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Socioeconomic Factors and Asthma Control in Children

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Summary

Objectives—The objective of this study was to evaluate the association between socioeconomic factors and asthma control in children, as defined by the Canadian Pediatric Asthma Consensus Guidelines.

Patients and Methods—Cross-sectional data from a completed study of 879 asthmatic children between the ages of 1 and 18 residing in the Greater Toronto Area were used. The database included data on demographics, health status, asthma control, and health-related quality of life. Stepwise forward modeling multiple regression was used to investigate the impact of socioeconomic status on asthma control, based on six control parameters from the 2003 Canadian Pediatric Asthma Consensus Guidelines.

Results—Only 11% of patients met the requirements for acceptable control, while 20% had intermediate control, and 69% had unacceptable asthma control. Children from families in lower income adequacy levels had poorer control.

Conclusions—Disparities in asthma control between children from families of different socioeconomic strata persist, even with adjustment for utilization of primary care services and use of controller medications.

Keywords

asthma control; disease management; children; inhaled corticosteroid; socioeconomic status

INTRODUCTION

Internationally, 300 million individuals have been diagnosed with asthma.¹ Asthma affects 10% of children in Europe² and is the most common chronic disease among Canadian

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children.³ Pediatric asthma prevalence and morbidity have increased worldwide since the 1960s,⁴ resulting in frequent hospital admissions and significant economic burden.^{2–5} In Canada, the annual rate of hospital admission among asthmatic children is 4–15%, varying by age and disease severity.⁵ Despite the established effectiveness of inhaled corticosteroids (controller medications) in the prevention of asthma exacerbations, poor control remains common.^{6–8}

Asthma prevalence is disproportionately high among children from low-income and minority families as well as children that reside in inner-city neighborhoods.^{9–11} Children from low-income families tend to have more severe asthma,^{12,13} which has been associated with higher total costs.⁵ The impact of socio-economic status on child health may go beyond pure income effects to include factors related to social structure, family characteristics, need and use of health resources. Due to the widespread prevalence of asthma in children, a better understanding of the socio-economic determinants of asthma control is required to improve current management among this vulnerable population. We hypothesized that lower socioeconomic status may be associated with poorer asthma control in children with asthma. The objective of this study was to evaluate the association between socioeconomic factors and asthma control in children, as defined by the Canadian Pediatric Asthma Consensus Guidelines.

METHODS

Design

A cross-sectional analysis of data from a clinical study completed between November 2000 and March 2003 was undertaken. The study was approved by the Research Ethics Boards of the Hospital for Sick Children and the University of Toronto.

The data were from a sample of 879 residents of the Greater Toronto Area recruited from a pediatric respirology practice, a pediatric allergy practice, a 19-physician family practice, two outpatient hospital-based clinics and two hospital emergency departments. The sample included children aged 1–18 years residing in Ontario with a documented clinical diagnosis of asthma or reactive airway disease recorded in the patient's medical record and a prescription for an anti-asthmatic medication at any point in the year preceding the interview.

Data

The study database included information regarding family demographics, socioeconomic status, drug plan coverage, asthma history, respiratory-related use of health services, symptom characteristics, and medication and spacer use. All data were previously collected using face-to-face interviews. Symptom frequency was assessed for the 4-week period prior to the interview separately for wheeze, cough, shortness of breath, and night-time symptoms. Common, validated structured response options were used, including none, one to two times per month, once per week, twice per week, thrice per week, once daily, twice daily, thrice daily, and four times per day.^{5,14} To increase the validity of reports of medication use, parents were asked to bring all asthma medications to the study interviews and the drug

identification numbers, which provide information on drug name and strength, were recorded along with dosage regimens. Recall intervals for medication and health services use demonstrated high levels of agreement with administrative and medical chart data in validity assessments.^{15–17} All analyses were undertaken in SAS release 9.1. This study assessed asthma control in children based on a composite measure of six equally weighted binary parameters derived from the 2003 Canadian Pediatric Asthma Consensus Guidelines (CPACG).¹⁸ These included daytime symptoms, night-time symptoms, need for β 2-agonist, physical activity level, school absences and asthma exacerbations. Data regarding the forced expiratory volume in one second and peak expiratory flow were not available and these lung function parameters were excluded from the analysis. Table 1 indicates how each of the guidelines control parameters was defined for the purpose of analysis.

SOCIODEMOGRAPHIC VARIABLES

The explanatory variables selected for study were based on a literature review of determinants of asthma control in children. Andersen's *Initial Behavioral Model* and his later *Emerging Model-Phase 4*¹⁹ provided a conceptual framework to group the explanatory variables into the following categories: Demographics (age, child sex), Social Structure (parent employment, parent education, ethnicity, parent born in Canada, primary language in the home, parent marital status, bedroom asthma triggers, exposure to secondhand smoke, season of the interview), Personal/Family (income adequacy level [income adequacy represents the household income adjusted for the family size and was divided into low, medium, and high²⁰], and drug insurance status [presence of a plan and type of plan]), Community (primary care utilization in last 6 months, specialist visits in last 6 months), Need (asthma duration, asthma education, receipt of an asthma action plan, co-morbidities, number of asthma triggers, asthma medication group), and Healthcare Use (peak-flow meter use, spacer use, use of daily anti-inflammatory [including inhaled corticosteroid (ICS), cromone, or mast cell stabilizer]). A *Socioeconomic Status* category was created which included income adequacy, employment status, education level, and drug insurance status. Annual family income adequacy rather than household income was selected based on the validated definition used in the National Population Health Survey by Statistics Canada,²⁰ which accounts for the number of individuals in each household as well as household income. Values are assigned to five strata ranging from low income/large family to high income/small family. In this study, the two lowest levels and the two middle levels were each combined to produce three strata to increase statistical power. While the inclusion of drug insurance status in the socioeconomic category is not common in the literature, drug insurance has been classified as an “enabling” variable with a high degree of mutability.¹⁹

The categories were used to establish the order of entry into the statistical model for all of the individual variables within each category. This is explained in detail below.

STATISTICAL ANALYSIS

For key sociodemographic variables, the mean and standard deviation or frequency distributions were calculated. Children were divided into three control subgroups. *Acceptable* control was defined as the satisfaction of all six parameters, based on the CPACG. *Intermediate* control was defined as the absence of any one of the six control

parameters. *Unacceptable* control was defined as failing any two or more control parameters. This has been used in other studies.⁷

A forward stepwise linear regression was used to analyze the number of asthma control parameters satisfied between zero and six. Univariate regression models were developed with each individual explanatory variable. Any explanatory variable that had a univariate coefficient with a probability of greater than 0.2 was eliminated from the analysis. The only exceptions were sex and age group, which were retained due to their established clinical relevance. The variables in the socioeconomic category were initially entered into the main model because they were the primary focus of the analysis. Next, the Social Structure variables were entered, which provided the secondary focus of the model. To determine the entry order of the remaining explanatory variables into the main model, regression models were created for each remaining category from the Andersen framework (Demographics, Need, Community, and Healthcare Use). The explanatory variables within each category were regressed on the number of asthma control parameters satisfied. Variables from these categories were entered into the main model from the highest to lowest adjusted R^2 values associated with their respective category regression sub-models. Within each category, explanatory variables were entered into the model sequentially according to the highest adjusted R^2 value associated with their univariate statistics.

In the main model, all of the variables were added one at a time based on their established order. The variables were retained if the probability associated with the Type 3 Sum of Squares was <0.05 .²¹ To reduce multicollinearity, the tolerance was evaluated after the addition of any explanatory variable. If the tolerance was <0.1 , the variable was removed.²² After each variable was added to the model, interactions with all of the preceding terms in the model were tested independently. Any interaction term that was significant at the 5% level (Type 3 Sum of Squares) was added to the model. At each step, any term that did not retain significance was removed.

RESULTS

Sample Characteristics

There were 870 children in this study and 809 had complete records and were used in the regression analysis. Sixty-one percent were male and the mean age was 6.9 years ($SD = 4.24$). Low, medium and high income adequacy described 26%, 37%, and 37% of the sample respectively. The parents of 83% of the children were married or common law. In terms of worsening asthma triggers, 6% of the children reported one, 7% reported two, 11% reported three, 13% reported four and 62% reported five or more. The mean number of primary care visits in the previous 6 months was 2.5 ($SD 3.4$, median = 1.0), while children had visited a specialist an average of 1.4 times ($SD 2.1$, median = 1.0) over the last 6 months. Additional sample demographics are presented in Table 2 based on the explanatory variables used in the regression analysis.

Figure 1 illustrates that 11% experienced acceptable control (all 6 parameters satisfied), 20% experienced intermediate control (five of six parameters satisfied), and 69% experienced unacceptable control (4 or fewer parameters satisfied) according to the CPACG definitions

(See Table 1). Figure 2 displays the proportion of children who satisfied each CPACG control parameter. The physical activity parameter was most often satisfied, with 77% reporting a normal physical activity level compared to other children. A majority (70%) of the children experienced night-time symptoms less than once per week, while slightly fewer children (61%) reported less than four daytime symptoms per week. The control parameters that were more difficult to attain included β_2 -agonist utilization, school absences, and exacerbations, which were satisfied among 57%, 54%, and 38% of the children, respectively.

Determinants of Asthma Control

The multiple regression analysis aimed to determine whether lower socioeconomic status may be associated with poorer asthma control in children. The dependent variable was the number of asthma control parameters satisfied (between 0 and 6) as defined by the CPACG. The final regression model was significant ($P < 0.0001$) and explained 26% of the variation.

The parameter estimates and confidence intervals for each of the dummy variables in the regression are presented in Figure 3 to illustrate the magnitude and direction of each effect. In terms of socioeconomic status, income adequacy was retained ($P = 0.0027$). The highest income adequacy level had a positive impact on asthma control, relative to the lowest income adequacy level, while the middle level had a smaller positive coefficient. Interviews that occurred during peak allergy/cold season were associated with the lowest level of asthma control, while those occurring during the low season were associated with the highest levels of control. Two of the most highly significant variables in the model included the number of worsening asthma triggers ($P < 0.0001$) and the daily use of an anti-inflammatory ($P < 0.0001$), which represented the need and health care use categories respectively. Both variables had negative coefficients, suggesting that children who reported more asthma triggers or used an anti-inflammatory on a daily basis had poorer control.

In terms of demographics, the child's sex was significant ($P = 0.006$); being female was associated with poorer control. The age of the child was also significant ($P = 0.003$), although it resulted in a significant interaction with the number of physician visits and was most pronounced among older children. Children who visited the physician often may represent a critical sub-group with respect to asthma control.

The most powerful variables that emerged based on the percentage of variation explained included the total number of primary care visits (32%), daily use of an anti-inflammatory (25%), the number of triggers that worsen asthma (19%), income adequacy (7%), interview season (5%), and child sex (3%).

DISCUSSION

Although good asthma control results in positive health outcomes for children²³ and is a realistic goal for most,²⁴ control was not achieved by two-thirds of children in the present study. Inadequate control has been reported in Canada,⁷ the US,^{6,25} and internationally.^{8,26,27} Poor control is associated with unnecessary morbidity, acute care visits, hospital admissions, caregiver work loss,²⁸ and in some cases, mortality.¹⁸ Well controlled asthma has been associated with reduced acute care and better quality of life.^{23,29}

The main finding from the analysis was that greater income adequacy was associated with better asthma control. A more allergenic season, more asthma triggers, greater physician visits and daily use of ICSs were all associated with poorer control, emphasizing the importance of adjusting for these factors.

The negative association between the number of asthma triggers and control was consistent with a study in adults which demonstrated that 54% of the patients with mild asthma were sensitized to at least one allergen, compared to 100% of the patients with severe asthma. Four percent of patients with mild asthma had multiple sensitizations versus 71% of those with severe asthma.³⁰ Another study indicated that among individuals 16 and over, perceived symptom responses to multiple triggers were associated with inferior control.³¹ The present results reinforce that sensitivity to asthma triggers plays an important role in asthma control.

The interaction between the number of physician visits and the age of the child suggested that a higher number of physician visits was associated with a lower number of control parameters satisfied. While this finding may indicate that physicians may be managing asthma as an acute rather than a chronic condition, suggesting a lack of continuity in the care or an inadequate emphasis on monitoring and improving control,³² it is also possible that a chronic care approach, involving frequent visits, was adopted for children who represented a more severe population of asthmatics or had not yet responded when control was assessed. This association between more physician visits and poorer control was more pronounced in older children, which was supported by previous findings that asthma control was attained more often among younger children.²⁶ Younger children may have more frequent physician visits⁵ regardless of their level of asthma control due to increased parental concern, closer monitoring or the process of asthma diagnosis.

Little research has been performed on the correlation between asthma control and income adequacy. Under-utilization of controllers among US low-income^{33–35} or Medicaid^{36,37} children suggested income was an important determinant in controller use. Studies on Manitoba children exposed a direct relationship between income and the proportion of children who were dispensed ICSs.³⁸ When the type of insurance and disease severity were controlled, children were less likely to receive ICSs if they came from a low-income family.³⁹ The literature suggests access to controller medications is the main mechanism through which socioeconomic status affects asthma control. However, patient compliance and provider adherence may influence the overall efficacy of the intervention and these factors may be independently affected by socioeconomic status.⁴⁰ For example, adherence has been associated with parental beliefs in medications,⁴¹ perceived need for treatment, understanding of preventative medications⁴² or environmental stressors,⁴³ all of which may be related to socioeconomic status.^{41–43} This may have contributed to lower levels of controller use among the lowest-income population in Manitoba despite universal drug coverage for children.^{39,44}

In the present analysis, daily use of ICS was negatively associated with control and explained a substantial amount of the variation. An association between higher doses of ICS and lower levels of asthma control has been found previously.³¹ Children receiving ICS may have represented asthmatics with improved overall management who were more aware of

their condition and consequently reported more control problems, although there was no interaction between ICS utilization and physician visits. Alternatively, a lack of adherence with prescribed controller medications^{45,46} may have contributed to the lower levels of control among these children, since the discontinuation of a controller medication may be related to symptoms, exacerbations, and β_2 -agonist utilization.⁴⁷ Children who reported taking an anti-inflammatory regularly may have also represented a more severe population where asthma control was more difficult to achieve. The interpretation is complicated by the cross-sectional study design. It is possible that children were prescribed an ICS after demonstrating poor control. In future, it will be important to utilize longitudinal studies to evaluate the impact of daily controller use on outcomes.

In the absence of a clear consensus, the definition of asthma control was based on the CPACG guidelines and used six equally weighted parameters. This approach was consistent with studies that assessed multiple dimensions of asthma.^{6,7,48} There is growing support for asthma control questionnaires involving combinations of equally weighted control parameters⁴⁹ as opposed to individual endpoints which may misrepresent the overall level of control achieved.²⁴ However, the question of whether control parameters are equally relevant is an important area for research. For this study, lung function data were not available, which may lead to an overestimation of control.⁵⁰ Since many guidelines lack well defined time-frames for measurements of control parameters, the recall period for several parameters was extended beyond a week to consider the significance of these events and capture seasonal differences. Consequently, the study time frames do not reflect the clinical evaluation of “current” asthma status.

Several study limitations should be noted. For β_2 -agonists, usage to prevent exercise-induced symptoms¹⁸ was counted and would thus increase the measure of utilization. The daytime symptoms parameter was slightly less stringent compared to other guidelines (allowed 3 symptoms versus 2 in other guidelines). School absenteeism is an important parameter commonly used to assess pediatric asthma.^{7,18,49} Yet it is dependent on caregiver–child interactions and influenced by caregiver judgment. Due to inconsistencies in the definition of exacerbation, urgent care visits were combined with attacks (Table 1) to identify children who experience repeated attacks, as well as those who under-report attacks or demonstrate “mild” asthma but require urgent care. This may limit comparability to other studies. Night-time symptoms may have been sensitive to respiratory viral infections⁵¹ and poor parental recall,⁵² although coughing provides unique information needed to customize management and was comparable to previous findings.⁵³ Normal physical activity was the parameter achieved most often, supporting the potential for increased exercise capacity.⁵⁴ However, physical activity may have been overestimated due to limited parental awareness, children’s tendency to adapt and conform to their peers,²⁷ or a lack of full consideration of the impact of school absences or other symptoms on physical activity. The validity of asthma health service and medication use data were evaluated separately by comparing reported information to data from the Ontario Health Insurance Program claims database and patient charts, revealing a high level of agreement.^{16,17}

Documentation of an asthma diagnosis in the patient’s chart was required for inclusion in this study. The diagnosis was based on the physician’s assessment and may have varied

between physicians, but is superior to patient/parent self-report of diagnosis, which is common in observational studies of this size. Also, children under the age of 1 year were excluded to rule out bronchiolitis. While pediatric asthma may consist of multiple phenotypes, guidelines do not currently distinguish between phenotypes in their recommendations for assessing asthma control.

Causation could not be inferred from any of the relationships reported due to the cross-sectional design. Sample selection was stratified according to type of clinical practice as well as urban and suburban settings. The children were not randomly selected which can lead to a selection bias. The children may have represented a more severe population of asthmatics compared to the general population, due to recruitment in emergency departments and specialized asthma clinics. However, these sites provided access to an important population of children who had utilized urgent care and for whom socioeconomic may be an important predictor of asthma control.

Important factors that help explain asthma control in children were recognized in this analysis. Lack of adherence with asthma medications may be associated with differences in socioeconomic⁵⁵ or psychosocial factors⁵⁶ and should be addressed in vulnerable populations. Medications such as montelukast, that can be easily administered orally and are not associated with the side effects of an ICS,¹⁸ require pragmatic evaluations to demonstrate their potential to improve medication adherence. Disparities in control between children from different socio-economic strata persisted even when factors related to the utilization of primary care services and controller medications were controlled. These results highlight the ongoing challenge facing physicians who treat pediatric asthma, which may be affected by complex factors beyond a physician's ability to influence directly, such as a child's sociodemographic background, parental and child behaviors affecting medication adherence, or a child's physical and social environments. It may be important to identify subgroups of children at risk who may have an elevated risk for uncontrolled asthma to better target interventions and improve quality of life.

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Fig. 1.

Number of control parameters satisfied and levels of control. Percent of children satisfying from zero to six asthma control parameters. (□) Acceptable asthma control (satisfied all six control parameters). (▨) Intermediate asthma control (satisfied five out of six control parameters). (■) Unacceptable asthma control (satisfied four or less of six control parameters).

Fig. 2.
Individual control parameters. Percent of children satisfying each asthma control parameter.

Fig. 3.

Parameter estimates from multiple linear regression of determinants of asthma control.

Indicates a reference category. AI, anti-inflammatory. Child age #primary care visits = indicates an interaction between these two variables. *P*, type III probability associated with the variable in the multiple regression model.

TABLE 1**Control Parameters Derived From Canadian Guidelines**

Canadian guidelines (38)	Definition for analysis
Daytime symptoms <4 days per week	Sum of the symptom frequencies for shortness of breath, chest tightness, wheeze and cough <4 days per week in the last month
Night-time symptoms <1 night per week	Frequency of night-time symptoms <once per week in the last month
Need for β_2 -agonist <4 doses per week	Frequency of all short-acting bronchodilator use <4 doses per week in the last month
Normal physical activity	Activity level is currently reported as equally or more active compared to other children of the same age
No school absences due to asthma	Number of school day absences due to asthma in the last month equals zero
Mild infrequent exacerbations	No asthma-related urgent care visits in last year AND fewer than six asthma attacks in the last 6 months

TABLE 2

Sample Characteristics

Characteristic	Frequency
Mean (SD) child age in years	6.94 (4.24)
4 years	32%
>4 to <10 years	43%
10 years	25%
Child sex	
Male	61%
Female	39%
Income adequacy	
Low	26%
Medium	37%
High	37%
Allergy/cold season at time of interview	
Low (July, August)	12%
Intermediate (April, Sept, Oct, Nov, Dec)	46%
Peak (Jan, Feb, March, May, June)	42%
Mean (SD) number of primary care visits in previous 6 months	2.49 (3.39)
Median	1.00
Mean (SD) number of asthma triggers	5.52 (2.59)
Median	5.00
Currently taking at least 1 daily dose of anti-inflammatory	53%