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ORIGINAL ARTICLE

Early farm residency and prevalence of asthma and hay fever in adults

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Abstract

Background: Asthma and hay fever have been found to be both positively and negatively associated with farming lifestyles in adulthood. Lack of congruency may depend upon early life exposure. **Objective:** To assess the importance of different periods of farm residency for asthma and hay fever in an adult Canadian population. **Methods:** We conducted a questionnaire survey in rural Saskatchewan, Canada. We assessed a history of asthma and hay fever with five categories of farm residency that were mutually exclusive: first year of life only, currently living on a farm, both first year of life and currently living on a farm, other farm living, and no farm living. Generalized estimating equations were used to adjust for clustering effects of adults within households. **Results:** Of the 7148 responding, 30.6% had an early farm living experience only, 34.4% had both early and current farm living experiences, while 17.4% had never lived on a farm. The overall prevalence of ever asthma and hay fever was 8.6% and 12.3%, respectively, and was higher in women. Sex modified the associations between ever asthma and hay fever with farm residency variables whereby women had a decreased risk for both asthma [adjusted odds ratio (OR_{adj}): 0.67, 95% confidence interval (CI): 0.47–0.96] and hay fever (OR_{adj}: 0.60, 95% CI: 0.44–0.83) with an early farm exposure only. Men currently living on a farm without an early farm exposure had an increased risk for ever asthma (OR_{adj}: 1.82, 95% CI: 1.02–3.24). **Conclusion:** Farm residency in the first year of life shows a protective effect for adult asthma and hay fever that appears to differ by sex.

Keywords

Chronic asthma, farming, rhinitis, rural, sex, wheeze

History

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Introduction

Living on a farm has been shown to be protective against the occurrence of hay fever and atopy in childhood. Such protection is strongly linked to exposure during the preschool years [1–3] and in particular, with farming exposures involving livestock [3–6]. Farms, as well as being sources of potential allergenic agents such as plants, animal dander, insects and mold spores, are also intense sources of microbial agents such as gram-negative bacteria, beta glucans and gram-positive bacteria found in livestock production [7–9]. A diverse but intense farm microbiome and the timing of farming exposures appear to be important conditions for the developing innate immune system of farm children, providing protection against asthma and other allergic diseases [7,8]. Furthermore, the pattern of immune responses, as

demonstrated in previous studies of farming environments, is believed to result from complex interactions between the genetic background of the individual and environmental influences [7,10].

While a farming environment seems to be protective for atopic conditions and to a lesser extent, diagnosed asthma in children, the findings to date are not as consistent for adults. Certain epidemiological studies of adult rural populations report similar inverse relationships between the farming environment and hay fever [11,12], atopy [13–15] and asthma [9,16]. Furthermore, adults who lived on a farm as a young child are also noted to have less hay fever [17] and atopy [15,18,19]. For asthma, the associations with early farming exposures are more mixed. Although reports from several studies indicate a lower prevalence of asthma or hay fever with a childhood history of farm living [9,18,20–22], farm-related exposures may not be related to a childhood farming background [23] and can be strongest with combined current and childhood histories of farm living [9].

Paradoxically, other studies, conducted primarily with occupationally exposed farming groups, report increases in

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adult onset asthma [16,20], respiratory symptoms [23–25], airways hyperresponsiveness [13] and decreases in lung function [26]. Results from Canadian studies of agricultural and rural populations, primarily with child populations, support the findings of inverse associations between farm living and less atopy [14,27], hay fever [28] and asthma [27,28]. However, studies with Canadian adults have yet to observe these protective associations for asthma [14].

Sex-specific effects for asthma are well noted in the literature with asthma being more prevalent in male children and female adults [29–31]. Although research is limited, there is a suggestion that the relationship between asthma and a farming lifestyle could be modified by sex. Asthma was significantly lower in female farming students compared to non-farming female students in one study of Canadian adolescents [27], and in another study of a New Zealand adult farming population, the prevalence of asthma was lower in female participants compared to males [9].

To date, studies do not clearly demonstrate the importance of farm living for asthma or hay fever in adults. As well, sex-specific effects may be important in this relationship and require further investigation. The purpose of this study was to assess the significance of different periods of farm residency exposure for asthma and hay fever in rural adults living in Canada. We hypothesized that hay fever and asthma would be lower in those residents with an early exposure to farming. Our specific research questions were: What periods of farm exposure are associated with the prevalence of asthma and hay fever in adulthood? Are these associations sex specific?

Methods

The Saskatchewan Rural Health Study is a prospective study of the respiratory health of a rural cohort living in Saskatchewan, Canada. The cohort study consists of two phases: a baseline cross-sectional with a clinical component completed in 2010–2011 (Phase 1); and a Phase 2 follow-up survey and clinical study that began in 2014. We report here on asthma-related findings from the baseline cross-sectional survey. The detailed methodology for the baseline study is published elsewhere [32,33]. Briefly, the cross-sectional study followed a mail out survey protocol developed by Dillman [34]. A multi-staged stratified cluster sampling procedure was used to identify tax-paying households greater than 60 km from an urban center in four quadrant areas (Southeast, Southwest, Northeast and Northwest) of the southern half of Saskatchewan. The number of subjects required for this study was estimated by a power calculation for sample size. Within these pre-selected quadrants, a total of 36 (nine per quadrant) of 297 rural municipalities (RMs) and 16 (four per quadrant) of 145 small towns were randomly selected through a computer generated program. Communities and RMs were visited to obtain tax payers lists to complete mail out surveys. Following approval to participate from local town and municipal councils, the target population of the mail out survey for adults 18 years of age or older came from 32 of 36 RMs and 15 of 16 small towns. A key respondent from each household completed the mailed questionnaire seeking information about the environmental and respiratory health for each adult household member [33]. There were 4264

households responding to the survey (response rate of 42.0%) with 8261 respondents 18 years and older. Of these, there were 7148 participants who were 18–75 years old, and who provided complete information on farm living. The mean age of participants was 52.5 ± 13.4 years with similar proportions of farm dwellers (41.9%) and non-farm dwellers (42.2%). The proportion of women was slightly higher in comparison to men (51.0% vs 49.0%).

Operational definitions

The variables used in this analysis were derived from questionnaire reported information. Ever hay fever was defined as a report of hay fever during the lifetime. Current hay fever was defined as a positive report of any hay fever during the past 12 months. Ever asthma was defined as a previous history of doctor diagnosed asthma and current asthma as a history of doctor diagnosed asthma and a history in the past 12 months of a visit to any of a hospital, emergency room outpatient or doctor's office, or a history of asthma medication use.

The variable, farm exposure, was derived from questions that assessed living in a farm environment: (a) in the first year of life (yes/no), (b) current residency (farm/non-farm) and (c) ever living on a farm (yes/no). The new farm exposure variable consisted of five mutually exclusive sub-groups and accounted for all participants:

- (1) *First year of life only*: Yes to living on a farm in the first year of life and no to current residence on a farm.
- (2) *Both first year of life and current living on a farm*: Yes to living on a farm in the first year of life and to current residence on a farm.
- (3) *Currently living on a farm*: Current residence on a farm and no to living on a farm in the first year of life.
- (4) *Other farm living*: Yes to ever lived on a farm but no to living on a farm in the first year of life, and no to current residence on a farm.
- (5) *No farm living*: No to ever farming, no to farm living in the first year of life, and current residence is a not on a farm.

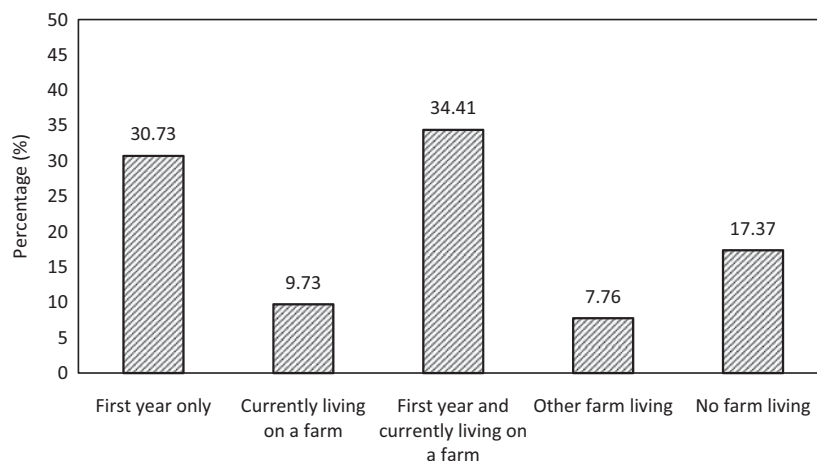
Potential confounders assessed included: age; sex; family history of chronic respiratory disease (asthma, emphysema, chronic bronchitis); pesticide exposure at work (herbicides, fungicides or insecticides); history of any respiratory allergy to house dust, cats, dogs, grasses, pollens, molds; study quadrant and body mass index (BMI). BMI was calculated from questionnaire reported height and weight.

The type of farm production (livestock or other production) was described for those participant who reported currently living on a farm or living on a farm in the first year of life.

Statistical analysis

Chi-square tests to determine the significance of the associations between categorical variables were conducted to evaluate univariate associations between the prevalence of asthma and hay fever and potential risk factors. In order to reduce misclassification bias with our outcomes, we excluded the 77 cases with COPD (including 32 cases of asthma) from our analyses, leaving 7148 participants in the final analysis.

Figure 1. Farm living exposure sub-groups.



As age, when considered as a continuous variable, was not normally distributed in our population, we grouped age according to quartiles. Associations between asthma and hay fever and livestock production in the first year of life and during current farm residency were tested using chi-square tests.

To account for within-subject dependencies that can occur due to clustering of participants within households, a generalized estimating equation using exchangeable correlation structure was applied in both bivariate and multivariate logistic regression analyses. The multivariate modeling conducted for each health outcome (ever and current asthma and hay fever), involved two steps. In the first model, the farm living exposure variable, along with potential confounding variables including (age groups, sex, smoking status, family history of chronic respiratory disease, education level, pesticides exposure at work, respiratory allergy, study quadrants and BMI (with asthma outcomes), were simultaneously entered into the regression model. Next, effect modification by sex was examined by entering two-way (farm living exposure, sex) interaction terms in the second model, respectively. To obtain odds ratio estimates of simple effects within a statistically significant interaction, the least squares means statement in Generalized Linear Modification Procedure (PROC GENMOD) of SAS 9.02 (SAS Institution, Cary, NC) was used. Statistical analyses were conducted using SPSS version 21 (SPSS Inc., Armonk, NY: IBM Corp.) and SAS 9.02. The strength of associations was presented by adjusted odds ratios (OR_{adj}) and their 95% confidence intervals (CIs).

Ethical approval

Return of the questionnaire by participants signified voluntary consent to participate in the cross-sectional baseline survey. Informed written consent from participants was obtained prior to clinical assessments. Ethics approval for the study was received from the Biomedical Ethics Research Committee at the University of Saskatchewan (BIO# 09-56).

Results

The prevalence of ever and current asthma was 8.6% and 6.9%, respectively. Ever and current hay fever were reported for 12.3% and 5.7% of participants. Most study participants

lived on a farm at some time during their life (82.6%) and 65.0% had lived on a farm in the first year of life. When we examined the mutually exclusive farming exposure periods of participants, most participants fell into one of two sub-groups: those who lived on a farm in the first year of life or those who were currently living on a farm and had also lived on a farm in the first year of life (Figure 1).

Farm production that included livestock production was more common in the first year of life (75.0%) than with current farm living (56.0%). We also examined if livestock production in the first year of life or livestock production on a current farm were inversely associated with asthma or hay fever. There was no association between livestock production and asthma or hay fever outcomes for those with a current farming history. However, there was a significant reduction in current and ever asthma and hay fever at the descriptive level ($p < 0.001$) for those with early life exposure to livestock compared to those with no early life livestock exposure.

Asthma and hay fever prevalence were proportionately higher in the 18–45 age group (Table 1) and the prevalence of current asthma and both current and ever hay fever were significantly higher in women (Table 1) compared to men. Asthma and hay fever also differed by geographical regions with the Southwest quadrant reporting the highest prevalence of asthma and hay fever (Table 1). The lowest prevalence of current and ever asthma were seen with the group who had a farming exposure in the first year of life only and with the group who currently living on a farm and also had a farming exposure in the first year of life (Table 1). Table 2 presents the distribution of personal and environmental characteristics of the study population by outcomes. There were no associations between pesticide use and any of the outcomes. A history of allergy and a family history of chronic respiratory disease were significantly higher in those with asthma or hay fever compared to those with no such histories (Table 2). Persons with hay fever were less likely to smoke and more likely to have a greater than Grade 12 education. Compared to participants with no asthma, persons with asthma were more likely to be obese.

In the multiple logistic regression analysis the relationships between farm residency and asthma and hay fever were modified by sex ($p < 0.05$). Figure 2 presents the prevalence of ever and current asthma and hay fever for the different

Table 1. Prevalence of asthma and hay fever in adults by age group, sex, quadrant and farm living exposure ($n = 7148$).

Characteristics	Ever asthma		Current asthma		Ever hay fever		Current hay fever	
	<i>n/N</i>	%	<i>n/N</i>	%	<i>n/N</i>	%	<i>n/N</i>	%
Age groups								
18–45 years	213/1927	11.1***	160/1927	8.3**	297/1927	15.4***	153/1927	7.9***
46–55 years	141/2027	7.0	109/2027	5.4	232/2027	11.4	98/2027	4.8
56–65 years	141/2027	8.3	131/1897	6.9	224/1897	11.8	93/1897	4.9
>65 years	106/1297	8.2	91/1297	7.0	129/1297	10.0	66/1297	5.1
Sex								
Male	286/3498	8.2	217/3498	6.2*	382/3498	10.9***	170/3498	4.9**
Female	331/3650	9.1	274/3650	7.5	500/3650	13.7	240/3650	6.6
Farm living exposure								
First year only	169/2188	7.7**	138/2188	6.3*	241/2188	11.0***	98/2188	4.5**
Currently living on a farm	68/695	9.8	56/695	8.1	103/695	14.8	45/695	6.5
First year and currently	190/2462	7.7	147/2462	6.0	271/2462	11.0	136/2462	5.5
Other farm living	59/559	10.5	52/559	9.3	80/559	14.3	37/559	6.6
No farm living	131/1244	10.5	98/1244	7.9	187/1244	15.0	94/1244	7.6
Quadrant								
Southwest	142/1341	10.6***	114/1341	8.5***	271/1341	20.2***	148/1341	11.0***
Southeast	155/1545	10.0	130/1545	8.4	196/1545	12.7	87/1545	5.6
Northeast	178/2077	8.6	141/2077	6.8	180/2077	8.7	80/2077	3.8
Northwest	142/2185	6.5	106/2185	4.8	235/2185	10.8	95/2185	4.3

Comparisons of the distributions of age group, sex and farm living exposures among ever and current asthma and ever and current hay fever groups were performed using Pearson's Chi-squared tests.

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

types of farm residency for men and women. Compared to women who never lived on a farm, the prevalence of ever and current asthma was lower for women who had only lived on a farm in the first year of life (8.0% vs 12.9% and 6.6% vs 9.2%, respectively). Similar results were noted for those women who currently lived on a farm and had also lived on a farm in the first year of life (7.4% vs 12.9% and 6.2% vs 9.2%, respectively). As well, compared to women who never lived on a farm, the prevalence of ever and current hay fever was significantly lower for those women who lived on a farm in the first year of life only (11.4% vs 18.1% and 4.6% vs 9.5%, respectively). Compared to men who never lived on a farm, the prevalence of ever asthma was significantly higher (12.9% vs 7.9%) for men who currently lived on a farm (Figure 2).

Table 3 presents the adjusted odds ratios and 95% CIs for current and ever asthma and hay fever for different periods of farm residency stratified by sex. After adjustment for covariates, there continued to be significant protective effects for asthma with a history of either living on a farm in the first year of life and at no other time or with a combined history of living on a farm in the first year of life and currently living on a farm. Similarly women, who had lived on a farm in the first year of life and at no other time had a decreased risk of both current and ever hay fever. There was a decreased risk of ever hay fever with a combined history of early and currently living on a farm. There were no significant associations observed between farm residency types and hay fever for men. A current history of farm living with no first year of life farm history continued to be a risk factor for ever asthma in men.

Discussion

The aim of this study was to assess the importance of different periods of farm residency and asthma and hay fever in rural adults. We found the overall a history of living on a farm, particularly in the first year of life, was protective for asthma

and hay fever but this effect was only significant for women and not for men. For men, currently living on a farm with no farm living in the first year of life was associated with an increase in ever asthma. The inverse associations found between disease and farming in women were consistent for both asthma and hay fever.

Previous reports from Europe also identify protective associations between either adult asthma or hay fever and early farm living [9,11,17,20,21]. While these European studies point to the importance of growing up on a farm or having a preschool farming exposure for decreased asthma and hay fever in adulthood, our results demonstrated that a combined first year and current farming exposure is protective for asthma or hay fever in rural Canadians as well. The importance of a combined farming exposure (both as a child and adult) has been observed by Douwes et al. in a study of New Zealand farmers [9] and the strongest protective effects for ever asthma were observed for current farmers who were also exposed to farming during childhood.

Asthma prevalence in our study was higher in females compared to males and similar to what has been previously reported in both urban and rural populations in Canada [35,36] and elsewhere [29]. Our study offers important information about sex-specific relationships between the farming environment and asthma. Sex specific findings of the protective effect of farming environments for females have been previously reported. In a Canadian study of 1199 rural adolescents, Ernst and Cormier [27] identified a lower prevalence of asthma, for those who lived on farms ($p < 0.005$). Female farm dwellers had a significantly lower prevalence of asthma (5.9% vs 11.4%, $p < 0.01$) and atopy (35.7% vs 53.3%, $p < 0.001$) compared to non-farm females that was not observed for males. Farming exposures in the first year of life were not evaluated in this study. Douwes et al. demonstrated similar sex specific relationships for asthma amongst a farming population in New Zealand [9].

Table 2. Personal and environmental characteristics of ever and current asthma, ever and current hay fever groups ($n = 7148$).

Characteristics	Ever asthma		Current asthma		Ever hay fever		Current hay fever	
	Yes ($n = 617$) n (%)	No ($n = 6531$) n (%)	Yes ($n = 491$) n (%)	No ($n = 6657$) n (%)	Yes ($n = 882$) n (%)	No ($n = 6266$) n (%)	Yes ($n = 410$) n (%)	No ($n = 6738$) n (%)
Age groups								
18–45 years	213 (34.5)***	1714 (26.2)	160 (32.6)**	1767 (26.5)	297 (33.7)***	1630 (26.0)	153 (37.3)***	1774 (26.3)
46–55 years	141 (22.9)	1886 (29.0)	109 (22.2)	1918 (28.8)	232 (26.3)	1795 (28.7)	98 (23.9)	1929 (28.6)
56–65 years	157 (25.4)	1740 (26.6)	131 (26.7)	1766 (26.5)	224 (25.4)	1673 (26.7)	93 (22.7)	1804 (26.8)
>65 years	106 (17.2)	1191 (18.2)	91 (18.5)	1206 (18.2)	129 (14.6)	1168 (18.6)	66 (16.1)	1231 (18.3)
Sex								
Men	286 (46.4)	3212 (49.2)	217 (44.2)*	3281 (49.3)	382 (43.3)***	3116 (49.7)	170 (41.5)**	3328 (49.4)
Women	331 (53.6)	3319 (50.8)	274 (55.8)	3376 (50.7)	500 (56.7)	3150 (50.3)	240 (58.5)	3410 (50.6)
Smoking status								
Current smoker	67 (10.9)	833 (12.7)	55 (11.2)	845 (12.7)	75 (8.5)***	825 (13.2)	36 (8.8)*	864 (12.8)
Ex-smoker	215 (34.8)	2258 (34.6)	165 (33.6)	2308 (34.7)	300 (34.0)	2173 (34.7)	138 (33.7)	2335 (34.6)
Never smoker	335 (54.3)	3440 (52.7)	271 (55.2)	3504 (52.6)	507 (57.5)	3268 (52.1)	236 (57.6)	3539 (52.5)
Family history of chronic respiratory disease								
Yes	241 (39.1)***	1525 (23.3)	203 (41.3)***	1563 (23.5)	297 (33.7)***	1469 (23.4)	149 (36.3)***	1617 (24.0)
No	376 (60.9)	5006 (76.7)	288 (58.7)	5094 (76.5)	585 (66.3)	4797 (76.6)	261 (63.7)	5121 (76.0)
Education level								
≤Grade 12	343 (55.6)	3800 (58.2)	273 (55.6)	3870 (58.1)	422 (47.8)***	3721 (59.4)	200 (48.8)***	3943 (58.5)
>Grade 12	274 (44.4)	2731 (41.8)	218 (44.4)	2787 (41.9)	460 (52.2)	2545 (40.6)	210 (51.2)	2795 (41.5)
Farm living exposure								
First year only	169 (27.4)**	2019 (30.9)	138 (28.1)*	2050 (30.8)	241 (27.3)***	1947 (31.1)	98 (23.9)**	2090 (31.0)
Currently living on a farm	68 (11.0)	627 (9.6)	56 (11.4)	639 (9.6)	103 (11.7)	592 (9.5)	45 (11.0)	650 (9.6)
First year and currently	190 (30.8)	2272 (34.8)	147 (29.9)	2315 (34.8)	271 (30.7)	2191 (34.9)	136 (33.2)	2326 (34.5)
Other farm living	59 (9.6)	500 (7.7)	52 (10.6)	507 (7.6)	80 (9.1)	479 (7.6)	37 (9.0)	522 (7.8)
No farm living	131 (21.2)	500 (7.7)	98 (20.0)	1146 (17.2)	187 (21.2)	1057 (16.9)	94 (22.9)	1150 (17.1)
Quadrant								
Southwest	142 (23.0)***	1199 (18.4)	114 (23.2)***	1227 (18.4)	271 (30.7)***	1070 (17.1)	148 (36.1)***	1193 (17.7)
Southeast	155 (25.1)	1390 (21.3)	130 (26.5)	1415 (21.3)	196 (22.3)	1349 (21.5)	87 (21.2)	1458 (21.6)
Northeast	178 (28.9)	1899 (29.1)	141 (28.7)	1936 (29.1)	180 (20.4)	1897 (30.3)	80 (19.5)	1997 (29.6)
Northwest	142 (23.0)	2043 (31.2)	106 (21.6)	2079 (31.2)	235 (26.6)	1950 (31.1)	95 (23.2)	2090 (31.0)
Body mass index (kg/m^2) ^a								
Normal (<25)	129 (22.2)***	1797 (28.9)	103 (22.5)***	1823 (28.8)	221 (26.3)	1705 (28.7)	98 (25.1)	1828 (28.6)
Overweight (25–30)	230 (39.6)	2546 (41.0)	176 (38.4)	2600 (41.0)	354 (42.1)	2422 (40.7)	164 (41.9)	2612 (40.8)
Obese (>30)	220 (38.2)	1867 (30.1)	179 (39.1)	1910 (30.2)	266 (31.6)	1823 (30.6)	129 (33.0)	1960 (30.6)
Pesticides exposure								
Yes	330 (53.5)	3528 (54.0)	265 (54.0)	3593 (54.0)	484 (54.9)	3374 (53.8)	219 (53.4)	3639 (54.0)
No	287 (46.5)	3003 (46.0)	226 (46.0)	3064 (46.0)	398 (45.1)	2892 (46.1)	191 (46.6)	3099 (46.0)
Any allergy								
Yes	473 (76.7)***	1917 (29.3)	380 (77.4)***	2010 (30.2)	763 (86.5)***	1627 (26.0)	373 (91.0)***	2017 (30.0)
No	144 (23.3)	4614 (70.7)	111 (22.6)	4647 (69.8)	119 (13.5)	4639 (74.0)	37 (9.0)	4721 (70.0)

Comparisons of the distributions of these characteristics among ever and current asthma and ever and current hay fever groups were performed using Pearson's chi-squared tests.

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

^aMissing $n = 357$ – no information available for BMI.

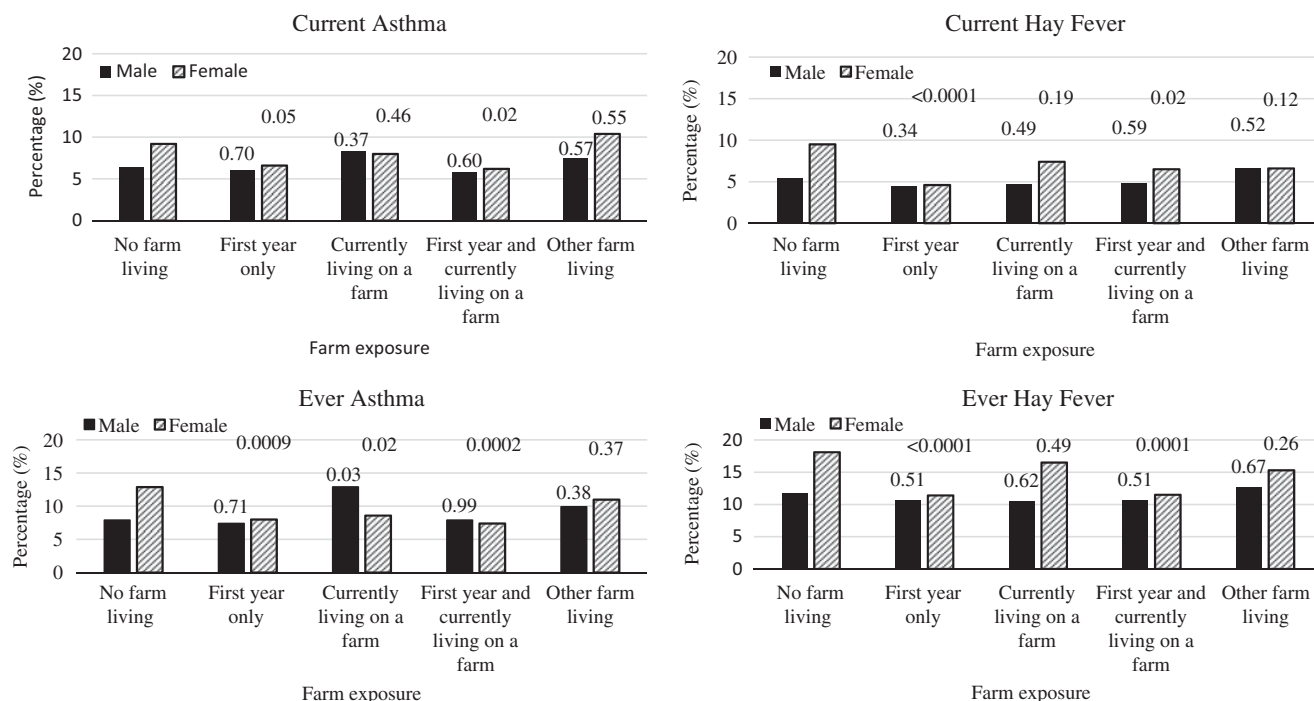


Figure 2. Sex-specific prevalence of asthma and hay fever by farm living exposure status. All within sex comparisons were made with reference to the No farm living group.

Table 3. Adjusted odds ratios and 95% CIs^a for current and ever asthma and current and ever hay fever associated with different farm living exposures sub-groups in adults stratified by sex.

	Farm living exposure (reference group is no farm living)			
	First year of life on a farm only <i>n</i> = 2188	Currently living on a farm <i>n</i> = 695	First year of life on farm and currently living on a farm <i>n</i> = 2462	Other farm living <i>n</i> = 559
Current asthma ^b				
Men	0.98 (0.62, 1.55)	1.32 (0.68, 2.56)	0.99 (0.62, 1.56)	1.25 (0.64, 2.44)
Women	0.79 (0.53, 1.18)	0.96 (0.60, 1.53)	0.78 (0.51, 1.20)	1.41 (0.87, 2.29)
Ever asthma ^b				
Men	1.03 (0.68, 1.56)	1.82 (1.02, 3.24)	1.16 (0.77, 1.76)	1.38 (0.77, 2.49)
Women	0.67 (0.47, 0.96)	0.68 (0.44, 1.04)	0.67 (0.46, 0.97)	1.00 (0.63, 1.56)
Current hay fever				
Men	0.79 (0.47, 1.31)	0.67 (0.29, 1.53)	0.97 (0.59, 1.58)	1.28 (0.61, 2.67)
Women	0.52 (0.34, 0.79)	0.97 (0.60, 1.56)	0.90 (0.60, 1.38)	0.78 (0.45, 1.34)
Ever hay fever				
Men	0.85 (0.59, 1.23)	0.73 (0.41, 1.31)	0.93 (0.65, 1.34)	1.14 (0.65, 2.00)
Women	0.60 (0.44, 0.83)	1.09 (0.75, 1.57)	0.68 (0.48, 0.95)	0.89 (0.59, 1.35)

The 95% CI is the significance for bold values.

^aMultivariate logistic regression models for each outcome were adjusted for age, smoking status, family history of chronic respiratory disease, education level, pesticides exposure at work, any respiratory allergy, region of the province (quadrant) and clustering within households.

^bAll models for asthma outcomes (current and ever) were adjusted for BMI, in addition to the variables mentioned above.

The protective effect for asthma from farm living, although significant overall, appeared to be consistently stronger for women [9]. While Douwes also found an inverse relationship for hay fever in men with early and current farm exposure [9], we did not find a similar association in our study for men but instead, observed an increase in asthma for men with a history of current farm living. Similar findings have been reported by others [13,16,20,25]. Importantly, this group of farmers with a current history of farming only may be an at-risk group for work exacerbated asthma [37,38].

Sex-linked differences in the prevalence and incidence of asthma and hay fever are well known with consistently higher

prevalence and incidence in male children and female adults [29–31]. Currently, there is limited information on the developmental differences in the immunological responses of males and females to similar environmental agents. The pattern of immune responses that characterize maturation of T helper cells into Th1 and Th2 responses results from complex interactions between the genetic background of the individual and environmental influences [39]. Specific lymphoid tissue, such as thymic tissue, may be important at certain stages of development of the immune function. Tulic et al. observed that the maturation of thymic T lymphocytes was slower in children with atopy [40]. Sex-related differences in the

response of mouse models on exposure to air pollution are noted whereby, the CD4:CD8 ratio in thymic tissue was decreased in female mice but not male mice when exposed to air pollutants [41]. Further study is required regarding sex-related regulation, whether inherent or steroidal, of immune cell function. Based on limited information to date, such associations may also be developmentally and exposure (concentration, timing and duration) dependent [42].

Recent reviews and studies have stressed the importance of microbial diversity and other factors in the farming environment as being influential in the development of early and continued protection for allergic diseases such as hay fever and asthma in rural populations [7,8,10,43,44]. Certain factors within the farm environment such as cows, straw and consumption of farm milk, could be important for the protective associations for asthma and hay fever [45]. Consistent with this, our study demonstrated, albeit at the univariate level, the importance of livestock exposure in the first year of life for a lower asthma and hay fever in adults. Hoppin et al. noted that farm women, who did not apply pesticides and who had also grown up on a farm, had a reduced risk of atopic asthma, suggesting that other factors within the farming environment may be important in the reduction of risk seen with adult farming populations, particularly those with an earlier farm exposure [44].

Our ability to explore the associations between farming and atopic asthma in adulthood was limited. Hay fever was modestly but significantly correlated with asthma ($r^2=0.08$, $p<0.05$), suggesting possible overlap between asthma and allergic conditions in this study. To account for the influence of allergy with our results, we adjusted for questionnaire reported allergy in the multivariate analysis and did not see any important changes in our results.

Migration away from farming environments by persons with respiratory conditions could account for the lower prevalence of asthma and hay fever observed with farm residency [46–48]. In a prospective study of grain and swine farmers, Chenard et al. [46] found reduced lung function in male farmers who had left swine farm production compared to those still farming. In a longitudinal study of Swedish male conscripts, Braback et al. [48] observed that conscripts with a previous history of allergy or asthma and who were raised on a farm were more likely to migrate away from the farming environment in adulthood. Studies of a healthy farmer effect with female workers are limited. However, in a prospective study of dairy farms in France, a history of asthma was predictive of early cessation of dairy farming in women and not in men [47], suggesting that sex differences could be important in certain migration patterns.

This study had several limitations. The response rate was moderate (42%) although the participation rate was similar between farm and non-farm dwellers (41.9% and 42.2%, respectively). The low response rate has implications for generalizability of our results particularly for our estimates of asthma and hay fever prevalence [49]. Our sample had a similar distribution by sex but had a greater proportion of older people when compared to the rural population with provincial health care coverage [50], suggesting that the sex-specific findings could be generalizable to that population while any age related findings should be interpreted with caution [50].

This study lacked information regarding the duration of farming exposure of study participants. Our choice to restrict an early life farming exposure to the first year of life was based on evidence by others that reduced risk for asthma and atopy were found with exposures to farm environments during this time period [3,4]. More information about other exposure periods in childhood would have been useful in assessing a dose response effect with early farming exposures for outcomes and in determining if other important time periods in childhood and adolescence could influence the nature of adult asthma and hay fever. Our farm living exposure variable also excluded those who could have come in contact with the farm environment as a worker or as a frequent visitor to the farm. Therefore, results are not generalizable to all persons in contact with a farm environment.

Our outcome and exposure results are based solely on questionnaire report by key informants from households and required recall of certain variables such as early farming exposure and past history of respiratory and other health conditions. Key informants were used to improve the efficiency of the mail out survey design. Proxy responses, particularly by family members, have shown reasonable agreement with self-reported responses [51–53]. In a previous community survey of a rural population, we demonstrated that proxy reporting of spousal smoking behaviors by questionnaire showed good agreement with self-reported smoking behaviors [53]. Our study lacked objective measures for asthma and hay fever outcomes. However, questionnaire report of asthma in adults has been previously validated against a doctor's assessment of asthma [54,55] indicating high sensitivity and specificity (0.79–0.80 and 0.97–0.98, respectively) and self-reported asthma by questionnaire is shown to be correlated with lower lung function in men and women [56].

Information regarding a family history of asthma and allergies was not available in this study. The information regarding a family history of respiratory disease that was used as a surrogate for a family history included asthma as one of several conditions. As a result of including other respiratory conditions alongside asthma, we may have over adjusted for the prevalence of a family history of asthma in the analyses.

This study investigated the importance of different periods of farm residency for asthma and hay fever in an adult rural population. The findings support previous work that demonstrates the specific importance of farm living during the first year of life for lower prevalence of asthma and hay fever in later life and furthermore, suggests that the nature of this relationship appears to be modified by sex. Results from this study support the need to investigate specific immunological, environmental, genetic and social factors for sex-related differences for adult asthma and allergic disorders in farming populations.

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Declaration of interest

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