



Factors contributing to risks for pediatric asthma in rural Saskatchewan

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ABSTRACT

Background: Rural children have lower reported rates of asthma compared with urban children. Although reasons for these differences remain unclear, 3 possible explanations exist: (1) environmental differences, (2) variations in health care access, and (3) variations in health risk behaviors.

Objective: We investigated asthma among children living on farms and in small towns and its potential determinants, including personal, behavioral, and environmental factors.

Methods: School children ($n = 842$, ages 6–13; participation rate = 72.0%) were involved in a 2003 cross-sectional study. Their parents completed a lung health survey that included questions about asthma, asthma-like symptoms, and potential determinants of asthma (demographic, environmental, health risk behaviors). Participating children were classified into farm dwellers (live on farm or acreage) and small town dwellers. Multiple logistic regression was used to investigate the association between asthma and wheeze with demographic, environmental, and behavioral exposures with simultaneous adjustment for confounders.

Results: Asthma and wheeze prevalence was not significantly different between farm and small town areas (current asthma: 16% vs 13%, respectively; current wheeze: 27% vs 21%, respectively) and followed consistent patterns. Factors associated with diagnosed asthma were dampness (odds ratio [OR] = 1.85; 95% confidence interval [CI] = 1.08–3.17), with enrollment in daycare found to be protective (OR = 0.53; 95% CI = 0.33–0.85). Being obese or overweight was associated with wheeze (OR = 1.77; 95% CI = 1.06–2.97).

Conclusion: Given the differences between areas and the associations between environmental risk factors and obesity with asthma and wheeze, the study findings support environment and health risk behavior explanations for the observed geographic variations.

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Introduction

Asthma is a disease characterized by episodic symptoms of cough, shortness of breath, wheeze, and chest tightness, which typically occur after exposure to irritants, allergens, respiratory infections, or after exercise.¹ More than 13% of Canadian children have been diagnosed with asthma.² With diagnoses increasing in Canada and also globally, asthma has become one of the most common chronic childhood diseases.² A lower prevalence of

asthma has been identified among rural compared with urban child populations.^{3–5} This lower prevalence is especially evident when comparing children from farming vs more urban environments.^{6,7}

There are several potential explanations for the variations in asthma prevalence observed between urban and rural children: (1) *Environmental:* Farm children may have different exposures⁸ or levels of exposures⁹ to irritants or allergens that could influence asthma prevalence. Farm environments may contribute to differences in asthma prevalence by altering immune responses. This environmental theory is typically explained by the hygiene hypothesis, which proposes that early life exposures influence immune system development, lowering the risk for asthma and allergic disease.¹⁰ (2) *Health care access:* Rural children have reduced access to health care or engage less in different health care practices, and therefore are less likely to become diagnosed with asthma, although they experience the same symptoms.^{11,12} (3) *Health risk behaviors:* Although more controversial, individual health behaviors, such as physical activity, could be underlying determinants of differential reported prevalence of asthma.¹³ Personal factors associated with asthma such as male sex and family

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history of asthma have been fairly well established and are typically consistent between locations.

Based on these theories, the aim of this study was to quantify the association between potential demographic, behavioral, environmental, and personal risk factors and asthma and wheeze. Through a dedicated comparison of children from small town versus farm status, we explored the association between potential risk factors and asthma and wheeze, in light of these explanations for observed geographical differences in asthma prevalence. The main hypothesis was that children from farms would exhibit lower risks for asthma and wheeze compared with children who lived in small town settings. We also hypothesized that the difference in asthma prevalence between farm and small-town dwelling could be explained by exploring a number of risk factors under the explanations outlined. This would help us understand more about mechanisms that may underlie this relationship. Although various farm-related exposures have been implicated as potential risks and also as protective factors for childhood asthma, the existing literature has many inconsistent findings, and therefore, uncertainty still exists.¹⁴

Methods

Study design and population

We used data from a 2003 cross-sectional study of children conducted in Estevan, Canada. Estevan is a major agricultural center in Southern Saskatchewan and is situated near a coal mining strip, coal-fired power production, and oil and gas drilling. This cross-sectional study was originally developed to examine lung health in the region and provide a sampling frame for a separate case-control study.¹⁵ In addition, the current analysis builds on a similar cross-sectional study completed in Estevan in 2000.^{14,16}

All children in Estevan enrolled in grades 1 through 6 during the 2002–03 academic year were approached to participate. Parents completed questionnaires within a 3-week period after distribution through the schools in January 2003. A reminder letter was sent 10 days after distribution. The participation rate was 72.0%, resulting in a sample size of 842 participants. Approvals to conduct the survey were obtained from the school boards and associated school principals in Estevan before distribution in the schools. Ethical approval was obtained from the Advisory Committee on Ethics in Biomedical Research at the University of Saskatchewan.

Study instrument

Questionnaire content was based on the American Thoracic Society's Children's Respiratory Disease Questionnaire,¹⁷ questionnaires used in the Student Lung Health study,¹⁴ and an asthma prevalence questionnaire used in a 1992 study conducted in Humboldt, Saskatchewan.¹⁸ The 2003 study questionnaire included items describing demographics, current and previous asthma and asthma-like symptoms, related atopic diseases, other illnesses, home environments, lifestyle factors, and family factors.

Variables considered in the study

Respiratory outcomes

Asthma and wheeze were defined based on past operational definitions proposed by Rennie and colleagues,¹⁶ using data from the 2,000 Estevan study. These definitions were similar to those used in other epidemiological studies of childhood asthma^{16,19} and have shown relatively good agreement with other measures of lung health, including physician diagnosis, other questionnaires, and physiological measures.¹⁹ The outcome definitions are largely based on The International Study of Asthma and Allergies in Childhood questionnaire, which has a sensitivity of 0.85 and specificity of 0.81 compared with physician diagnosis of asthma.²⁰ Parent-completed questionnaires optimize cost-effectiveness, sensitivity,

and specificity when measuring pediatric asthma prevalence at a population level.^{21,22}

Ever asthma was assessed by the question "Has this child ever been diagnosed as having asthma by a doctor?" *Current asthma* was defined by ever asthma and at least one of the following: an emergency department visit for asthma, a physician's office visit for asthma, a visit to an intensive care unit for asthma, a self-reported asthma episode or wheeze, or medication use for asthma in the past 12 months. *Ever wheeze* was defined as wheeze or whistling coming from the chest without a cold or wheeze with shortness of breath or wheeze during or after exercise. *Current wheeze* was defined as ever wheeze with symptoms reported in the past 12 months.

Location of residence

Location of residence was based on the question "Where is your home located?" The child was considered to be a farm dweller if they lived on a farm or acreage. If it was reported that the child lived in town, they were considered a small town dweller.

Environmental factors

Environmental factors were also explored as potential risk factors. Unless otherwise specified, operational definitions were chosen based on past precedents as outlined in Lawson et al.¹⁰ House dampness was considered present if there was a positive response to the question "Does your house have any damage caused by dampness (eg, wet spots on walls or floors)?" House mold was considered present if there was a positive response to the question "Are there signs of mold or mildew in any living areas in your home?"²³ Children were considered to have pets in the home if the pet had fur or feathers. Home renovations included those that had occurred during the child's lifetime. Type of housing unit was defined as single-family dwelling or other dwelling. The presence of home fireplaces and dehumidifiers were based on self-report of currently having one in the house. Finally, home crowding was defined using a continuous variable describing the number of people in the home divided by the number of rooms in the home.¹⁴

Behavioral factors

Current parental smoking status was defined as parental smoking for the mother or father at the time of questionnaire completion.¹⁰ Ever smoking was defined as parental smoking that occurred in the past, and did not include current smokers.¹⁰ Participation in sports and physical activity was considered high if the answer to "How many times a week does your child engage in vigorous physical activity long enough to make him/her breathe hard?" was "Three or more times per week," based on the assumption that most children would exercise at a high level.

Personal factors

Operational definitions were based on past precedents.¹⁰ Age groups were classified as younger (ages 6–9) and older (ages 10–13).¹² Father's and mother's education levels were classified as high school or less vs any postsecondary education. History of respiratory allergies was considered present if the child had allergies to house dust, grain dust, pollen, trees, grasses, mold or mildew, dogs, cats, or birds/feathers. A child was considered low birth weight if parents reported a weight of less than 2.5 kg at birth. Premature birth was defined as being born more than 2 weeks before the expected birth date. A child was considered overweight or obese if their reported height and weight measured more than the adult equivalent of 25 kg/m² based on centile curves derived internationally.²⁴

Statistical analysis

All analyses were conducted using SAS version 9.2 statistical analysis software (SAS Institute Inc., Cary, North Carolina). We first described the study population using conventional descriptive statistics. We then compared distributions of variables in the 2 study

Table 1
Personal characteristics and demographics by geographic status

	Overall (n = 834) n (%)	Farm (n = 91) n (%)	Small Town (n = 743) n (%)	P value
Sex				
Male	419 (50)	33 (36)	386 (52)	.005
Female	415 (50)	58 (64)	357 (48)	
Age group				
Younger (6–9)	392 (47)	42 (46)	350 (47)	.83
Older (10–13)	442 (53)	49 (54)	393 (53)	
Father's education				
High school or less	449 (56)	50 (56)	399 (56)	.99
More than high school	359 (44)	40 (44)	319 (44)	
Mother's education				
High school or less	402 (49)	41 (46)	361 (50)	.64
More than high school	415 (51)	48 (54)	367 (50)	

groups (small town vs farm) using χ^2 tests for categorical variables and independent samples *t* tests for continuous measures.

We conducted regression analyses to identify potential risk factors for the asthma outcomes and to test the focal hypothesis that farm residence status was associated with lower risks for these outcomes. We forced residence type (farm vs small town) into all models. Other potential determinants were examined individually then collectively using multiple logistic regression analyses. We used generalized estimating equations to account for the clustered nature of the sampling scheme, with students nested within families. We chose to control for clustering by family but not schools because covariance parameter estimates suggested much larger clustering by family (0.025) compared with clustering by school (0.001). We used a purposeful modeling strategy, with consideration of past evidence and theory, as well as statistical criteria (backwards elimination with a liberal alpha level of 0.1) in the selection of covariates. Presented estimates of effect included adjusted odds ratios and their 95% confidence limits.

Results

A description of demographic factors and environmental, behavioral, and personal risk factors stratified by farm vs small town

Table 3
Prevalence of asthma and asthma-like symptoms by geographic status

	Overall (n = 834) n (%)	Farm (n = 91) n (%)	Small Town (n = 743) n (%)	P value
Current wheeze	169 (22)	24 (27)	145 (21)	.28
Ever wheeze	231 (28)	27 (30)	204 (28)	.74
Current asthma	110 (13)	15 (16)	95 (13)	.48
Ever asthma	158 (19)	18 (20)	140 (19)	.94

geographic status are presented in Tables 1 and 2. Children from farms were more likely to be female (64% compared with 48%; $P = .005$) but did not differ statistically ($P > .05$) by age or parental education levels. Children from farms were more likely to participate in regular vigorous physical activity compared with children from within town (77.3% vs 62.9%, respectively; $P = .01$). Although no other statistically significant differences were found between farm and small town children with regard to environmental, behavioral, and personal risk factors, children from farms tended ($P < .10$) to have fewer indoor pets, were more likely to live in a home with renovations, were more likely to live in a single-family dwelling, and were more likely to live in a home with a fireplace, but were less likely to report past attendance at a daycare and to have parents that smoked or previously smoked.

Table 3 presents a comparison of asthma and asthma-related outcomes between the groups. Although the prevalence of asthma and wheeze was slightly greater in the farm group compared with the small town group, the differences were not statistically significant.

As seen in Table 4, the results from the descriptive study are confirmed after adjustment for potential confounders. Associations between each independent variable and the disease outcomes based on the multivariate analysis are also presented in Table 4.

Risk factors for ever wheeze included male sex (odds ratio [OR], 1.55; 95% confidence interval [95% CI], 1.07–2.25), living in homes with dampness (OR, 1.51; 95% CI, 0.99–2.31), personal history of allergy (OR, 6.24; 95% CI, 4.22–9.23), maternal history of asthma (OR, 2.06; 95% CI, 1.12–3.80), and being overweight or obese (OR, 1.53; 95% CI, 0.95–2.47). Children with a personal history of allergy (OR, 7.66; 95% CI, 4.98–11.77), maternal history of asthma (OR, 2.45; 95% CI, 1.24–4.84), and children who are overweight or obese

Table 2
Environmental and behavioral factors by geographic status

	Overall (n = 834) n (%)	Farm (n = 91) n (%)	Small town (n = 743) n (%)	P value
Environmental factors				
Homes with dampness	20.5	21.1	20.7	.49
Homes with mold or mildew	15.3	16.7	15.1	.46
Homes with indoor pets	59.5	46.1	61.1	.09
Homes with renovations	42.7	50.6	41.7	.27
Single-family dwelling	89.1	93.4	85.9	.13
Homes with fireplace	35.3	49.4	33.6	.23
Homes with dehumidifier	10.7	13.5	11.7	.41
Crowding (persons/room) (Mean/SD)	0.7 (0.3)	0.7 (0.2)	0.7 (0.3)	.83
Behavioral factors				
Children breastfed	74.3	79.8	73.6	.22
Children that attended daycare	71.5	59.6	72.9	.09
Mother that currently smoke	23.1	17.1	23.8	.24
Mother ever smoked	15.2	7.1	16.1	.09
Mother that smoked during pregnancy	24.6	14.4	25.9	.07
Father that currently smoke	31.0	24.7	31.8	.30
Father ever smoked	15.5	6.7	16.5	.09
Weekly physical activity	64.4	77.3	62.9	.01
Personal factors				
Children with allergies	23.5	29.7	22.8	.22
Fathers with asthma	7.1	12.2	6.5	.37
Mothers with asthma	7.9	10.0	7.7	.45
Born underweight (<2,500 g)	5.0	3.3	5.3	.46
Overweight or obese	15.4	20.9	14.7	.13
Children born premature	10.0	4.4	10.6	.10

Table 4

Results of multivariate logistic regression: adjusted odds ratios describing risk factors for asthma and asthma-like symptoms

Covariate	Ever wheeze OR (95% CI)	Current wheeze OR (95% CI)	Ever diagnosed asthma OR (95% CI)	Current diagnosed asthma OR (95% CI)
Demographics				
Farm residence (Ref: small town)	1.02 (0.55, 1.89)	1.20 (0.61, 2.37)	0.87 (0.43, 1.77)	1.00 (0.43, 2.32)
Male sex (Ref: female)	1.55 (1.07, 2.25)	1.31 (0.85, 2.03)	2.18 (1.41, 3.36)	1.94 (1.16, 3.25)
Father education: More than high school (Ref: High school or less)	1.00 (0.69, 1.45)	0.74 (0.47, 1.14)	1.46 (0.94, 2.27)	1.14 (0.68, 1.91)
Environmental factors				
Dampness	1.51 (0.99, 2.31)	1.54 (0.97, 2.47)	1.85 (1.08, 3.17)	1.25 (0.64, 2.43)
Behavioral factors				
Daycare	0.91 (0.61, 1.34)	0.77 (0.49, 1.20)	0.53 (0.33, 0.85)	0.47 (0.28, 0.79)
Father current smoker	1.03 (0.70, 1.53)	1.16 (0.75, 1.80)	0.72 (0.43, 1.19)	0.63 (0.35, 1.14)
Personal factors				
Premature birth	1.05 (0.55, 1.98)	1.12 (0.50, 2.52)	2.37 (1.06, 5.27)	1.76 (0.65, 4.71)
Personal allergies	6.24 (4.22, 9.23)	7.66 (4.98, 11.77)	7.03 (4.56, 10.83)	7.89 (4.90, 12.70)
Father with asthma	1.60 (0.80, 3.23)	1.85 (0.84, 4.08)	2.96 (1.51, 5.81)	3.23 (1.42, 7.37)
Mother with asthma	2.06 (1.12, 3.80)	2.45 (1.24, 4.84)	3.31 (1.64, 6.68)	2.80 (1.30, 6.01)
Overweight or obese	1.53 (0.95, 2.47)	1.77 (1.06, 2.97)	1.08 (0.58, 2.00)	1.63 (0.85, 3.13)
Normal birth weight (Ref: underweight)	1.67 (0.77, 3.65)	1.48 (0.56, 3.87)	0.65 (0.20, 2.13)	0.58 (0.14, 2.42)

(OR, 1.77; 95% CI, 1.06–2.97) were more likely to report *current wheeze*.

Risk factors for *ever asthma* included male sex (OR, 2.18; 95% CI, 1.41–3.36), living in homes with dampness (OR, 1.85; 95% CI, 1.08–3.17), being born prematurely (OR, 2.37; 95% CI, 1.06–5.27), personal history of allergy (OR, 7.03; 95% CI, 4.56–10.83), paternal history of asthma (OR, 2.96; 95% CI, 1.51–5.81), and maternal history of asthma (OR, 3.31; 95% CI, 1.64–6.68). A history of daycare attendance was associated with lower relative odds of ever asthma (OR, 0.53; 95% CI, 0.33–0.85). Males were more likely to have current asthma than females (OR, 1.96; 95% CI, 1.16–3.25). Children that had attended daycare were less likely to have current asthma (OR, 0.47; 95% CI, 0.28–0.79). Children that reported personal history of allergy (OR, 7.80; 95% CI, 4.90–12.70), paternal history of asthma (OR, 3.23; 95% CI, 1.42–7.37), and maternal history of asthma (OR, 2.80; 95% CI, 1.30–6.01) were more likely to also report current asthma.

Discussion

The purpose of the current study was to examine differences in asthma and wheeze prevalence by farm and small town status, in light of 3 potential explanations. We found, unexpectedly, that asthma and wheeze prevalence were similar between small town and farm locations. We did confirm commonly identified personal characteristics associated with asthma and wheeze and identified environmental characteristics that were associated with asthma in this primarily rural region.

The farm and small town groups were almost equally likely to have been given a diagnosis of asthma (ever asthma), but a slightly higher and statistically nonsignificant proportion of farm children reported current asthma and wheeze, contrary to findings observed in other settings, suggesting that living in a small town does not increase the risk of asthma or wheeze compared with farm children.^{3–5} Other contextual risk factors may account for differences in asthma prevalence observed geographically in other studies,^{3–5} as well as between different groups in our own study. Possibly the 2 geographic groups are too similar to compare, because those children living in town may have been regularly exposed to allergens and irritants commonly experienced in the farm group, because: (1) the population and area size of Estevan are relatively small compared with what may be considered a more “urban” center and, as such, those in town may have lived in close proximity to farms that surround Estevan and hence shared in their environmental exposures; (2) other exposures common to the farm and nonfarm groups may have affected the entire population and their

asthma symptoms and diagnoses; and (3) farm dwellings and farming practices may be different from those of previous studies where associations between farming and asthma have been reported. Hence, environmental exposures may be similar among this population. Analogously, both groups may have had similar access to health care, or engaged in similar health behavior patterns given the close proximity of the dwellings.

Our study findings largely support *environmental* explanations for geographic variations in asthma and wheeze prevalence. Environmental factors that were strongly associated with asthma and wheeze were home dampness as a risk factor and prior daycare attendance as a protective factor. Home dampness as a risk factor for asthma and wheeze is consistent with findings reported elsewhere.^{14,15,25} A higher proportion of town children attended daycare than rural children, and this had an apparent protective effect. Midodzi et al²⁶ also found that daycare attendance was protective for wheeze among primary school students. Environmental factors such as these that differed between our farm and small town groups may be underlying the geographic variations in asthma prevalence.

The *health care access* explanation was not supported by our findings. Both wheeze and asthma were higher in the farm group, suggesting that differences are not the result of differences in diagnostic patterns. However, our study focused on a rather small regional population, and health care access would likely be very similar between farm and nonfarm children in our setting. Similar studies have found that of those that wheeze, farm and nonfarm children are equally likely to have an asthma diagnosis,¹² indicating that diagnostic patterns or access to care are not a significant factor underlying the differences in prevalence in our setting.

The *health risk behaviors* explanation was partially supported by the findings. Being overweight or obese was found to be positively associated with asthma, and a higher proportion of children living on farms were overweight or obese compared with children living in town. Few studies have examined individual health behaviors as risk factors for wheeze and asthma. Lawson et al⁵ found that although health behaviors and obesity did not mediate the association between geographic region (metro, adjacent to metro, and rural) and asthma, being overweight or obese, having a high physical activity level, and exposure to passive smoke elevated risks for asthma. Therefore, differences in levels of various health behaviors may contribute to geographic variation in asthma prevalence.

The present study has limitations. Because of the cross-sectional nature of the survey, determining temporality in these associations may be difficult. Because no significant prevalence differences were

found between groups, future research should include a comparison group that may be less likely to be exposed to the farming environment. Examining specific exposures on the farm that may explain asthma and asthma-like symptom prevalence in rural areas also may be important. Finally, response bias may occur, because parents of children with asthma or wheeze may be more likely to complete the questionnaire than parents of children without these conditions. Therefore, absolute prevalence rates may be inflated. However, participation was good in our study (72%), and there was no reason to expect the observed effects to differ by residence status, so response bias should be minimal in our setting.

The present study also has strengths. Few large population-based studies have been reported that compare pediatric respiratory outcomes by small town vs farm status. Furthermore, because all students in Estevan were surveyed, selection bias was minimized, because all potential participants were equally likely to be selected for the study. Finally, study results may be generalized to other farm and small town populations with similar farm and environmental exposures. However, caution must be used when comparing these results with those of populations from other countries where both farming procedures and health care practices may differ widely.

Our findings have implications for prevention and further research. Results obtained from this study contribute to a better understanding of factors that directly and indirectly contribute to the occurrence of pediatric asthma. Because many of the risk factors found to be associated with asthma and wheeze are personal characteristics (ie, parent history of allergy and sex), health care professionals may be able to closely monitor groups of children that experience higher risks for asthma and asthma-like symptoms. Some exposures, such as home dampness, are modifiable risk factors. One also must note that asthma prevalence rates in this study of rural children were higher than the national average of 13%.² Therefore, asthma is still a major concern, even in rural areas where asthma is generally found to be lower.^{3–5} The high prevalence is also concerning because exposures in rural environments may exacerbate symptoms once a child has developed asthma.²⁵ Results also may aid in the identification of factors in rural environments that exacerbate asthma and asthma-like symptoms in pediatric populations.

In summary, this epidemiological study failed to find differences in childhood asthma prevalence by farm and small town status. Results still aid in understanding geographic variation in pediatric lung health outcomes and test 3 potential explanations for geographic variation in asthma and wheeze prevalence. Study findings support the environment and health risk behavior explanations. This information may be used to prevent and reduce the impact of asthma and asthma-like symptoms in rural child populations.

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