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Relationship of asthma management, socioeconomic status, and medication insurance characteristics to exacerbation frequency in children with asthma

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Abstract

Background—Less than 25% of asthmatic children are well controlled.

Objective—To identify factors associated with asthma exacerbation causing emergency department (ED) visits or hospitalizations related to health status, socioeconomic status (SES), and drug insurance.

Methods—In this retrospective cohort study, complete data were collected on 490 asthmatic children regarding demographics, SES, drug plan characteristics, health status, health resource use, and symptoms. Interview data were linked to administrative data on asthma ED visits and hospitalizations occurring in the following year. Multiple Poisson regression identified

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independent variables associated with ED visits or hospitalizations in the full cohort and in a subgroup with prescription drug insurance.

Results—Younger age, previous emergency visits, nebulizer use, pet ownership, and receipt of asthma education but not an action plan were significantly associated with more frequent exacerbations. In the full cohort, children with high income adequacy had 28% fewer exacerbations than did children with low income adequacy. In the subgroup with drug insurance, girls had 26% fewer exacerbations than did boys, and children with food, drug, or insect allergies had 52% more exacerbations than did children without allergies. Children of families with annual insurance deductibles greater than $90 had 95% fewer exacerbations. Every percentage increase in the proportion of income spent out-of-pocket on asthma medications was associated with a 14% increase in exacerbations.

Conclusions—Asthma history, disease management factors, and SES were associated with exacerbations requiring urgent care. In families with drug plans, the magnitude of asthma medication cost-sharing as a proportion of household income, rather than income alone, was significantly associated with exacerbations.

INTRODUCTION

In a recent US study,[1] only 24% of asthmatic children met 4 parameters of asthma control, and only 11% of Canadian children met 6 parameters of control as defined by clinical guidelines.[2] Poor control results in morbidity, with severe exacerbations often requiring oral corticosteroid therapy, emergency care, or hospitalization.[3] Hospitalization rates in asthmatic children vary from 4% to 15%, depending on age, sex, severity, and other factors.[4–6] Emergency department (ED) visits are more common[7]: approximately 19% of asthmatic children experience ED visits,[4–6] and 35% of these children require oral corticosteroid therapy.[8]

The ability to achieve control and avoid exacerbations is related to provider knowledge and practices,[1] access to and use of health care services,[8,9] asthma education,[10,11] and the availability of insurance to pay for care.[12–14] It is also affected by the child's environment and risk of allergen exposure, which, in turn, can be associated with socioeconomic status (SES).[15,16] Thus, the factors contributing to the control of asthma are complex. The objective of this study was to identify factors related to severe exacerbations in asthmatic children, manifest as ED visits or hospitalizations. It was hypothesized that children with more exacerbations would come from lower-income families, would have poorer insurance coverage, and would have less access to or use of appropriate health care services, including asthma action plans.

METHODS

Approval was granted by the research ethics boards of The Hospital for Sick Children, Brampton Memorial Hospital, and Sunnybrook Health Sciences Centre. Written informed consent was provided by parents and participants 16 years or older. Assent was provided by younger participants.

Study Design and Sample

This retrospective cohort study enrolled children aged 1 to 18 years. Patients were recruited between November 1, 2000, and March 31, 2003, from a pediatric respirology practice, a pediatric allergy practice, a 19-physician family practice, 2 hospital-based outpatient clinics, and 2 hospital EDs in Ontario. The diagnosis was confirmed by a medical record notation of asthma or reactive airway disease. The latter diagnosis was occasionally documented for very young children presenting to the ED with recurrent wheeze or other phenotypes suggestive of asthma. Participants must have had an asthma prescription (bronchodilator, inhaled corticosteroid, mast cell stabilizer, theophylline, or leukotriene antagonist) in the preceding year. Although not random, sampling was designed to recruit a mix of patients residing in urban and suburban areas representing a range of asthma severity and experiencing diverse levels of management. Participants provided written consent to link baseline interview data to administrative claims data. The latter data were used to follow each patient for 1 year after the interview.

Data Collection

Information on family socioeconomic and demographic characteristics and the child's asthma history, medications, nebulizer and spacer use, previous respiratory-related health care services use, daytime and nighttime symptoms, asthma attacks, and exposures to triggers such as pets were collected in interviews with parents or children old enough to respond independently, usually 13 years or older. Hospitalizations and ED visits during 1-year follow-up were derived from the Canadian Institute for Health Information National Ambulatory Care Reporting System, the Canadian Institute for Health Information Discharge Abstract Database, and the Ontario Health Insurance Plan claims database. Interview data were linked to administrative data using a unique encrypted health insurance number. The diagnostic code for asthma (*International Classification of Diseases, Ninth Revision, Clinical Modification,* code 493 or *International Classification of Diseases, 10th Revision,* code J45) was used to label health care services as asthma related. Hospitalizations and ED visits constituted the outcome of interest, severe acute exacerbation, heretofore referred to as exacerbation. These events were considered asthma related if the primary or "most responsible" diagnosis was asthma.

Analysis

Descriptive statistics described variables related to sociodemography, asthma history, symptoms, previous health care services use, health status, and disease management. The analysis to identify factors associated with exacerbation was undertaken in the full cohort and in a subgroup consisting of children with medication insurance (87% of the sample). Owing to the number and heterogeneity of potential explanatory variables, it was hypothesized that the creation of a more homogeneous subgroup of drug plan holders would enable better detection of main effects of drug plan characteristics.

Because exacerbation occurs infrequently and in a minority of children, multiple Poisson regression was undertaken in the whole sample and in the drug plan subgroup. The dependent variable, exacerbations, was represented by a count of urgent visits (hospitalizations and ED visits) during 1-year follow-up. An ED visit that resulted in a

hospital admission was counted as a single exacerbation. Potential explanatory variables for the regression models were drawn from interview data. Asthma severity was determined from parent-reported prestudy admissions and ED visits, symptom frequency, and asthma attacks, which were defined as the sudden worsening of symptoms resulting in difficulty breathing that required additional medication and that may or may not have resulted in an unscheduled physician or ED visit. Family income adequacy was measured based on the validated definition from the National Population Health Survey.[17] This adjusts annual household income by the number of individuals residing in each household. Values were assigned to 3 strata ranging from low-income/large family to high-income/small family. Data were collected on the amount of deductibles, fixed copayments, and percentage copayments in families with medication insurance. A binary deductible variable was created through recursive partitioning to determine a cutoff point for observing significant effects. An income-indexed cost-sharing variable was also created that summed all sources of out-of-pocket payments (deductibles and copayments) and divided the total by reported income.

Univariate regressions were performed to determine the optimal structure for continuous and categorical variables. Collinearity between variables was investigated using the variance inflation factor (VIF). Variables were removed using information from univariate analyses until all had a VIF of 5 or less. Because of the number and variety of potential explanatory variables, separate Poisson regression models were built for groups of covariates related to (1) health status and asthma management, (2) SES, and (3) drug plan characteristics. Backwards stepwise regression was used to remove variables until $P < .10$ for all. The variables remaining in the 3 reduced models were then placed into a final model, and backwards stepwise regression was performed until regression coefficient $P < .05$ for all. Collinearity was assessed in the final reduced model to ensure a VIF of 5 or less. These steps were repeated for the drug plan subgroup. Deviance was used to scale the models to achieve satisfactory goodness of fit. Because missing data occurred for only 5.4% of the records, records with missing data were excluded from the regression models rather than using imputation.

RESULTS

Sample Characteristics

Of 522 consenting participants, descriptive statistics were reported for 518, and regression analysis was conducted on 490 medical records with complete data. Baseline characteristics are given in Table 1. The results for age and sex of the child are typical in that male predominance is usually seen in younger children with asthma. Slightly more than one-third of responding parents were born outside of Canada, and the sample represented a generally higher income group. Most families had prescription drug insurance (87%), a coverage rate consistent with the national average.[18] Children’s asthma characteristics are given in Table 2. Almost two-thirds rated the child’s health status as no better than “good.” Almost half of the children had symptoms more than 3 times per week, suggestive of inadequate control as per clinical guidelines.[19] Inadequate control was further exemplified by high rates of attacks and ED visits or hospitalizations in the previous year. Less than half of the children had some form of asthma education or an action plan.

Determinants of Exacerbation

Table 3 indicates the full model consisting of variables that retained significance. Regression coefficients were exponentiated to facilitate interpretation but should not be confused with odds ratios. Most of the retained variables were related to health status and asthma management. During the study year, children 10 years and older had 42% fewer exacerbations than did children younger than 4 years. Children with a previous ED visit had 3 times more exacerbations in the study year, whereas children using a nebulizer or having a pet had 62% and 46% more exacerbations, respectively. Children who were recruited from a physician's office or an asthma clinic (non-ED site) had significantly fewer exacerbations. Although children who reported receiving asthma education had 37% more exacerbations, those with an asthma action plan had 28% fewer exacerbations. During the interview, a wide range of materials, from brochures to educational sessions, were construed as "asthma education," whereas an action plan referred specifically to a disease management plan to prevent exacerbation. Families with medium or high income adequacy demonstrated 28% fewer exacerbations compared with those with low income adequacy.

Table 4 presents the model for the drug plan subgroup (n = 424). Findings related to age, previous ED visits, use of a nebulizer, presence of a pet, and having an asthma action plan were similar to those of the full cohort. In this more homogeneous subgroup, it was also observed that girls demonstrated 26% fewer exacerbations and that children with a history of reaction to food, medications, or insect bites had 52% more exacerbations. Children who were recruited from a physician's office or an asthma clinic (non-ED site) had significantly fewer exacerbations. In this analysis, income adequacy was not significant, but several drug plan characteristics were significant predictors of exacerbation. Children from families with annual deductibles (the amount that must be paid out-of-pocket before insurance benefits provide coverage) of at least $90 had 95% fewer exacerbations. Because the effect of out-of-pocket expenditures on the rate of exacerbations may depend on household income, the model also examined the effect of income-indexed out-of-pocket expenditures as a continuous variable, defined as the sum of deductibles and per-drug copayments as a percentage of household income. When controlling for income in this way, there was a positive association between the proportion of income spent on prescription asthma medications and the number of exacerbations in that the rate of exacerbation was increased by 14% for every 1% increase in the proportion of income spent on prescription asthma medications.

DISCUSSION

The importance of controlling exacerbations vs other indicators of poor asthma control has been recognized.[3,10,20–22] Current US guidelines distinguish between impairment, defined by symptom frequency and activity limitations, and risk, which considers the likelihood of exacerbation.[19] The present study found that exacerbations were significantly increased in younger children, boys, children with previous ED visits, and children from low-income families. These findings support previous research demonstrating the significant impact of age, sex, disease severity, and SES on asthma morbidity.[9,23,24] Although evidence of the effectiveness of asthma action plans is mixed,[10,11,25,26] the study found that children with

action plans had fewer subsequent exacerbations. The study further revealed the adverse effects of medication cost-sharing on health outcomes in children. In the drug plan cohort, the significant effect of income adequacy was not observed. Instead, a specific and highly significant income effect was observed through cost-sharing of prescription asthma medications. For each percentage point increase in the proportion of income devoted to out-of-pocket payment for asthma medication, the rate of exacerbation increased by 14%. This suggests that as out-of-pocket medication costs consumed an increasing proportion of income, the more the child was at risk for exacerbation.

Although the relationship between low SES and poorer outcomes in children with asthma is well-known,[9,12,23,27] the cause has received little attention. A putative cause may be inadequate access to or use of asthma medications. Compared with children with prescription drug insurance, children from families without insurance had an increased probability of a recurrent ED visit.[13] However, even with government-sponsored drug insurance, such as Medicaid, children from lower-income families underuse inhaled corticosteroids.[24,28,29]

Regardless of the type of insurance plan, changes in benefits schemes are increasing the share of the cost falling on subscribers. The Rand Health Insurance Experiment demonstrated long ago that patients reduce their consumption of health care resources when faced with cost-sharing.[30] A more recent study[31] demonstrated that among families with drug plan benefits, even small increases in cost-sharing can result in significant reductions in the use of essential asthma medications in children. That study, which did not control for SES and looked only at medication use and not at health outcomes, found that cost-sharing reduced the use of more costly asthma medications, such as controllers, to a greater extent than the less costly short-acting β-agonists. A study[14] that looked at health outcomes found that when previously uninsured children with asthma were enrolled in a state plan, not only did ED visits and hospitalizations decline but unmet need for prescribed medications decreased from 21% to 6%. That study, however, did not examine the effect of cost-sharing. Thus, the present study is the first to examine the impact of medication cost-sharing on health outcomes in children with asthma.

Studying the health impact of cost-sharing is complicated by the wide array of cost-sharing mechanisms that involve premiums, deductibles, fixed copayments, percentage copayments, and caps that exert complex effects on medication acquisition behaviors. Tying the amount of deductibles to household income attempts to reduce the impact that large out-of-pocket costs have in households with lower income levels. In Manitoba, a switch from a fixed deductible and copay to an income-indexed deductible resulted in a reduction in inhaled corticosteroid prescriptions in higher-income children with asthma (who faced the highest deductibles) and in children with mild to moderate asthma.[32] Little improvement was observed in low-income children with severe asthma, who continued to have the lowest rates of controller use after the policy change that effectively reduced their deductible. Because a fixed copayment is neutral to the cost and type of medication, there is little incentive to reduce the use of expensive drugs (eg, controllers) more than cheaper ones (eg, short-acting β-agonists). A study of privately insured adults found that after fixed copayments were

doubled, days supplied for asthma medications (inhaled corticosteroids, oral corticosteroids, antileukotrienes, and all classes of bronchodilators) decreased by 32%.[33]

When consumers must pay a percentage of the total drug cost (coinsurance), there is an incentive to forgo more costly medications or to substitute them with cheaper drugs. When a British Columbia drug program changed from zero cost-sharing to fixed copayments and then to 25% coinsurance with an income-indexed deductible, seniors' use of inhaled corticosteroids, inhaled anticholinergics, and inhaled β-agonists all decreased.[34] Similarly, a 37% reduction in monthly consumption of inhaled corticosteroids was found in social assistance beneficiaries after a change in Quebec's drug plan from zero cost-sharing to 25% coinsurance plus a quarterly deductible of Can$25.[35]

When consumers have to pay for medications after the plan has capped reimbursement at a set number of monthly refills, there is a strong incentive to reduce utilization,[36,37] particularly for individuals who take multiple medications, which is common for children with persistent asthma. Consequent increased use of health care services can negate any savings to drug plans and increase overall expenditures.[38]

Inhaled corticosteroids are the medications most needed for control of underlying inflammation, and they are often prescribed for the long-term. That they are among the most expensive and the ones for which parents have safety concerns creates conditions for poor adherence in the face of cost-sharing.[39] An optimal cost-sharing policy would consider the factors described previously herein and a child's personal asthma management plan and be designed to promote adherence. "Value-based insurance design" has been proposed to mitigate the deleterious effects of cost-sharing by aligning purchasing incentives with disease management goals.[40, 41] Research is required to examine the health effects of these types of plans in children with asthma.

This study has several limitations. Although the cohort was not randomly selected, a heterogeneous sample was assembled through diverse recruitment sites to reduce selection bias. Moreover, the results may be relevant for populations served by private or public drug programs. The interview data relied on the accuracy of parent recall. In an assessment of recall validity, the parents in this study were found to be highly reliable reporters of prestudy ED visits and hospital admissions.[42] This study did not directly assess the effect of medication adherence on exacerbation; however, the interview data contained detailed information on other potential confounders, unavailable in administrative data. The results regarding the effects of out-of-pocket expenditures on exacerbations are difficult to interpret. The finding that higher deductibles were associated with fewer exacerbations seems paradoxical. Furthermore, the existence of a positive association between the proportion of income spent on asthma medications and subsequent exacerbations could be related to the quality of disease management, adherence to medication regimens, or parental behaviors and health beliefs. Greater research is needed to explore possible explanations for this observed association.

In addition to confirming the significant effects of socioeconomic and disease characteristics on the frequency of asthma exacerbations, this study found that children with action plans

have significantly fewer exacerbations. This study further revealed that it is not simply income level but how much of the household income is consumed by out-of-pocket spending on prescription asthma medications that contributes to deleterious health outcomes. Given the movement toward increased cost-sharing in drug plans,[43] research is needed to evaluate the separate effects of diverse cost-sharing mechanisms.

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Table 1

Baseline Demographic and Socioeconomic Characteristics of the 490 Study Participants

Characteristic	Value[a]
Child age, mean (SD), y	7.1 (4.1)
Child age group, No. (%)	
1–4 y	156 (32)
>4 to <10 y	203 (41)
10–18 y	131 (27)
Child sex, No. (%)	
Male	290 (59)
Female	200 (41)
Parent born in Canada, No. (%)	
No	172 (35)
Yes	318 (65)
Parent marital status, No. (%)	
Married/common law	418 (85)
Single/widowed/separated/divorced	72 (15)
Mother's education, No. (%)	
Completed secondary or less	116 (24)
Some university/college	68 (14)
Completed university/college	301 (61)
Unknown	5 (1)
Mother's employment status, No. (%)	
Employed full- or part-time	364 (74)
Social assistance or disability beneficiary	16 (3)
Homemaker	93 (19)
Student	12 (2)
Unknown	5 (1)
Income adequacy, No. (%)	
Low	102 (21)
Medium	178 (36)
High	210 (43)
Drug plan benefits, No. (%)	
Employer or private drug plan	396 (81)
Public/government drug plan	28 (6)
No drug plan	66 (14)
Percent of income spent out-of-pocket on child's asthma medications, No. (%)	
0%	105 (21)
>0% to ≤1%	306 (62)
>1% to ≤3%	53 (11)
>3%	26 (5)

[a]Percentages may not sum to 100% owing to rounding.

Table 2

Asthma Characteristics of the 490 Children

Characteristic	Value[a]
Duration of asthma, mean (SD), y	6.0 (4.1)
Self- or parent-reported health status, No. (%)	
Poor	44 (9)
Fair	94 (19)
Good	160 (33)
Very good	136 (28)
Excellent	53 (11)
Unknown	3 (1)
Asthma symptom frequency (per week), No. (%)	
0	146 (30)
1–3	125 (26)
>3–10	103 (21)
>10	116 (24)
History of reaction to food, medications, or insect bites, No. (%)	140 (29)
Has a pet cat or dog, No. (%)	188 (38)
Reported asthma attacks in the past 6 mo, No. (%)[b]	
0 or 1	161 (33)
2 or 3	191 (39)
≥4	138 (28)
Nonurgent physician visits in the past 6 mo for asthma, mean (SD), No.	2.2 (3.1)
Asthma admissions in the past 12 mo, No. (%)	
No	366 (75)
Yes	124 (25)
Emergency department visits in the past 12 mo, No. (%)	
No	243 (50)
Yes	247 (50)
Uses a nebulizer, No. (%)	146 (30)
Received asthma education, No. (%)	
No	283 (58)
Yes	207 (42)
Received an asthma action plan, No. (%)	
No	339 (69)
Yes	151 (31)
Site of study recruitment, No. (%)	
Emergency department	66 (13)
Physician’s office or asthma clinic	424 (87)

[a] Percentages may not sum to 100% owing to rounding.

[b] Based on parent reports, asthma attack was defined as the sudden worsening of symptoms resulting in difficulty breathing that required additional medication and that may or may not have resulted in an unscheduled physician or emergency department visit.

Table 3

Significant Determinants of Urgent Care in the Full Cohort

Variable	Level	Estimate	exp(estimate)	Standard Error	95% CI	Pr > ChiSq
Intercept	NA	−0.6426	0.53	0.2559	−1.1443 to −0.141	0.012
Income adequacy	High	−0.3274	0.72	0.1601	−0.6413 to −0.0135	0.0409
(reference = low)	Medium	−0.3319	0.72	0.1652	−0.6556 to −0.0082	0.0445
Age group (reference = 1 to <4 y)	≥10 y	−0.5393	0.58	0.2253	−0.9808 to −0.0977	0.0167
	4–10 y	−0.1620	0.85	0.1369	−0.4304 to 0.1063	0.2367
No. of nonurgent asthma-related physician visits in past 6 mo	NA	0.0454	1.05	0.0171	0.0118 to 0.079	0.0081
ED visit in past year	Yes	1.1169	3.06	0.1931	0.7384 to 1.4955	<.0001
Uses a nebulizer	Yes	0.4838	1.62	0.1374	0.2145 to 0.7532	0.0004
Received asthma education	Yes	0.3112	1.37	0.1314	0.0537 to 0.5687	0.0179
Received asthma action plan	Yes	−0.3232	0.72	0.1495	−0.6162 to −0.0302	0.0306
Has a pet	Yes	0.3811	1.46	0.1406	0.1055 to 0.6567	0.0067
Site of study recruitment	Non-ED	−1.1298	0.32	0.1421	−1.4084 to −0.8512	<.0001

Abbreviations: CI, confidence interval; ED, emergency department; NA, not applicable; Pr > ChiSq, probability that the regression coefficient is statistically significant in the full final statistical Poisson regression model.

Table 4

Significant Determinants of Urgent Care in the Drug Plan Subgroup

Variable	Level	Estimate	exp(estimate)	Standard Error	95% CI	Pr > ChiSq
Intercept	NA	−0.5602	0.57	0.2542	−1.0584 to −0.0619	0.0276
Age group (reference = 1 to <4 y)	≥10 y	−0.6710	0.51	0.2349	−1.1315 to −0.2105	0.0043
	4–10 y	−0.1803	0.84	0.1509	−0.476 to 0.1153	0.2319
Child sex	Female	−0.2981	0.74	0.1427	−0.5778 to −0.0183	0.0368
No. of nonurgent asthma-related physician visits in past 6 mo	NA	0.0501	1.05	0.0189	0.013 to 0.0872	0.0082
ED visit in past year	Yes	1.0444	2.84	0.2022	0.6481 to 1.4407	<.0001
Uses a nebulizer	Yes	0.5309	1.70	0.1466	0.2435 to 0.8183	0.0003
Received asthma action plan	Yes	−0.5645	0.57	0.1725	−0.9026 to −0.2264	0.0011
History of reaction to food, drugs, or insect bites	Yes	0.4193	1.52	0.1652	0.0955 to 0.7432	0.0112
Has a pet	Yes	0.4099	1.51	0.1458	0.124 to 0.6957	0.0049
Site of study recruitment	Non-ED	−1.2432	0.29	0.1576	−1.5521 to −0.9343	<.0001
Annual deductible ≥$90	Yes	−2.9521	0.05	1.0831	−5.0749 to −0.8293	0.0064
Out-of-pocket expenditures as a % of household income	NA	0.1351	1.14	0.0284	0.0794 to 0.1908	<.0001
Type of drug plan (reference = employee benefit plan)	Self-insured or other	−1.1591	0.31	0.5061	−2.1512 to −0.1671	0.022
	Provincial social assistance	0.1376	1.15	0.3216	−0.4928 to 0.7679	0.6688

Abbreviations: CI, confidence interval; ED, emergency department; NA, not applicable; Pr > ChiSq, probability that the regression coefficient is statistically significant in the full final statistical Poisson regression model.