med.* 2000; **162**: 873–7.
- 15 Litonjua AA, Vj C, Weiss ST, Gold DR. Race, socio-economic factors, and area of residence are associated with asthma prevalence. *Pediatr. Pulmonol.* 1999; **28**: 394–401.
- 16 Schwartz J, Gold D, Dockery DW, Weiss ST, Speizer FE. Predictors of asthma and persistent wheeze in a national sample of children in the United States. Association with social class, perinatal events, and race. *Am. Rev. Respir. Dis.* 1990; **142**: 555–62.
- 17 Willms JD. *Vulnerable Children: Findings from Canada's National Longitudinal Survey of Children and Youth*. University of Alberta Press, Edmonton, 2002.
- 18 SAS Institute Inc. *SAS/STAT User's Guide*, Version 9.0 ed. SAS Institute, Inc., Cary, NC, 2003.
- 19 Research Triangle Institute. *SUDAAN Software*. Research Triangle Institute, Research Triangle Park, NC, 2003.
- 20 Yeo D, Harold M, Liu T. *Bootstrap Variance Estimation for the National Population Health Survey: Proceedings of the Survey Research Methods Section*. Paper presented at: American Statistical Association, 1999.
- 21 Hosmer D, Lemeshow S. *Applied Logistic Regression*. John Wiley & Sons, New York, 2000.
- 22 Ronmark E, Perzanowski M, Platts-Mills T, Lundback B. Incidence rates and risk factors for asthma among school children: a 2-year follow-up report from the obstructive lung disease in Northern Sweden (OLIN) studies. *Respir. Med.* 2002; **96**: 1006–13.
- 23 The International Study of Asthma and Allergies in Childhood (ISAAC) Steering Committee. Worldwide variation in prevalence of symptoms of asthma, allergic rhinoconjunctivitis, and atopic eczema: ISAAC. *Lancet* 1998; **351**: 1225–32.
- 24 von Maffei J, Beckett WS, Belanger K, Triche E, Zhang H *et al.* Risk factors for asthma prevalence among urban and nonurban African American children. *J. Asthma* 2001; **38**: 555–64.
- 25 Senthilselvan A, Lawson J, Rennie DC, Dosman JA. Stabilization of an increasing trend in physician-diagnosed asthma prevalence in Saskatchewan, 1991–1998. *Chest* 2003; **124**: 438–48.
- 26 Braback L, Hjertqvist A, Rasmussen F. Trends in asthma, allergic rhinitis and eczema among Swedish conscripts from farming and non-farming environments. A nationwide study over three decades. *Clin. Exp. Allergy* 2004; **34**: 38–43.
- 27 Braun-Fahrlander C, Lauener R. Farming and protective agents against allergy and asthma. *Clin. Exp. Allergy* 2003; **33**: 409–11.
- 28 Eder W, von Mutius E. Hygiene hypothesis and endotoxin: what is the evidence? *Curr. Opin. Allergy Clin. Immunol.* 2004; **4**: 113–17.
- 29 Von Essen S. The role of farm exposures in occupational asthma and allergy. *Curr. Opin. Allergy Clin. Immunol.* 2001; **1**: 151–6.
- 30 Wong GW, von Mutius E, Douwes J, Pearce N. Environmental determinants associated with the development of asthma in childhood. *Int. J. Tuberc. Lung Dis.* 2006; **10**: 242–51.