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Contact with livestock – a protective effect against allergies and asthma?

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Summary

Background A 'protective farm factor' possibly related to livestock exposure is hypothesized to reduce the risk for allergic sensitization.**Objective** The purpose of this study was to determine whether 4-H club youth, who have opportunities for contact with livestock through club activities, have reduced risks of respiratory and allergic symptoms according to residence on a farm or exposure to livestock.**Methods** A cross-sectional postal survey was completed by British Columbia 4-H members 8–20 years of age; a subset underwent skin prick testing as well. The association of farm residence and livestock exposure variables with symptoms were evaluated using logistic regression with adjustment for age, sex, cat and/or dog ownership, parental history of allergic disease, parental education, number of older siblings and exposure to smokers at home.**Results** Questionnaires were completed by 1158 participants (response rate 50.3%); of these, a subset of 317 had skin prick tests (SPTs) (response rate 64.4%). Current residence on a farm was associated with a lower prevalence of ever having wheeze and asthma, as well as symptoms of atopic dermatitis. Variables relating to residence in a farm or rural area with livestock were more strongly associated with respiratory and allergic symptoms than were the livestock exposure variables such as frequency of contact and hours of barn use. The adjusted odds ratios for living in a farm residence in comparison with a rural non-livestock area were 0.49 (95% confidence interval (CI) 0.27–0.89) for diagnosed asthma, 0.51 (95% CI 0.30–0.85) for allergic rhinitis and 0.45 (95% CI 0.24–0.84) for atopic dermatitis.**Conclusion** Our findings suggest that some aspects of the farm environment, not just attributable to contact with livestock, were protective for respiratory and allergic conditions among 4-H youth.**Keywords** allergic symptoms, farm, livestock, questionnaires, surveys*Submitted 16 February 2006; revised 17 June 2006; accepted 17 July 2006*

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Introduction

Up to one-half of children are affected by allergies, and the prevalence of asthma has risen over the last four decades. Because genetic factors cannot explain the increase in asthma prevalence over the short period of time the changes have occurred, strong environmental influences are thought to affect the expression of allergic diseases [1].

The prevalence of asthma and allergies is known to vary widely between [2] and within countries [3], typically showing a lower prevalence in rural areas. Although no differences in asthma, wheezing and atopic disorders were found between Finnish university students when compar-

ison was made between urban and rural non-farm residences during childhood, a 'protective farm factor' was identified, in which a farm environment during childhood reduced the risk of asthma, episodic wheezing and allergic rhinitis (AR) irrespective of family size [4].

The association between allergy and farming was first noted in the 19th century by Charles Blackley, who observed that it was rare among farmers, despite their high exposure to pollen [5]. Publications over the past 6 years have shown that the prevalence of hayfever, AR and/or atopy among children of farmers was two to three times lower than that of children whose parents were not farmers [6–9]. For example, in a large European-based study, the prevalence of hayfever, asthma and atopic

sensitization, but not eczema, were significantly reduced in farm children [9]. The strongest protective effect of the childhood farm environment has been shown for early childhood and possibly during the gestational period [9, 10].

Contact with livestock was proposed by Von Ehrenstein et al. [7] as being the important farm-related factor for the findings of reduced allergic disease in farm children. Their findings that frequency of livestock contact was associated with decreasing prevalence of atopic diseases have been replicated elsewhere [8, 11].

We conducted a survey of children belonging to the 4-H programme, an agriculturally based youth education programme promoting traditional skills development in animal, horticultural, and non-farm projects. There is much opportunity for contact with livestock as a result of club activities, without necessarily living on a farm. The purpose of the paper was to evaluate whether farm residence and contact with livestock were protective against asthma, allergic symptoms and allergic sensitization, as assessed by skin prick testing, among 4-H youth.

Materials and methods

Study design

A self-administered questionnaire along with introduction letter, a letter of support from the 4-H provincial council and a postage-paid reply envelope was mailed to all 4-H members of five regions in British Columbia in July and August of 2001. Questionnaires were sent to a 50% sample of members from the two remaining largest provincial regions in May of 2002. Repeat mail-outs to potential participants who had not responded were also carried out.

The study protocol was approved by the University of British Columbia Clinical Ethics Committee.

The questionnaire items included standard allergic and respiratory symptom questions from the International Study of Asthma and Allergic Disease in Children (ISAAC) survey [2], along with questions on physician diagnosis of asthma, hayfever, eczema and bronchitis. Type of residence (farm, rural non-farm and urban) was asked for current and past residence (before age 2), as well as whether they had (and types of) livestock and poultry. Rural non-farm was further categorized according to presence or absence of livestock, including horses. The farm residences all had livestock; the three exceptions were classified as rural non-livestock. Other information obtained included size of current acreage/lot, frequency of contact with livestock or poultry, average amount of time spent in a barn per week, past and current exposure to pets, the number of older siblings, whether family members had asthma or allergic diseases and if there were smokers present in the home.

Two ISAAC questionnaire items used had highest specificity and sensitivity for AR (having sneezing or a runny or blocked nose accompanied by itch-watery eyes in the past year) and atopic dermatitis (having itchy rash in the folds of the elbows, behind the knees, in front of the ankles, under the buttocks, or around the neck, ears or eyes, at any time in the past year) [12]. Having wheeze in the past year and ever being diagnosed with asthma were also principal outcomes of interest for further analysis. These four outcomes were representative of distinct types of respiratory and allergic symptoms/conditions that were commonly assessed in the pertinent literature.

In addition to the questionnaire and invitational letter, 4-H members from one region (Fraser Valley) were invited to participate in skin prick testing with permission from their club leader. A signed parental consent form was also required. Testing locations included agricultural fairs and meetings of Fraser Valley 4-H clubs. Skin prick testing was performed over the period of July 2001 to January 2002. Allergy skin tests were performed on the forearm using the epicutaneous method with a prick lanceter (Bayer Inc., Toronto, Canada). In total, 18 inhalant allergens were applied: *Dermatophagoides farinae* and *Dermatophagoides pterynissinus*, dog hair, cat dander, mixed grasses, Pacific western 10 tree mix, Pacific weeds, *Alternaria Alternaria*, *Cladosporium cladosporoides* and *Aspergillus mix (Niger, Fumigatis)*, horse, cow, goat, sheep and mouse hair, rabbit fur, mixed feathers and hay dust. Normal saline and histamine (1 mg/mL) were used as negative and positive controls, respectively. A weal diameter which was 3 mm or greater than the negative control was considered a positive skin prick test (SPT) reaction.

Data analysis

Differences in prevalence of symptoms and in means of each group were evaluated using χ^2 analysis and analysis of variance, respectively, using SPSS/PC Version 10.0 (SPSS, Chicago, IL, USA). A correlation matrix of independent variables was examined for potential collinearity. Stata 8 (Stata Corp, College Station, TX, USA) was used for logistic regression analysis. The logistic model included robust and cluster functions that relax the assumption of independence by adjusting standard errors for clustering due to family membership, thus, resulting in wider confidence intervals (CIs). Exposure variables were analysed separately and then adjusted for potentially confounding variables, including: age, sex, presence of dog in the home, cat in the home, parental history of allergic disease, presence of smokers in the home and the number of older siblings. A two-sided α level of 0.05, or 95% CI for the odds ratios (ORs) that did not include 1, was considered statistically significant.

Table 1. Personal and family characteristics and livestock exposures by current area of residence* of 4-H youth

	Farm (%)	Rural with livestock (%)	Rural, no livestock (%)	Urban (%)	P-value
<i>N</i>	675	245	130	106	
Personal characteristics					
Female sex	63.0	69.4	72.3	84.9	0.000
Average age (years $\pm$ SD)	13.8 $\pm$ 2.8	13.7 $\pm$ 2.6	12.6 $\pm$ 2.5	13.0 $\pm$ 2.5	0.000
Physically active most or all days	55.7	40.7	43.2	31.7	0.000
Family characteristics					
Smokers in the home currently	14.3	12.7	15.6	18.1	0.598
Presence of older siblings	68.1	64.5	63.8	61.5	0.429
Parent with atopic disease	50.1	47.8	63.1	71.8	0.000
Parent with post-secondary education	68.3	70.5	76.2	80.0	0.046
Dog at home	88.5	83.5	75.0	68.6	0.000
Cat at home	85.5	81.8	65.3	52.9	0.000
Livestock exposures					
Animal-related 4-H project	98.1	95.5	90.0	88.7	0.000
Type of 4-H project					0.000
Cattle	45.8	14.7	13.9	32.1	
Horse	16.1	27.7	18.9	18.7	
Lamb/goat	19.4	13.9	5.7	15.2	
Other livestock	8.0	16.0	2.5	8.3	
Non-livestock	10.7	27.7	59.0	25.6	
Farm residence < age 2	39.2	14.6	18.1	28.1	0.000
Lot/Acreage size: > 50 acres	51.6	5.7	7.0	0.0	0.000
Barn hours: > 7 h/week	39.6	25.2	17.4	6.0	0.000
Contact with livestock: most or all days	90.4	83.7	23.4	19.8	0.000

*Farm, live on a farm with livestock; Rural with livestock, live in a rural area and have livestock (including horses); Rural, no livestock, live on a farm or rural area with no livestock; Urban, live in an urban area and have no livestock.

Results

For the 1158 participants, the response rate was 50.3%. Out of 2548 questionnaires mailed, 1143 questionnaires were not returned and 247 were excluded due to outdated membership ($n = 148$), undeliverable mail ($n = 63$) and duplicate identification ($n = 36$). Just over one-half (56.4%) were single members from one household. The κ values comparing pairs of family participants showed excellent agreement, ranging from 0.85 to 0.88 for area of residence and other family characteristics. For the subset of 317 participants who underwent skin prick testing, the participation rate was 64.4% for those in clubs whose members were permitted to take part. All participants completed skin prick testing for all 18 allergens.

Table 1 lists the characteristics for 1156 participants according to the four categories of current area of residence (two participants did not indicate their type of residence). There were a higher percentage of female 4-H members living in urban areas; urban parents were better educated and had a higher prevalence of atopic disease. Youth living on farms were more physically active while those living in rural areas without livestock were younger on average. The 4-H members had opportunity for livestock contact regardless of place of residence. Those currently living on a farm had the highest percentage of members having an animal-

related 4-H project, residing in a farm before age 2, living on a large acreage, spending more time in a barn and having greater contact with livestock. However, the majority of urban dwellers (almost 90%) were involved in an animal-related 4-H project, with 20% having contact with livestock on most or all days. The type of livestock differed for farms vs. rural non-farm areas with livestock. Farms had a greater frequency of cattle (70.3% vs. 11.1%) and poultry (52.6% vs. 37.7%); similar distributions were observed for horses (56.5% vs. 55.7%) and lambs/goats (33.6% vs. 27.9%). Rabbits were bred in three urban homes. For a subset of 404 respondents for whom the information was available, there were no significant differences between areas of residence as to whether 4-H member or their parents completed the questionnaire (data not shown). Parents from rural areas with livestock completed 30.8% of the questionnaires, which ranged up to 44.4% for parents from rural areas without livestock.

The prevalence of respiratory and allergic symptoms or conditions was consistently lower for those currently living on a farm (Table 2); the prevalence was generally highest for those living in rural areas without livestock or in urban areas. The differences between current areas of residence were statistically significant for ever having wheeze, diagnosed asthma, having atopic dermatitis in the past year and diagnosis of eczema.

Table 2. Prevalence of respiratory and allergic symptoms/conditions by current area of residence* of 4-H youth

	Farm (%)	Rural with livestock (%)	Rural, no livestock (%)	Urban (%)	p-value
<i>N</i>	675	245	130	106	
Symptoms and conditions					
Wheeze (past year)	12.6	15.4	19.7	14.6	0.186
Wheeze (ever)	22.7	25.2	32.8	30.8	0.048
Dry cough at night (past year)	13.6	14.9	16.0	18.3	0.593
Woken by shortness of breath (past year)	3.8	4.1	6.4	1.9	0.379
Asthma (ever diagnosed)	12.0	15.7	21.6	18.1	0.020
Atopic dermatitis (past year)	6.9	8.8	14.7	11.5	0.022
Eczema (ever diagnosed)	12.9	21.1	23.8	26.7	0.000
Allergic rhinitis (past year)	18.1	18	27.8	22.1	0.069
Hayfever (ever diagnosed)	6.7	9.1	12.1	7.0	0.182

*Farm, Live on a farm with livestock; Rural with livestock, live in a rural area and have livestock (including horses); Rural, no livestock, live on a farm or rural area with no livestock; Urban, live in an urban area and have no livestock.

Table 3. Adjusted odds ratios (OR)* (95% confidence intervals) for selected respiratory and allergic symptoms of 4-H youth according to area of residence category

	<i>N</i>	Wheeze (past year)		Asthma (ever diagnosed)		Allergic rhinitis (past year)		Atopic dermatitis (past year)	
		Crude OR	Adjusted OR	Crude OR	Adjusted OR	Crude OR	Adjusted OR	Crude OR	Adjusted OR
Current residence [†]									
Rural, no livestock	130	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Urban	106	0.70	0.66	0.80	0.78	0.74	0.69	0.76	0.60
		0.35–1.40	0.30–1.47	0.42–1.54	0.37–1.66	0.40–1.35	0.34–1.39	0.35–1.64	0.26–1.38
Rural with livestock	245	0.74	0.92	0.67	0.72	0.57	0.53	0.56	0.54
		0.42–1.30	0.47–1.78	0.39–1.17	0.38–1.36	0.34–0.95	0.29–0.95	0.29–1.08	0.26–1.11
Farm	675	0.59	0.74	0.49	0.49	0.58	0.51	0.43	0.45
		0.36–0.96	0.41–1.33	0.30–0.80	0.27–0.89	0.37–0.89	0.30–0.85	0.24–0.76	0.24–0.84
Residence with livestock (< age 2 and current) [‡]									
Consistent no livestock	189	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Livestock to no livestock	41	1.22	1.84	1.72	1.65	1.28	1.32	0.86	0.78
		0.51–2.91	0.69–1.93	0.78–3.80	0.60–4.52	0.60–2.71	0.56–3.10	0.31–2.38	0.24–2.49
No livestock to livestock	341	0.87	1.08	0.76	0.81	0.79	0.75	0.58	0.60
		0.54–1.42	0.60–1.93	0.47–1.24	0.47–1.39	0.51–1.21	0.45–1.26	0.33–1.01	0.31–1.13
Consistent livestock	576	0.67	1.02	0.62	0.62	0.60	0.56	0.45	0.50
		0.42–1.06	0.59–1.80	0.40–0.98	0.37–1.06	0.40–0.90	0.33–0.93	0.26–0.76	0.27–0.92

*Adjusted for age, sex, smokers present in home, cat ownership, dog ownership, parent history of atopic disease, parental education, and number of older siblings.

[†]Farm, live on a farm with livestock; Rural with Livestock, live in a rural area and have livestock (including horses); Rural, no Livestock, live on a farm or rural area with no livestock; Urban, live on an area and have no livestock.

[‡]Consistent, before age 2 and currently; No livestock, live in an urban or rural residence without livestock; Livestock, live in a farm or rural residence with livestock.

After adjustment for potential confounding factors, ORs were determined for the relationship between different areas of residence and other livestock exposure categories with the four outcomes of having wheeze in the past year, diagnosis of asthma, symptoms of AR or atopic dermatitis (Tables 3 and 4). When compared with rural areas without livestock, farm youth currently living on a farm had significantly lower unadjusted and adjusted ORs for

doctor-diagnosed asthma, AR and atopic dermatitis (Table 3). Although there was a trend of a protective effect of farm residence, there were no significant associations for the comparison of farm to urban areas (data not shown). Youth who consistently lived in residence with livestock before age 2 and currently had one-half of the risk of AR or atopic dermatitis when compared with those consistently living in residences without livestock. The highest

Table 4. Adjusted odds ratios (OR)* (95% confidence intervals) for selected respiratory and allergic symptoms of 4-H youth according to livestock exposure category

		Wheeze (past year)		Asthma (ever diagnosed)		Allergic rhinitis (past year)		Atopic dermatitis (past year)	
	<i>N</i>	Crude OR	Adjusted OR	Crude OR	Adjusted OR	Crude OR	Adjusted OR	Crude OR	Adjusted OR
Size of lot/acreage [†]									
< 2 acres	290	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2– < 50 acres	490	0.87	0.87	0.80	0.84	0.82	0.70	0.59	0.63
		0.59–1.29	0.54–1.41	0.54–1.18	0.53–1.33	0.58–1.17	0.45–1.09	0.36–0.95	0.37–1.08
> 50 acres	371	0.54	0.70	0.56	0.61	0.59	0.57	0.51	0.64
		0.34–0.86	0.41–1.19	0.34–0.87	0.36–1.05	0.40–0.88	0.34–0.94	0.30–0.86	0.35–1.18
Time spent in barn									
None	251	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
0– < 7 h/week	515	0.98	1.03	0.77	0.74	0.81	0.78	0.60	0.60
		0.63–1.53	0.64–1.69	0.51–1.15	0.46–1.18	0.55–1.18	0.51–1.20	0.36–0.99	0.36–1.00
> 7 h/week	346	1.03	1.01	0.56	0.49	0.81	0.71	0.70	0.78
		0.64–1.66	0.60–1.69	0.35–0.89	0.28–0.85	0.54–1.22	0.44–1.14	0.41–1.19	0.44–1.40
Contact with livestock									
Never	137	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Sometimes	148	0.91	1.20	1.72	1.96	0.66	0.68	0.80	0.87
		0.47–1.76	0.58–2.49	0.91–3.27	0.91–4.22	0.37–1.16	0.36–1.28	0.40–1.58	0.43–1.73
Often/daily	862	0.86	1.22	1.01	1.32	0.67	0.67	0.44	0.45
		0.52–1.42	0.69–2.17	0.60–1.73	0.68–2.57	0.44–1.02	0.40–1.11	0.25–0.75	0.25–0.81

*Odds ratios were derived from logistic regression analysis with adjustment for age, sex, smokers present in home, cat ownership, dog ownership, parent history of atopic disease, parental education and number of older siblings.

[†]Additional adjustment was done for physical activity (most or all days vs. less than twice a week).

ORs, although not statistically significant, were observed for those 41 subjects who moved from rural areas with livestock to rural areas without livestock (80.5%) or to urban areas. Analysis of type of residence before age 2 showed results similar to that of current residence, but it was the comparison of farm to urban residence that yielded significantly lower adjusted ORs for AR (just failing to reach statistical significance for wheeze and atopic dermatitis) (data not shown).

Current residence on a larger acreage of at least 50 acres, in comparison with under 2 acres, was associated with lower risks for having wheeze in the past year, diagnosed asthma, and atopic dermatitis or AR; the latter remained significant even after adjustment for potential confounders (Table 4). Spending at least 7 h/week in a barn was the only significant association for diagnosed asthma, which remained so, even after adjustment for confounders.

The only statistically significant reduction in risk for frequent contact with livestock was observed for the atopic dermatitis (Table 4). Because frequency of contact with livestock was collinear to and affected by residence on a farm or rural area where there was livestock (and can, therefore, be considered to be intermediate in the causal pathway from exposure to disease), these variables were not entered together in the logistic regression model [13]. Time spent in a barn, which showed no collinear relationship with any of the independent exposure variables, was

found to affect only the relationship of farm residence with diagnosed asthma, so that it was no longer statistically significant (data not shown).

Additional analysis (data not shown) adjusting for number of participants per family showed similar results as did the analysis that was limited to one family member (with the exception that there was no longer a protective effect of current farm residence on diagnosed asthma).

There were no significant differences or consistent trends in the prevalence of SPTs according to current residence in a livestock vs. non-livestock area or with any of the livestock exposure variables as listed in Tables 3 and 4 (data not shown). While those living on a larger acreage of at least 50 acres showed a trend of having a lower prevalence of positive SPTs, those currently living in farms or residences with livestock had a slightly higher prevalence. There were no significant differences in symptoms when comparing those who had skin prick testing with those answering questionnaires only, although differences were found for a number of characteristics, such as physical activity, cat ownership, parental atopy and presence of smokers at home (data not shown).

Discussion

Our study of British Columbia 4-H youth confirmed that current residence on a farm was associated with a lower

prevalence of most allergic symptoms, including eczema and symptoms of atopic dermatitis and AR. There were also reduced risks of ever having wheeze and doctor-diagnosed asthma associated with current residence in a farm, but only when contrasted to residence in rural areas where no livestock was kept. No significant differences in the prevalence of hayfever were found between farm, rural livestock, rural non-livestock or urban categories. Many recent studies have demonstrated that children whose parents are farmers have lower rates of hayfever, AR and/or atopy [6–8, 14], eczema [9], and asthma [14] when compared with children whose parents were not farmers.

There was some indication of reduced skin test positivity associated with living on larger acreage; however, there was no clear evidence of a protective effect of residence in a farm or contact with livestock on allergic sensitization. A limitation to our study is that the small sample of 4-H youth who underwent skin prick testing may not be representative of the entire 4-H population. A reduction in allergic sensitization among farm children had been the most consistent finding in the literature, as illustrated by the recent study of Finnish children [11], a longitudinal study of Austrian children [15], and an earlier Swiss study reporting lower sensitization in children of full-time farmers (OR 0.24 (0.09–0.66)) than part-time farmers (OR 0.54 (0.15–1.96)) [6].

There are some recent studies that do not support a 'protective farm effect' of farm residence on allergies, asthma and atopy. Similar to our study, Klintberg et al. [14] found no differences in positive SPTs between children of Swedish farmers and non-farmers despite finding a lower prevalence of asthma and some allergic symptoms in children of farmers. In a New Zealand study, Wickens et al. [16] found that SPT positivity was associated with regular contact with poultry or pig, and current farm residence was associated with an increased risk of current AR for 7–10-year-old children, after adjusting for other factors.

Inconsistencies in the degree of protection extended by farm residence have been attributed to different types of farming [17]. Downs et al. [17] found the prevalence of current wheeze was lower among farm children in one rural area of New South Wales, but not for another rural area; however, this has been attributed to livestock vs. crop-based farming for the latter. A recent study of rural Iowa children by Chrischilles et al. [18], found such inconsistencies in farm children's symptoms between two counties despite similarities in agricultural production. In this instance (although not documented), the authors noted that many farm and non-farm children had significant exposures to livestock through chores and participation in extracurricular groups. Our 4-H study population differed in many respects from a typical community sample. Livestock contact was not limited to farms; rural and urban residents had opportunity for

contact with livestock through club activities. The common presence of pets, along with opportunities for exposure to livestock, may have influenced the expression of allergic sensitization. Even though this generalized exposure would tend to obscure differences between groups, reporting of allergic symptoms and diagnosis of asthma generally did show a gradient of being lower in the farm and rural areas and highest in rural non-livestock and urban areas of residence.

A selection effect may be present as we found that the highest prevalence of symptoms was observed for those who had moved from residences with livestock to those without. This suggests the possibility that the decision to move from a livestock residence may have been prompted by familial allergies. A Canadian study also found that children with previous or intermittent farm exposures who were not currently living on a farm had a higher prevalence of respiratory and allergic symptoms than farm children, similar to that of children consistently not living on farms [19].

The 'hygiene' hypothesis [20] was advanced to explain decreased allergic symptoms with early exposure to antigens such as the endotoxin found in barns where animals are housed and fed [1]. Greater indoor exposure to endotoxin has been shown to be related to reduced allergic sensitization in children [21] and has been associated with enhanced type 1 immunity for infants under 2 years of age [22]. We found that a greater amount of time spent in a barn was inversely associated with diagnosed asthma, but no statistically significant relationship was shown with allergic symptoms. Children with frequent livestock contact have been shown to have lower rates of asthma/wheeze/etc. [4], and allergic disease [7, 8, 11], compared with children with infrequent livestock contact. Whether the associations can be explained by 'reversed causality', such that children may avoid exposure to livestock if they are already sensitized, cannot be evaluated in our study. We found that the frequency of contact with livestock, the variable most often cited as the candidate for the 'protective farm factor', was significantly related only to atopic dermatitis among the 4-H members. A study of rural youth in Crete found no gradient between intensity of animal contact and positive SPTs; however the relationship was statistically significant for urban youth [23].

Our cross-sectional questionnaire-based study had a number of limitations, including a low response rate of 50%. However, the percentage of females who answered the questionnaire (67.4%) does reflect the current membership profile of 67.2% females in the BC 4-H program [24]. As well, currently the most common livestock projects for the 4-H program were cattle, horse and lamb/goat, as was also indicated by our survey group. The mail questionnaire used was restricted in size and content, thus, information on residence was only available for

two points in time. Recall bias is a possibility, particularly for retrospectively assessed exposures before age 2. There is potential for misclassification of both exposure and outcome information. The designation of 'farm, rural and urban' was based on the subject's interpretation, without written definitions. Non-differential misclassification would bias results towards the null. Similarly, questions from the ISAAC core questionnaire pertaining to AR have been shown to have good specificity but lower sensitivity that may dilute potential associations [25]. Although there were no systematic differences according to those who completed the questionnaires, there is a possibility of response bias [26]. In conclusion, our findings of decreased allergic symptoms and asthma that were related to past or present residence in a farm or rural area with livestock, suggests that some aspects of the farm environment are protective for respiratory and allergic conditions among 4-H youth. The protective associations found for consistent farm residence throughout childhood and large acreage size despite opportunity for contact with livestock in this population, suggest that the relationships related to farming are real and pervasive.

Further research is needed to determine what aspects of the farm environment may explain this phenomenon of reduced asthma and allergic symptoms among youth living on farms. Attributing farm-related decreases in childhood allergies and asthma to livestock exposure alone appears to be too simplistic an explanation. Follow-up and longitudinal studies of farm families, including objective measurement of exposures and outcomes, should offer insights into this most interesting question.

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