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# The Association Between Farming Activities and Respiratory Health in Rural School Age Children

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# The Association Between Farming Activities and Respiratory Health in Rural School Age Children

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**ABSTRACT.** This study assessed the prevalence of asthma in Canadian children living on and off farms and the risk of asthma and respiratory symptoms of children exposed to certain farming activities. A cross-sectional survey was sent to parents of school children ages 6 to 13 living in an agricultural community in rural Saskatchewan. History of asthma and respiratory symptoms (cough, phlegm, or wheeze), location of home, and exposure to farming activities including haying, harvesting**,** moving, or playing with hay bales, feeding livestock, cleaning or playing in barns, cleaning pens, and emptying or filling grain bins were assessed. The response rate was 90.6% ($n$ = 553). The prevalence of asthma and respiratory symptoms were 18.8% and 39.8%, respectively, and did not differ by home location (farm/nonfarm). In the adjusted multivariable models conducted with each farming activity separately, children who were exposed to emptying and filling of grain bins had a higher odds of asthma (odds [OR] = 2.18, 95% confidence interval [CI]: 1.03–4.62]. Reports of playing on or near hay bales (OR = 1.89, 95% CI:1.19–3.01), (OR = 2.08, 95% CI:1.07–4.06), and cleaning pens (OR = 2.70, 95% CI:1.05–6.97) were associated with increased respiratory symptoms. Certain farming activities associated with dust and animals appear to be risk factors for asthma and respiratory symptoms in this study population and should be avoided.

**KEYWORDS.** Asthma, children, cough, farming activities, phlegm

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## *INTRODUCTION*

Asthma is a disorder of the bronchial airways characterized by periods of inflammation and reversible bronchospasm.[1] Environmental factors such as viruses, allergens, and pollutants interact with the genetic makeup of the individual to produce symptoms of disease. Although asthma prevalence is increasing worldwide, some studies have shown a lower prevalence of asthma and respiratory symptoms in farm children.[2–4] Farming exposures after the first year of life appear to be primarily protective. Children living on farms who were fed raw milk or exposed to high levels of endotoxin in the first year of life were less likely to develop atopy or have asthma in later childhood.[5] Ege and colleagues found negative associations between asthma and pig keeping, staying in animal sheds, or haying.[6] Exposure to poultry has been shown to be positively associated with asthma.[7] Merchant and colleagues found that exposure to swine was associated with an increased risk of asthma and the risk was stronger with exposure to feed with antibiotic supplementation.[8] There is good evidence in studies with adult farming populations to suggest that exposure to certain farming environments is associated with reports of increased respiratory symptoms such as cough and phlegm and asthma.[9] We proposed to examine the relationships between asthma or respiratory symptoms of wheeze, cough, and/or phlegm and specific farming activities in a rural group of school-age children where exposure to farming environments was a possibility for many of the children.

## *METHODS*

### *Study Population and Design*

This cross-sectional study was conducted in the town and surrounding area of Humboldt, Saskatchewan (approximate population 5600). Children attending Grades 1 to 12 in any of the three primary schools or the one high school were eligible to participate in the overall study of respiratory health in school children. The response rates to the survey varied greatly between the high school group (67%) and the elementary school group (90.6%). Thus, we limited our present analysis to participants from the three elementary schools (Grades 1 to 8).

### *Data Collection*

The questionnaires used for the children's study was based on the 1979 Children's Respiratory Questionnaire of the American Thoracic Society (ATS) and a previous Humboldt Study questionnaire.[10,11] Questionnaires assessed demographics, respiratory history, and general environmental factors that also included assessment of farming activity exposure and location of home (farm/nonfarm). The parent most familiar with the child's health was asked to complete a questionnaire and sign consents for participation in the health screening that included skin testing, buccal smears for genetic studies, blood pressure, and lung function.

Questionnaires were distributed through the schools to the parents. Children returned the questionnaires to the school for collection by the research assistants. Reminder letters were sent out 1 week after the distribution of the questionnaire in order to improve the response rate.

### *Respiratory Symptoms*

Asthma was defined as a report of asthma before or during the past 12 months that had been previously diagnosed by a doctor. Cough was defined by a report of usually coughing. Wheeze was defined as chest sounding wheezy or whistling with or without a cold. Phlegm was defined by a report of congestion or bringing up phlegm with or without a cold. The prevalence of cough, wheeze and phlegm was 6.5%, 22.6%, and 29.7%, respectively. A positive history of respiratory symptoms was defined as a positive parental report of at least one of the following: cough, wheeze, or phlegm.

### *Farming Exposures*

Parents indicated exposure to seven selected farming activities by the question, "In the past 12 months has this child spent more than 1 hour on a regular basis near any of the following

activities?" Individual activities assessed were: haying (yes/no), harvesting (yes/no), moving or playing on or near hay bales (yes/no), feeding livestock (yes/no), cleaning or playing in barns (yes/no), cleaning pens (yes/no), emptying or filling grain bins (yes/no).

### *Statistical Analysis*

The analysis was based on the results for 553 children from Grades 1 to 8 who participated in the study. Chi-square tests for association were used to test associations between asthma prevalence or respiratory symptoms, environmental factors, and location of home (farm or nonfarm) at the univariate level. As multicollinearity was possible between the specific farming activities (more than one activity likely to occur on the same farm), intercorrelations between farming activities were tested using Spearman's rank correlation and all were found to be correlated. Correlations ranged from r = .15 for cleaning/playing in barns by emptying/filling grain bins to r = .65 for feeding livestock by cleaning/playing in barns. All results were significant $p < .001$. As a result, separate multivariable logistic regression models to examine associations between asthma or respiratory symptoms and each farming activity were developed, adjusting for covariates that were statistically significant in the univariate analyses or that were deemed clinically relevant (i.e., parental history of allergy, passive smoking in the home, home dampness, pets living in the home, and home heating). Level of significance was set at $\alpha = .05$.

## *RESULTS*

When we examined associations between asthma or respiratory symptoms and demographic and household environmental factors (data not presented), children with asthma were more likely to be male ($p < .05$), to have a parental history of allergy ($p < .001$), and were more likely to be bottle fed as an infant ($p < .05$). Similar to children with asthma, children with respiratory symptoms were also more likely to be male ($p < .05$) and have a parental history of allergy ($p < .001$). However, children with respiratory symptoms were also more likely to be exposed to passive smoking in the home ($p < .01$) and to live in damp housing ($p < .001$).

Figure 1 shows the proportion of study subjects participating in the seven different farming activities assessed. One-third of subjects reported a history of farming activities of at least one hour regularly in the past year, irrespective of home location. The most frequent exposures for children were haying activities or the moving of or playing on or near hay bales (19.5%) and the least frequent was cleaning pens (3.6%).

Table 1 shows the frequency of exposure to the farming activities for children with asthma compared to children with no asthma. Children with asthma were found to be more likely than children without asthma to be near the emptying/filling of grain bins ($p < .05$). Table 1 also shows the frequency of exposures to the farming variables for children with respiratory symptoms compared to those with no respiratory symptoms. Children who were near haying activities

FIGURE 1. Farming activity participation in study children.

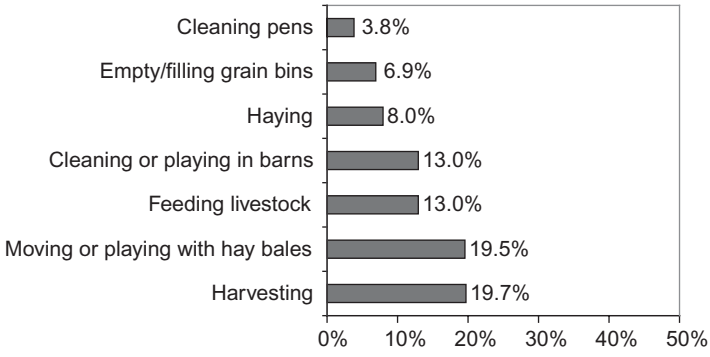

TABLE 1. Frequency of Participation in Farming Activities by Report of Asthma/No Asthma or Respiratory Symptoms/No Respiratory Symptoms ($n$ = 553)

| Farming activity | Asthma $n$ = 104 $n$ (%) | No asthma $n$ = 449 $n$ (%) | Respiratory symptoms $n$ = 220 $n$ (%) | No respiratory symptoms $n$ = 333 $n$ (%) |
|---|---|---|---|---|
| Haying | | | | |
| No | 94 (90.4) | 415 (92.4) | 196 (89.1) | 313 (94.0) |
| Yes | 10 ( 9.6) | 34 (7.6) | 24 (10.9)† | 20 (6.0) |
| Harvesting | | | | |
| No | 77 (74.0) | 367 (81.7) | 170 (77.3) | 274 (82.3) |
| Yes | 27 (26.0)* | 82 (18.3) | 50 (22.7) | 59 (17.7) |
| Moving or playing with hay bales | | | | |
| No | 79 (76.0) | 366 (81.5) | 163 (74.1) | 282 (84.7) |
| Yes | 25 (24.0) | 83 (18.5) | 57 (25.9)‡ | 51 (15.3) |
| Feeding livestock | | | | |
| No | 89 (85.6) | 392 (87.3) | 184 (83.6) | 297 (89.2) |
| Yes | 15 (14.4) | 57 (12.7) | 36 (16.4) | 36 (10.8) |
| Cleaning/playing in barns | | | | |
| No | 93 (89.4) | 388 (86.4) | 185 (84.1) | 296 (88.9) |
| Yes | 11 (10.6) | 61 (13.6) | 35 (15.9) | 37 (11.1) |
| Pens | | | | |
| No | 99 (95.2) | 433 (96.4) | 207 (94.1) | 325 (97.6) |
| Yes | 5 (4.8) | 16 (3.6) | 13 (5.9)† | 8 (2.4) |
| Empting or filling grain bins | | | | |
| No | 91 (87.5) | 424 (94.4) | 202 (91.8) | 313 (94.0) |
| Yes | 13 (12.5)† | 25 (5.6) | 18 ( 8.2) | 20 ( 6.0) |

*$p$ < .10; †$p$ < .05; ‡$p$ < .01.

TABLE 2. Results of Logistic Regressions for Individual Farming Activities by (a) Asthma and by (b) Respiratory Symptoms

| Multivariable models | Farming activities | (a) Asthma Adjusted OR[a] (95% CI) | (b) Respiratory symptoms Adjusted OR[a] (95% CI) |
|---|---|---|---|
| Model I | Haying(ref = no) | 1.08 (0.50–2.36) | 2.08 (1.07–4.06)* |
| Model II | Harvesting(ref = no) | 1.41 (0.83–2.38) | 1.42 (0.90–2.25) |
| Model III | Hay bales(ref = no) | 1.13 (0.65–1.96) | 1.89 (1.19–3.01)† |
| Model IV | Feeding livestock(ref = no) | 1.05 (0.55–1.99) | 1.70 (1.00–2.89) |
| Model V | Barns(ref = no) | 0.73 (0.36–1.47) | 1.60 (0.95–2.71) |
| Model VI | Cleaning pens(ref = no) | 1.15 (0.39–3.39) | 2.70 (1.05–6.97)* |
| Model VII | Grain bins(ref = no) | 2.18 (1.03–4.62)* | 1.35 (0.67–2.76) |

[a]Adjusted for age, sex, parental allergy, parental smoking, dampness, pets, and home heating.
*$p$ < .05; †$p$ < .01.

had increased respiratory symptoms of cough, phlegm or wheeze ($p$ < .05). Children exposed to the moving of hay bales or playing near or on hay bales ($p$ < .01) and cleaning pens ($p$ < .05) also had increased respiratory symptoms compared to children who did not participate in those activities. Results of the logistic regression analyses for asthma or respiratory symptoms with each farming activity are shown in Table 2. After adjusting for covariates, the odds of asthma were 2.18 times greater among children exposed to grain bins compared to those who were not. Exposure to haying activities (OR = 2.08, 95% CI: 1.07–4.06) and exposure to moving or

playing on or near hay bales (OR = 1.89, 95% CI: 1.19–3.01) were associated with an increased odds of respiratory symptoms. In addition, the odds of respiratory symptoms were 2.70 times greater among children exposed to the cleaning of pens compared to those who were not.

## *DISCUSSION*

In this study population of rural school children, those exposed to certain farming activities in the past year were more likely to have either asthma or respiratory symptoms such as cough, phlegm, or wheeze. Specifically, children exposed to the emptying and filling of grain bins were more likely to have asthma. Children exposed to haying, playing on or near hay bales, or cleaning pens were more likely to experience respiratory symptoms.

There is limited study of the association between farming exposures and asthma and respiratory symptoms in children, particularly for specific farming activities. Rennie found that participation in farming activities by children on a regular basis in the past 12 months was associated with increased risk of wheeze and a decreased risk of ever asthma.[10] Ernst and colleagues conducted a study of 1199 French Canadian adolescents 12 to 19 years of age and found current wheeze, airway hyperresponsiveness, and skin test positivity to common allergens to be significantly less frequent in adolescents raised on farms and these differences were particularly pronounced in girls.[2] These authors did find, however, that farm children were significantly more allergic to farm allergens that were nonfarm children.[2] Ege and colleagues, in a 2007 study of 8268 school-age children ages 5 to 13 in five European countries, reported an inverse relationship between asthma and regular exposure (at least once a week) to pig keeping (OR = 0.77, 95% CI: 0.38–0.86), frequent stays in animal sheds (OR = 0.71, 95% CI: 0.54–0.95), and involvement in haying (OR = 0.56, 95% CI: 0.38–0.81).[6] On the other hand, exposure to pressed hay was associated with an elevated odds of asthma (OR = 1.32, 95% CI: 0.93–1.88).[6] A 2005 cohort study by Merchant and colleagues of children from birth through 17 years of age in Iowa found children living on farms that raised swine to have an increased odds of asthma (OR = 1.88, 95% CI: 1.02–3.45). Interestingly, the magnitude of the association increased with the use of feed that contained antibiotics (OR = 2.47, 95% CI: 1.29–4.74).[8] It appears that the results of our study, although supporting the findings in other research of increased respiratory symptoms in children exposed to livestock, do not support previous findings for other farming activities. The use of different definitions of asthma and respiratory symptoms between studies could be one reason for the identified differences. In our study, we examined respiratory symptoms (cough, wheeze, and/or phlegm) that are commonly reported by adults on exposure to certain farming environments.[12] These symptoms are not usually assessed with children in farming environments and may account for the positive associations found here with certain farming activities that have not been reported elsewhere.

Many features of the agricultural workplace make it an environment that could lead to respiratory irritation and damage. Grain dust exposure has been shown to be associated with decreased lung function and increased respiratory symptoms in adults.[13] The chief component of grain dust is grain but a variety of other components can also be found in grain dust, including plant matter; molds and spores (mainly *Aspergillus* and *Cladosporium* species); in humid grain, thermophilic *Actinomycete*; mycotoxins; bacteria and their biochemical components. In addition, excretions from livestock and poultry, birds, and rodents and their associated endotoxins, peptidoglycans, and proteolytic enzymes can be present in grain dust. Inorganic matter such as soil and silica, including quartz, is also frequently present.[14] Other organic dusts found in agricultural environments also contain a variety of components. In swine confinement buildings, the dust is mainly composed of the animal feeds, but the main sources of microorganisms, allergens, and toxins are animal dander, urine, and feces.[14]

In our study, haying was associated with both asthma and respiratory symptoms. In Saskatchewan, the primary types of hay are alfalfa, timothy, and bromegrass. These grasses are often collected and stored at their maximum weight and flower. As is the case for grain dust, hay dust can contain a wide variety of components, including pollens, mold, and bacteria.[15] The composition of hay may vary depending on the above mentioned factors and may influence the reactivity of subjects to the specific mixture of grasses.

Cleaning pens may also expose children to higher dust concentrations and endotoxins, as has been shown in studies of adult poultry workers.[12,15] Endotoxin is a stable glycolipid component of the outer membrane of gram-negative bacteria that can be collected and assayed in settled dust from mattresses or floors of homes and is present in high amounts in swine confinement and poultry houses.[16] Endotoxin has inflammatory effects and if inhaled, can exacerbate airflow obstruction and airway inflammation in individuals.[17]

Research has also shown that there are other important factors in a farming environment that make it a susceptible environment for asthma and respiratory symptoms. Exposures inside animal houses include gases from feces and urine of animals.[18] A survey by Radon and colleagues of 6937 German adults, 18 to 45 years of age, found that the prevalence of self- reported asthma symptoms increased with self-reported odor annoyance.[18]

Among adults, associations between asthma, wheeze, and type of farming have been found. Senthilselvan and colleagues identified grain farming as a significant predictor of asthma and wheeze (OR = 1.9; 95% CI: 1.1–3.5 for asthma and OR = 1.7, 95% CI: 1.3–2.4 for wheeze).[19] In a study of grain and poultry workers in Saskatchewan, Alberta and Manitoba, Kirychuk and colleagues found poultry workers to have a greater prevalence of current and chronic respiratory conditions including cough wheeze and phlegm.[12] Thus, the nature and source of the dust may be important factors in determining what specific farming environments are more likely to be associated with wheeze, respiratory symptoms and asthma in children.

## *Study Strengths and Limitations*

This study had an excellent response rate and assessed the respiratory health of a large population of rural children with exposure to farming environments.

There were also limitations. As this was a cross-sectional study, farming exposure, asthma, and respiratory symptoms are assessed at a single point in time so it is not possible to determine causality between exposures and asthma or respiratory symptoms reported. For the most part, the associations between respiratory symptoms and asthma need to be examined longitudinally to determine patterns of association.

Parental reporting can be a source of response bias. Parents needed to be aware of the nature and the extent of the farming activities of their children. In order to limit this reporting bias, we did ask parents to have the person most familiar with the child to answer the questionnaire.

Although many of the associations between farming exposures and respiratory health reported in the literature are those involving intensive livestock or grain handling, the exposures assessed in the current study would be classified as minimal exposures and need further evaluation. We asked parents to report if children had been involved in any of the preidentified seven farming exposures on a regular basis in the past year of more than 1 hour at a time. It would be essential to examine nature of these exposures more objectively perhaps through personal monitoring of exposures[20] or activity diaries to determine in more detail the extent of exposures and whether the intensity of exposure produces different respiratory responses in participants.

There were multiple tests used to assess associations between each activity and respiratory outcomes at the multivariable level. Consequently, spurious findings are possible and these preliminary findings should be interpreted cautiously.

## *Conclusions*

The associations between certain farming activities and asthma or respiratory symptoms support the findings for adults in farming environments. The well-known association between farming exposures and increased respiratory

symptoms or disease in adult farmers that were also found for children in this study suggests the need to examine whether these exposures during childhood influence the later development and nature of respiratory disease in adult farming populations. Therefore, for children, avoidance of these exposures seems prudent.

## REFERENCES

1. Roy SR, Milgrom H. Management of the acute exacerbation of asthma [review]. *J Asthma.* 2003;40: 593–604.

2. Ernst P, Cormier Y. Relative Scarcity of asthma and atopy among rural residents raised on farms. *Am J Respir Crit Care Med*. 2000;161:1563–1566.

3. 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.

4. Aref AA, Borders TF, Patterson PJ, Rohrer JE, Xu KT. Prevalence and correlates of paediatric asthma and wheezing in a largely rural USA population. *J Paediatr Child Health.* 2004;40:189–194.

5. Braun-Fahrländer C, Riedler J, Herz U, Eder W, Waser M, Grize L, Maisch S, Carr D, Gerlach F, Bufe A, Lauener RP, Schierl R, Renz H, Nowak D, von Mutius E; Allergy and Endotoxin Study Team. Environmental exposure to endotoxin and its relation to asthma in school age children. *N Engl J Med*. 2002;347:869–877.

6. Ege MJ, Frei R, Bieli C, Schram-Bijkerk D, Waser M, Benz MR, Weiss G, Nyberg F, van Hage M, Pershagen G, Brunekreef B, Riedler J, Lauener R, Braun-Fahrländer C, von Mutius E; PARSIFAL Study team. Not all farming environments protect against the development of asthma and wheeze in children. *J Allergy Clin Immunol*. 2007;119:1140–1147.

7. Wickens K, Lane JM, Fitzharris P, Siebers R, Riley G, Douwes J, Smith T, Crane J. Farm residence and exposures and the risk of allergic diseases in New Zealand children. *Allergy*. 2002;57:1171–1179.

8. Merchant JA, Naleway AL, Svendsen ER, Kelly KM, Burmeister LF, Stromquist AM, Taylor CD, Thorne PS, Reynolds SJ, Sanderson WT, Chrischilles EA. Asthma and farm exposures in a cohort of rural Iowa children. *Environ Health Perspect.* 2005;113:350–356.

9. Dosman JA, Lawson JA, Kirychuk SP, Cormier Y, Biem, J, Koehncke N. Occupational asthma in newly employed workers in intensive swine confinement facilities. *Eur Respir J*. 2004;24:698–702.

10. Rennie DC. A population based study of asthma and wheeze in school age children. Dissertation, University of Saskatchewan, Saskatoon, Alberta, Canada; 1996.

11. Ferris BG. Epidemiology Standardization Project (American Thoracic Society). *Am Rev Respir Dis*. 1978; 118(6 Pt 2):1–120.

12. Kirychuk SP, Senthilselvan A, Dosman JA, Juorio V, Feddes JJ, Willson P, Classen H, Reynolds SJ, Guenter W, Hurst TS. Respiratory symptoms and lung function in poultry confinement workers in western Canada. *Can Respir J*. 2003;10:375–380.

13. Clancy RL, Ruhno J, Scicchitano R, Cripps AW, Hensley MJ, Saunders NA, Wrigley C, Walsh B, Sutherland DC. Wheat dust-associated respiratory disease in a farming community. *Aust N Z J Med*. 1991; 21:222–226.

14. Gallagher LM, Crane J, Fitzharris P, Bates MN. Respiratory health hazards in agriculture. *Am J Respir Crit Care Med*. 1998;158(5 Pt 2):S1–S76.

15. Faria NM, Fachinni LA, Fassa AG, Tomasi E. Farm work, dust exposure and respiratory symptoms among farmers. *Rev Saude Publica.* 2006;40:827–836.

16. Waser M, Schierl R, von Mutius E, Maisch S, Carr D, Riedler J, Eder W, Schreuer M, Nowak D, Braun-Fahrländer C; ALEX Study Team. Determinants of endotoxin levels in living environments of farmers' children and their peers from rural areas. *Clin Exp Allergy*. 2004; 34:389–397.

17. Schwartz DA. Does inhalation of endotoxin cause asthma? *Am J Respir Crit Care Med*. 2001;163:305–306.

18. Radon K, Schulze A, Ehrenstein V, van Stien RT, Praml G, Nowak D. Environmental exposure to confined animal feeding operations and respiratory health of neighboring residents. *Epidemiology*. 2007;18:300–308.

19. Senthilselvan A, Chen Y, Dosman JA. Predictors of asthma and wheezing in adults. Grain farming, sex and smoking. *Am Rev Respir Dis*. 1993;148:667–670.

20. Rabinovitch N, Liu AH, Zhang L, Rodes CE, Foarde K, Dutton SJ, Murphy JR, Gelfand EW. Importance of the personal endotoxin cloud in school-age children with asthma. *J Allergy Clin Immunol.* 2005;116: 1053–1057.