
Differences in respiratory symptoms and pulmonary function in children in 2 Saskatchewan communities

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Background: Asthma prevalence is known to vary among different geographical regions both nationally and internationally. However, there is limited understanding of the nature of differences within geographical regions.

Objective: To evaluate the prevalence of asthma in 2 prairie communities and differences in the patterns of respiratory symptoms between the communities.

Methods: A cross-sectional questionnaire survey was sent through schools in Estevan and Swift Current, Saskatchewan, to parents of 2,231 children in grades 1 to 6. Asthma prevalence was determined by questionnaire report of physician-diagnosed asthma. Pulmonary function tests (PFTs) using spirometry were conducted in children in grades 1 to 4. To evaluate respiratory morbidity without the use of a diagnostic label, similar comparisons were made between communities for respiratory symptoms.

Results: The overall response rate to the survey questionnaire was 91.3%. The prevalence of *ever asthma* in Estevan was 21.4% (95% confidence interval [CI], 20.1%–22.7%) compared with 16.2% (95% CI, 15.1%–17.3%) in Swift Current. A higher proportion of girls in Estevan (19.7%; 95% CI, 17.9%–21.5%) compared with girls in Swift Current (12.5%; 95% CI, 11.1%–13.9%) reported a history of asthma. There was no difference found between towns for boys. These findings were supported by findings for respiratory symptoms, including wheeze and cough. For both boys and girls, the forced expiratory flow at 25% to 75% of forced vital capacity and the ratio of forced expiratory volume in 1 second to forced vital capacity were lower in Estevan compared with Swift Current.

Conclusions: Differences in the distribution of childhood asthma can be found within regions. These results are strengthened by PFTs and cannot be fully explained by diagnostic biases.

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INTRODUCTION

During the past few decades, asthma prevalence in children has been increasing in several western nations.^{1,2} Geographical variations have been reported internationally^{3,4} and nationally.^{5,6} Although national and international variations in asthma have been much explored,^{3,4,7,8} there is limited information about the nature of asthma within regions.^{9,10} At present, many studies, assessing patterns in childhood asthma prevalence, have managed to provide more reliable findings for prevalence among geographical areas by using similar methodologic designs and collection methods.^{3–6} Environ-

mental factors are an important determinant in the differences found in childhood asthma among and within regions.^{8,9} However, it may be more difficult to identify potential differences that are a result of variability in asthma diagnostic practices.¹⁰ The purposes of this study were to investigate the prevalence of asthma in 2 agricultural communities located within the same geographical region, where one community was the site of petroleum processing and coal mining industries, and to evaluate differences in the patterns of respiratory symptoms between the communities.

METHODS

In 2000, we conducted a cross-sectional, population-based study of children residing in 2 southern Saskatchewan communities, Estevan and Swift Current. These communities were primarily settled 100 to 125 years ago by British and European immigrants. Both communities are agricultural centers, although Estevan is also the site of coal strip mining, coal-fired power production, and oil and gas drilling. Children attending grades 1 to 6 were evaluated for respiratory conditions, including asthma and wheeze, using survey questionnaires and spirometry. Before data collection, ethical approval was obtained from the research institution. School and local health boards in each community provided approval for the study.

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Questionnaires

Questionnaires were distributed through the schools to 1,211 students in Swift Current and 1,020 students in Estevan. All students in grades 1 to 6 received a questionnaire to be completed by their parents. The questionnaire was derived from the American Thoracic Society's Children's Respiratory Disease Questionnaire¹¹ and self-administered questionnaires used in the Student Lung Health Study.⁵ The same study protocol used in previous childhood studies by the researchers was used.^{3,12,13}

Ever asthma was defined by a positive response to the question, "Has this child ever been diagnosed as having asthma by a doctor?" *Current asthma* was defined by a positive response to this question and at least 1 of the following: an emergency department visit for asthma, physician's office visit for asthma, and/or wheeze or self-reported asthma episode in the past 12 months. *Wheeze* was defined by a positive report of wheeze without a cold, wheeze at night, wheeze with shortness of breath, or wheeze after exercise. Other respiratory symptoms evaluated included cough without a cold, phlegm or congestion without a cold, and other respiratory illnesses (a positive report of bronchitis, pneumonia, whooping cough, and/or croup). A summary variable, *cough and wheeze*, indicating presence of both symptoms, was computed. *Respiratory allergy* was evaluated by a positive questionnaire response that indicated symptoms arising from exposure to any of the following allergens: house dust, grain dust, pollen, trees, grasses, mold or mildew, dog, cat, birds/feathers, farm animals, and/or chemicals. A positive history of *breathing medications* was defined by the use of inhaled β_2 -agonists, inhaled corticosteroids, leukotriene receptor antagonists, and/or theophyllines in the past 12 months.

Pulmonary Function Data

Students in grades 1 to 4 were eligible to undertake pulmonary function tests (PFTs), which were performed in both communities by trained technicians in early February 2000 through April 2000. The PFTs were conducted at the schools during regular school hours using a dry rolling seal spirometer (Sensormedics model 922; Sensormedics Corporation, Anaheim, CA). The testing procedure was explained during a general assembly at each school before testing. Consent was received from a parent (or guardian) and the child undergoing testing.

Spirometry evaluation was based on the American Thoracic Society's guidelines for spirometry with children.¹⁴ The following spirometric measurements were evaluated: forced vital capacity (FVC), forced expiratory volume in 1 second (FEV_1), forced expiratory flow at 25% to 75% of FVC ($FEF_{25\%-75\%}$), peak expiratory flow rate (PEFR), and FEV_1/FVC ratio. Calibration of the equipment was conducted twice daily, adjusting for altitude.

Height was measured against a wall using a fixed tape measure with subjects standing in socks on a hard floor. Weight was measured using a calibrated spring scale with

subjects in socks and dressed in normal indoor clothing. From these measures, body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters.¹⁵

Statistical Analysis

All analyses were conducted using SPSS statistical software, version 11.0 (SPSS Inc, Chicago, IL). Throughout the analysis, the level of significance (α) was set at .05.

Differences in the prevalence of asthma, as well as other respiratory conditions, between the 2 study communities were compared using the χ^2 test for proportions. Comparisons were made between the 2 communities overall and within sex. Strength of association was tested using odds ratios (ORs) and 95% confidence intervals (CIs) after adjusting for age. Comparisons of the prevalence of morbidity measures were also made between boys and girls within each community.

A comparison of pulmonary function measures was made based on a subset of the study population. Comparisons were made between students in grades 1 to 4 who could and could not complete PFTs using χ^2 testing and independent-sample *t* tests. Because there are known differences in pulmonary function based on age, sex, and height,¹⁶ differences in pulmonary function were considered after statistical adjustment for these factors and appropriate interaction terms using analysis of covariance.¹⁷ Analyses were conducted to determine whether there were differences in pulmonary function between Swift Current and Estevan children after stratifying by sex. The dependent variable was the pulmonary function variable of interest. If the variances between any 2 groups were not similar, the Mann-Whitney *U* test was used to compare communities.

RESULTS

Completed questionnaires were returned by 88.9% of children in Swift Current and 94.2% of children in Estevan. Swift Current children were more likely to have parents with more than a grade 12 education and were more likely to be taller and have a lower BMI (Table 1). The age-sex distribution in the 2 towns was similar.

A comparison of respiratory and nonrespiratory conditions between the 2 communities identified significant differences for asthma, wheeze, cough, phlegm, congestion, and current use of breathing medications. In each case, a higher prevalence of these conditions was reported for Estevan children. No differences were seen between the communities with regard to the nonrespiratory conditions. Overall, there was a significantly higher proportion of ever asthma in Estevan (21.4%; 95% CI, 20.1%–22.7%) compared with Swift Current (16.2%; 95% CI, 15.1%–17.3%). The resulting adjusted OR was 1.41 (95% CI, 1.13–1.76).

Despite a significant overall difference between communities for ever asthma prevalence, when stratified by sex (Fig 1), there was a higher prevalence of asthma in girls from Estevan (19.7%; 95% CI, 17.9%–21.5%) compared with girls

Table 1. Demographics and Anthropometric Measurements of the Study Population

Variable	Swift Current (n = 1,077)	Estevan (n = 961)
Sex, no. (%)		
Male	540 (50.1)	485 (50.5)
Female	537 (49.9)	476 (49.5)
Ethnic background, no. (%)		
White	1,016 (94.3)	919 (95.6)
Nonwhite	61 (5.7)	42 (4.4)
Residence, no. (%)		
Urban	1,017 (94.4)	913 (95.0)
Rural	60 (5.6)	48 (5.0)
Parent's highest education level, no. (%)		
Grade 12 or less	395 (36.7)*	404 (42.0)
Higher than grade 12	682 (63.3)	557 (58.0)
Age, mean (SD), y	8.74 (1.76)	8.68 (1.78)
Height, mean (SD), cm†	130.8 (8.8)*	129.2 (9.0)
Weight, mean (SD), kg	28.8 (7.6)	29.4 (8.1)
Body mass index, mean (SD)‡	16.6 (2.8)*	17.4 (2.9)

* $P < .05$ between Swift Current and Estevan children.

† Based on a subsample: $n = 678$ for Swift Current and $n = 627$ for Estevan.

‡ Body mass index is calculated as weight in kilograms divided by the square of height in meters.

from Swift Current (12.5%; 95% CI, 11.1%–13.9%) with an adjusted OR of 1.73 (95% CI, 1.23–2.44). No difference was found between towns for boys (Estevan, 23.1%; Swift Current, 20.0%; adjusted OR, 1.20; 95% CI 0.89–1.62). These differences were more pronounced with the use of current asthma (adjusted OR for girls, 2.23; 95% CI, 1.49–3.34; adjusted OR for boys, 1.17; 95% CI, 0.84–1.62).

Within-town comparisons between boys and girls revealed a significantly higher prevalence of asthma in boys in Swift Current compared with girls. No significant difference existed in asthma prevalence between boy and girls in Estevan. The resulting adjusted ORs (Table 2) were 1.76 (95% CI, 1.26–2.45) in Swift Current and 1.22 (95% CI, 0.90–1.66) in

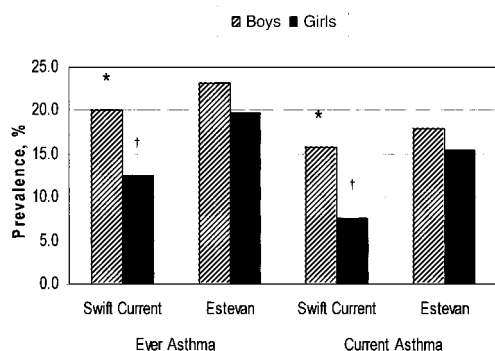


Figure 1. Prevalence of ever asthma and current asthma by community and sex. * $P < .05$ between boys and girls within the same community. † $P < .05$ between Swift Current and Estevan children.

Table 2. Adjusted Odds Ratios Comparing Boys to Girls for Asthma and Various Respiratory Symptoms*

Variable	Adjusted OR (95% CI)	
	Swift Current	Estevan
Ever asthma	1.76 (1.26–2.45)	1.22 (0.90–1.66)
Current asthma	2.25 (1.52–3.34)	1.19 (0.85–1.67)
Ever wheeze	1.59 (1.20–2.11)	1.27 (0.96–1.68)
Ever cough	1.66 (1.27–2.19)	1.17 (0.90–1.53)
Ever wheeze and cough	2.05 (1.44–2.90)	1.29 (0.94–1.78)
Ever phlegm	1.61 (1.04–2.49)	1.06 (0.72–1.56)
Respiratory allergy	1.24 (0.95–1.61)	1.18 (0.89–1.56)

Abbreviations: CI, confidence interval; OR, odds ratio.

* ORs were adjusted for age. Girls served as the referent.

Estevan. BMI was not adjusted for in multivariate analysis as these data were not available for children in grades 5 and 6.

To evaluate whether diagnostic labeling of asthma could have been responsible for the sex-related findings, we compared communities on asthma-related symptoms, including cough and wheeze (Tables 2 and 3). Girls in Estevan continued to have a significantly higher prevalence of wheeze, cough, phlegm, or congestion in the past 12 months, ever having a respiratory illness, current use of breathing medications, cough at night, or cough when waking than girls in Swift Current. The prevalence of these respiratory symptoms in Estevan girls was similar to boys in both Estevan and Swift Current. There was no difference between communities for frequency of school absenteeism due to chest illness or report of accident or injury in the past 12 months that required emergency department use. When we investigated symptoms and report of asthma between boys and girls within towns, we found higher adjusted ORs in Swift Current than in Estevan for all symptoms and asthma (Table 2). In addition, as indicated by the CIs for the adjusted ORs, which included unity, there was no significant difference in the symptoms between boys and girls in Estevan.

Comparisons of morbidity in persons with asthma were made between communities (Table 4). After stratifying by sex, boys with asthma in Swift Current had a significantly higher frequency of respiratory illness in the past 12 months and respiratory allergy than did boys with asthma in Estevan. Estevan girls with asthma had a higher frequency of hayfever and physician visits for asthma in the past 12 months than did Swift Current girls. Other measures of morbidity and asthma characteristics in children with asthma were similar.

Of the study population who attended grades 1 to 4 ($n = 778$ in Swift Current and 682 in Estevan), 81.1% in Swift Current and 84.9% in Estevan completed PFTs. Ever asthma prevalence in the grade 1 to 4 population was 16.5% in Swift Current and 21.7% in Estevan. There were no significant differences between the 2 communities with regard to the proportion of subjects who could and could not complete PFTs. Reasons for not completing PFTs included lack of consent, refusal at the time of testing, being sick or away on

Table 3. Distribution of Health Indicators in Estevan and Swift Current Stratified by Sex

Indicator	Boys, No. (%)		Girls, No. (%)	
	Swift Current (n = 540)	Estevan (n = 485)	Swift Current (n = 537)	Estevan (n = 476)
Wheeze				
Ever without a cold	156 (28.9)	151 (31.1)	109 (20.3)*	125 (26.3)
Ever with shortness of breath	76 (14.1)	63 (13.0)	35 (6.5)*	48 (10.1)
Ever after exercise	92 (17.0)	82 (16.9)	49 (9.1)*	67 (14.1)
In the past year	111 (20.6)	119 (24.5)	77 (14.3)*	104 (21.8)
Cough				
Ever without a cold	170 (31.5)	173 (35.7)	116 (21.6)*	153 (32.1)
In the past year	134 (24.8)	137 (28.2)	83 (15.5)*	114 (23.9)
Wheeze and cough				
Ever without a cold	104 (19.3)	104 (21.4)	56 (10.4)*	83 (17.4)
In the past 12 months	73 (13.5)	73 (15.1)	32 (6.0)*	58 (12.2)
Phlegm or congestion				
Ever without a cold	56 (10.4)	61 (12.6)	36 (6.7)*	57 (12.0)
In the past year	24 (4.4)	32 (6.6)	14 (2.6)	22 (4.6)
Respiratory illness				
Ever	247 (45.7)	228 (47.0)	202 (37.6)*	209 (43.9)
In the past year	88 (16.3)	55 (11.3)	84 (15.6)*	51 (10.7)
Absence from school with a chest illness (>2 days)	63 (11.7)	62 (12.9)	59 (11.1)	62 (13.2)
Currently using breathing medications	75 (13.9)	76 (15.7)	34 (6.3)*	55 (11.6)
Accident or injury in the past year	88 (16.3)	75 (15.5)	59 (11.0)	56 (11.8)
Allergy				
Respiratory allergy	171 (31.7)	151 (31.1)	148 (27.6)	132 (27.7)
Hayfever	38 (7.0)	29 (5.4)	27 (5.6)	37 (7.8)
Eczema	81 (15.0)*	96 (19.8)	100 (18.6)	96 (20.2)
Cough at night	144 (26.7)	152 (31.3)	132 (24.6)*	147 (30.9)
Cough when waking	109 (20.2)	111 (22.9)	87 (16.2)*	103 (21.6)

* $P < .05$ between Swift Current and Estevan children.

the day of testing, unable to complete, and unacceptable PFTs. Within each town, significant differences were found between those who could and could not complete acceptable PFTs. In Swift Current, persons who could complete acceptable PFTs were older than those who could not. In Estevan, persons who could complete the PFTs were older, taller, and heavier; had a higher BMI; reported more cough in the past 12 months; reported more participation in physical activity; and reported less hospitalization and respiratory illness in the past 12 months than subjects who could not complete PFTs.

Figure 2 shows the results of the pulmonary function evaluation within sex between the 2 communities. Boys in Estevan had significantly higher FVC than boys in Swift Current (mean difference of adjusted values, 56 mL; $P = .004$). Both boys and girls in Estevan had significantly lower $FEF_{25\%-75\%}$ and FEV_1/FVC ratio than subjects in Swift Current. For these 2 PFTs, results of girls in Estevan were similar to boys in Swift Current. The difference in mean adjusted $FEF_{25\%-75\%}$ values between Swift Current and Estevan was 119 mL/s ($P = .004$) for boys and 89 mL/s ($P = .02$) for girls. The difference in mean adjusted FEV_1/FVC ratio between Swift Current and Estevan was 1.91% ($P < .001$) for boys

and 0.95% ($P = .02$) for girls. There were no significant differences between Estevan and Swift Current in FEV_1 or PEFr for boys and girls and in FVC for girls.

DISCUSSION

This study has several important findings. Asthma prevalence in Estevan was significantly higher than in Swift Current, using 2 definitions: ever and current. Furthermore, respiratory patterns observed for asthma continued even when we excluded the diagnostic label of asthma and used respiratory symptoms alone as a measure of asthma. There was an atypical sex pattern of asthma prevalence in Estevan but not in Swift Current, where Estevan girls seemed to have nearly as much asthma as boys. Pulmonary function results, adjusted for age and height, support the conclusions of increased respiratory morbidity in Estevan compared with Swift Current.

Geographic variations in asthma prevalence have been observed internationally³ and nationally.^{5,6} Prevalence of ever asthma in 6- to 7-year-olds using the International Study of Asthma and Allergy in Children protocol has shown a range from 3.7% in Southeast Asia to 26.8% in Oceania, with a

Table 4. Characteristics of Children With Asthma by Sex and Community*

Characteristic	Boys		Girls	
	Swift Current (n = 108)	Estevan (n = 112)	Swift Current (n = 67)	Estevan (n = 94)
Wheeze and cough ever	72.2	63.4	53.7	62.8
Respiratory illness in the past 12 months	29.6†	17.9	31.3	22.3
Any respiratory hospitalization	58.3	50.9	40.3	44.7
Absence from school with a chest illness (>2 days)	31.5	27.3	32.8	26.9
Currently using breathing medications	63.0	57.1	40.3	53.2
Allergy				
Respiratory allergy	74.1†	60.7	68.7	71.3
Hayfever	19.4	11.6	11.9†	25.5
Eczema	33.3	34.8	31.3	37.2
Visited a physician in the past 12 months for asthma	50.0	51.8	32.8†	51.1
Visited an emergency department in the past 12 months for asthma	21.3	22.3	9.0†	20.2
Missed school in the past 12 months for asthma	28.7	27.7	26.9	30.9
Age at diagnosis, mean (SD), y	3.55 (2.44)	3.20 (2.99)	3.43 (2.36)	3.59 (2.76)
Mean adjusted FVC, L (95% CI)	2.20 (2.13–2.26)	2.27 (2.21–2.34)	2.00 (1.93–2.08)	1.95 (1.89–2.01)
Mean adjusted FEV ₁ , L (95% CI)	1.84 (1.79–1.90)	1.83 (1.77–1.88)	1.71 (1.64–1.78)	1.67 (1.62–1.73)
Mean adjusted FEF _{25%–75%} , L/s (95% CI)	2.03 (1.91–2.15)†	1.80 (1.68–1.91)	2.11 (1.96–2.25)	1.99 (1.86–2.11)
Mean adjusted PEFR, L/s (95% CI)	3.64 (3.49–3.79)	3.67 (3.52–3.81)	3.60 (3.40–3.80)	3.54 (3.37–3.71)
Mean adjusted FEV ₁ /FVC ratio, % (95% CI)	84.11 (82.47–85.74)†	80.65 (79.06–82.23)	86.13 (84.36–87.90)	86.26 (84.75–87.78)

Abbreviations: CI, confidence interval; FEF_{25%–75%}, forced expiratory flow at 25% to 75% of forced vital capacity; FEV₁, forced expiratory volume in 1 second; FEV₁/FVC, ratio of forced expiratory volume in 1 second to forced vital capacity; FVC, forced vital capacity; PEFR, peak expiratory flow rate.

* Results are presented as percentages of children unless otherwise indicated.

† $P < .05$ between Swift Current and Estevan children.

global prevalence of approximately 10.2%.³ The prevalence found in the current Estevan population is near the upper end of the international spectrum.

In the past decade, 3 population-based studies have been conducted in Saskatchewan before the present study, all of which used questionnaire report of physician-diagnosed asthma.^{12,13,18} The ever asthma prevalence in these studies ranged from 10.0% to 11.2%. Despite not having previous prevalence estimates to identify asthma trends over time in Estevan or Swift Current, the current findings could signal a general increase in asthma prevalence regionally.

With regard to current asthma, approximately 78% of the ever asthma group in Estevan and 72% of the ever asthma group in Swift Current had a history of symptomatic asthma within the past 12 months. A recent national study of Canadian 5- to 9-year-olds⁵ found current asthma prevalence to be 13.0% overall, with the highest rates being reported in Prince Edward Island (18.0%) and the lowest in Saskatoon (10.0%). In the current study, current asthma prevalence in Estevan is

slightly lower than the highest rate found in Prince Edward Island and is higher than the rates found in Saskatoon, the nearest geographical testing site for the Canadian study.⁵

In a recent cross-sectional study in Alberta by Hessel et al,⁹ differences for asthma prevalence within a small geographical region were found where current asthma prevalence for 5- to 9-year-olds was 11.0% in Red Deer and 15.4% in Medicine Hat. The current asthma prevalence in Estevan is higher than that reported in Medicine Hat and is at the higher end of what has been identified in similar age groups in other cross-sectional studies of Canadian, young, school-aged populations. Similar to the study by Hessel et al, the current study showed geographical variation within a reasonably small area. This finding promotes the necessity of evaluating asthma at local levels.

Despite being in a similar geographical region, environmental conditions and/or community awareness of asthma can be reasons for variability of reported asthma between communities. Communities differed in the kinds of industrial

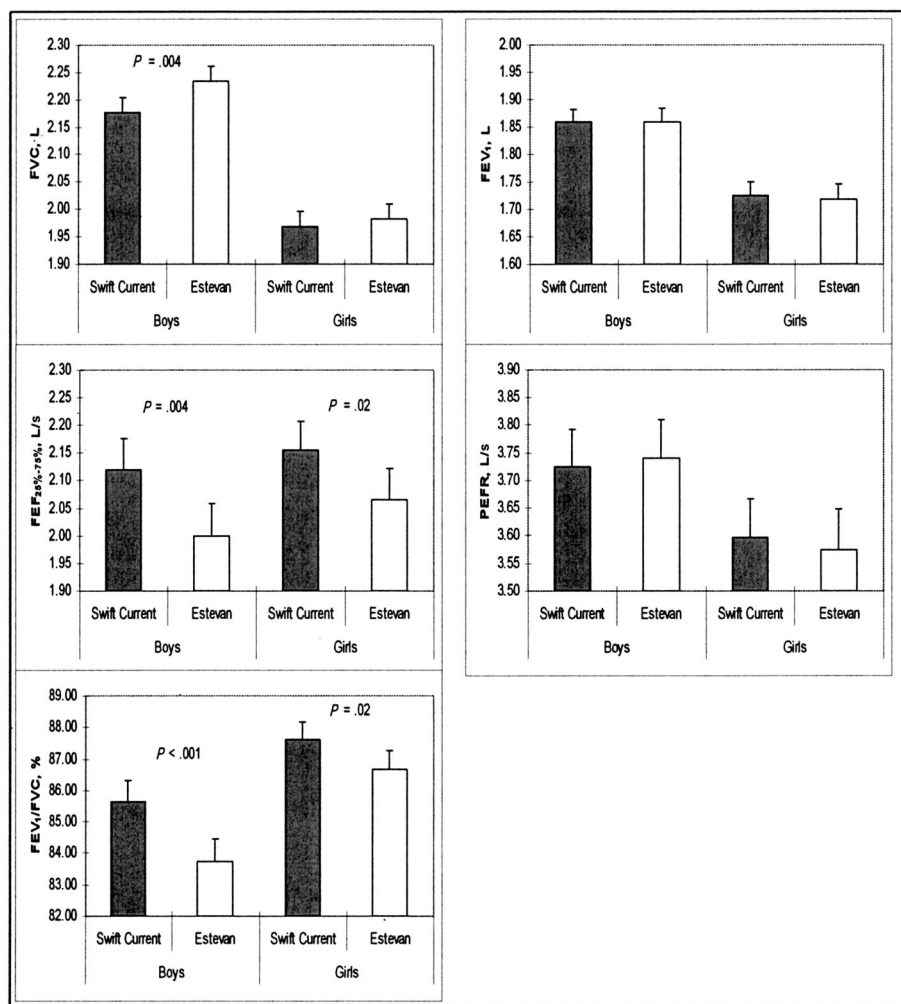


Figure 2. Mean adjusted pulmonary function in boys and girls from Estevan and Swift Current, Saskatchewan. Values were adjusted for age, height, and an interaction term for age times height in girls for forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV₁). Error bars indicate 1 SE. Sample sizes are 317 boys in Swift Current, 314 girls in Swift Current, 296 boys in Estevan, and 282 girls in Estevan. FEF_{25%-75%}, forced expiratory flow at 25% to 75% of FVC; FEV₁/FVC, ratio of FEV₁ to FVC; and PEFR, peak expiratory flow rate.

activity present. Without information on outdoor air quality in both communities, it was not possible to identify whether or not outdoor air quality could be the reason for the differences seen by sex and between communities. Data collection occurred simultaneously in both communities and when schools were in session, potentially limiting differential exposure between communities to the outdoor environment. Management practices, including diagnostic labeling, have been thought to be important. There could have been a higher rate of asthma diagnosis by Estevan physicians because of the public concern of potential industrial-related respiratory problems within the community.¹⁹ Residents may be more aware of respiratory symptoms, leading to increased visits to physicians and potential asthma diagnosis. Diagnostic bias and awareness of potential environmental conditions in the community have been considered by several researchers, and although they have been found to account for some of the increase in asthma, these conditions cannot explain all of the increases or differences in asthma prevalence.^{20,21} Such explanations are also unlikely in the present study, because a

large proportion of children with asthma were symptomatic for episodes of wheeze or asthma within the past 12 months. Also, our findings were supported after ignoring the diagnosis of asthma and examining instead reported respiratory symptoms.

The sex differences between communities identified in this study are not typically seen in other studies that compared communities. It has been repeatedly shown that, until puberty, a significantly greater proportion of boys will have asthma compared with girls. After puberty, the trend begins to reverse.^{22,23} Although the frequency ratio for asthma in boys compared with girls can be as high as 2:1,²² the present ratio of boys to girls for asthma in Estevan (1.19:1) is lower. Although the trend toward typical sex patterns is seen with Estevan children, the magnitude is not as large as expected. Swift Current children show the more typical sex frequency ratio (1.61:1) reported for asthma. These trends are even more noticeable with current asthma.

In a cohort of 626 New Zealand children aged 13 years, Sears et al²⁴ examined the relationship among asthma, atopy,

and sex. Sears et al found that boys had significantly more atopy than girls based on skin prick testing (50% vs 37%) and that sex differences for asthma could at least partially be attributed to sex differences in atopy. The current study indicated no such trend for either community. We did not see sex differences in reporting of a respiratory allergy for either Estevan (31% vs 28%) or Swift Current (31% vs 28%). A limitation of the current study, however, was that there was no objective measure of atopy to reliably compare findings with those found in the study by Sears et al.

The reasons for sex differences in childhood asthma are not clear. Some explanations include differences in hormonal influences, lung growth rates, relative size of the airway to the lung, atopy patterns, and physical activity behaviors.^{24–27} Reasons for the atypical sex pattern for asthma in Estevan remain unclear. Although asthma prevalence in girls surpasses boys around puberty, girls in Estevan could be exposed and/or responding to triggers that are accelerating the inflammatory process, resulting in an earlier asthma diagnosis. This could be due to both host or environmental characteristics and is worthy of further investigation, particularly with preschool and young school-aged populations.

Similar to the findings for prevalence, subjects in Estevan had reduced pulmonary function. Differences in lung function were not due to the observed differences in height between communities, because this factor was controlled for in the analysis. Despite the difference between the communities, the general findings were similar to findings in other similar study populations and would be classified as within the normal range.^{28–30} However, previous studies have shown that pulmonary function deficits could continue if the deficits begin in early life, particularly when asthma is present.^{31,32} This may be important among Estevan children who were experiencing lower pulmonary function and higher asthma prevalence compared with children in Swift Current.

Despite being within a similar geographic region, there were significant differences in respiratory health between these 2 study communities that should be investigated further. This was a population-based study with high response rates and strong support (parents, students, physicians, nurses, principals, and teachers) in both communities. An atypical asthma sex pattern in Estevan suggests that increased asthma prevalence among girls in Estevan may account for the elevated asthma prevalence in Estevan, boys in Estevan may be underdiagnosed for asthma, or a combination of both situations. Further investigation of variability of asthma within regions is warranted as is further study of the nature of sex patterns in childhood asthma.

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REFERENCES

1. Mannino DM, Homa DM, Pertowski CA, et al. Surveillance for Asthma—United States, 1960–1995. *MMWR CDC Surveill Summ.* 1998;47(SS-1):1–27.
2. Burr M, Butland B, King S, Vaughan-Williams E. Changes in asthma prevalence: two surveys 15 years apart. *Arch Dis Child.* 1989;64:1452–1456.
3. The International Study of Asthma and Allergies in Childhood (ISAAC) Steering Committee. Worldwide variations in the prevalence of asthma symptoms: the International Study of Asthma and Allergies in Childhood (ISAAC). *Eur Respir J.* 1998;12:315–335.
4. Pearce N, Weiland SK, Keil U, et al. Self-reported prevalence of asthma symptoms in children in Australia, England, Germany and New Zealand: an international comparison using the ISAAC protocol. *Eur Respir J.* 1993;6:1455–1461.
5. Health Canada. *Childhood Asthma in Sentinel Units: Report of the Student Lung Health Study Results 1995–1996.* Ottawa, ON, Canada: Respiratory Disease Division, Laboratory Centre for Disease Control; 1998.
6. Dales RE, Raizenne M, El-Saadany S, et al. Prevalence of childhood asthma across Canada. *Int J Epidemiol.* 1994;23:775–781.
7. The International Study of Asthma and Allergies in Childhood (ISAAC) Steering Committee. Worldwide variation in prevalence of symptoms of asthma, allergic rhinoconjunctivitis, and atopic eczema: ISAAC. *Lancet.* 1998;351:1225–1232.
8. Duhme H, Weiland S, Rudolph P, et al. Asthma and allergies among children in West and East Germany: a comparison between Munster and Greifswald using the ISAAC phase I protocol. *Eur Respir J.* 1998;11:840–847.
9. Hessel P, Klaver J, Michaelchuk D, et al. The epidemiology of childhood asthma in Red Deer and Medicine Hat, Alberta. *Can Respir J.* 2001;8:139–146.
10. Peat JK, Toelle B, Gray EJ, et al. Prevalence and severity of childhood asthma and allergic sensitisation in seven climatic regions of New South Wales. *Med J Aust.* 1995;163:22–26.
11. Ferris B Jr. Epidemiology standardization project. *Am Rev Respir Dis.* 1978;118:36–47.
12. Chen Y, Rennie D, Dosman J. Influence of environmental tobacco smoke on asthma in nonallergic and allergic children. *Epidemiology.* 1996;7:536–539.
13. Rennie DC, Dosman JA. Distance to health care and the prevalence of asthma in school age children. *J Agric Saf Health.* 1999;5:271–278.
14. American Thoracic Society. Standardization of spirometry—1987 update. *Am J Respir Crit Care Med.* 1987;136:1285–1298.
15. Centers for Disease Control and Prevention. *Percentiles for Body Mass Index.* Atlanta, GA: Centers for Disease Control and Prevention; 2000.
16. American Thoracic Society. Lung function testing: selection of reference values and interpretive strategies. *Am Rev Respir Dis.* 1991;144:1202–1218.
17. Kleinbaum D, Kupper L, Muller K. *Applied Regression Analysis and Other Multivariable Methods.* 2nd ed. Boston, MA: PWS-Kent Publishing Co; 1988.
18. Habbick B, Pizzichini M, Taylor B, et al. Prevalence of asthma, rhinitis and eczema among children in 2 Canadian cities: the International Study of Asthma and Allergies in Childhood. *Can Med Assoc J.* 1999;160:1824–1828.
19. Hill R, Williams J, Tattersfield A, Britton J. Change in the use

-
- of asthma as a diagnostic label for wheezing illness in school-children. *BMJ*. 1989;299:898.
20. Burr M. Is asthma increasing? *J Epidemiol Community Health*. 1987;41:185–189.
21. Manfreda J, Becker AB, Wang PZ, et al. Trends in physician-diagnosed asthma prevalence in Manitoba between 1980 and 1990. *Chest*. 1993;103:151–234.
22. Coultas D, Samet J. Epidemiology and natural history of childhood asthma. In: Tinkleman DG, Naspitz CK, editors. *Childhood Asthma: Pathophysiology and Treatment*. New York, NY: Marcel Dekker Inc; 1994:71–115.
23. De Marco R, Locatelli F, Sunyer J, et al. Differences in incidence of reported asthma related to age in men and women. *Am J Respir Crit Care Med*. 2000;162:68–74.
24. Sears M, Burrows B, Flannery E, et al. Atopy in childhood, I: gender and allergen related risks for development of hay fever and asthma. *Clin Exp Allergy*. 1993;23:941–948.
25. Redline S, Gold DR. Challenges in interpreting gender differences in asthma. *Am J Respir Crit Care Med*. 1994;150:1219–1221.
26. Clough JB. The effect of gender on the prevalence of atopy and asthma. *Clin Exp Allergy*. 1993;23:883–885.
27. Bjornson C, Mitchell I. Gender differences in asthma in childhood and adolescence. *J Gend Specif Med*. 2000;3(8):57–61.
28. Xuan W, Peat J, Toelle B, et al. Lung function growth and its relation to airway hyperresponsiveness and recent wheeze: results from a longitudinal population study. *Am J Respir Crit Care Med*. 2000;161:1820–1824.
29. Weiss S, Tager I, Speizer F, Rosner B. Persistent wheeze: its relation to respiratory illness, cigarette smoking, and level of pulmonary function in a population sample of children. *Am Rev Respir Dis*. 1980;122:697–707.
30. Studnicka M, Frischer T, Neumann M. Determinants of reproducibility of lung function tests in children aged 7 to 10 years. *Pediatr Pulmonol*. 1998;25:238–243.
31. Berhane K, McConnell R, Gilliland F, et al. Sex-specific effects of asthma on pulmonary function in children. *Am J Respir Crit Care Med*. 2000;162:1723–1730.
32. Weiss ST, Tosteson T, Segal M, et al. Effects of asthma on pulmonary function in children: a longitudinal population-based study. *Am Rev Respir Dis*. 1992;145:58–64.
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