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Risk Factors for Repeat Adverse Asthma Events in Children After Visiting an Emergency Department

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Objective.—The aim of this study was to identify risk factors for long-term adverse outcomes in children with asthma after visiting the emergency department (ED).

Methods.—A prospective observational study was conducted at the ED of a pediatric tertiary hospital in Ontario, Canada. Patient outcomes (ie, acute asthma episodes and ED visits) were measured at baseline and at 1- and 6-months post-ED discharge. Time trends in outcomes were assessed using the generalized estimating equations method. Multiple conditional logistic regressions were used to model outcomes at 6 months and examine the impact of drug insurance coverage while adjusting for confounders.

Results.—Of the 269 children recruited, 81.8% completed both follow-ups. ED use significantly reduced from 39.4% at baseline to 26.8% at 6 months ($P < .001$), whereas the level of acute asthma episodes remained unchanged. Children with drug insurance coverage were less likely to have acute asthma episodes (adjusted odds ratio [AOR] = 0.36; 95% CI, 0.15–0.85; $P < .02$)

or repeat ED visits (AOR = 0.45; 95% CI, 0.20–0.99; $P < .05$) at 6 months. Other risk factors for adverse outcomes included previous adverse asthma events and certain asthma triggers (eg, cold/sinus infection). Washing bed linens in hot water weekly was protective against subsequent acute asthma episodes.

Conclusions.—Our study demonstrated significant improvements in long-term outcomes in children seeking acute care for asthma in the ED. Future efforts remain in targeting the sustainability of improved outcomes beyond 6 months. Risk factors identified can help target vulnerable populations for proper interventions, which may include efforts to maximize insurance coverage for asthma medications and strategies to improve asthma self-management through patient and provider education.

KEY WORDS: asthma; children; drug insurance coverage; emergency department visit; risk factors

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Asthma is the most common chronic disease in children. In Canada, according to the National Longitudinal Survey of Children and Youth, the prevalence of asthma in children under 12 years old was 11.2%.¹ To and colleagues,² using the health administrative databases in Ontario, reported a prevalence of 19.6% in children aged under 10 years.

Children with asthma suffer from significant morbidity, including visits to emergency departments (EDs), urgent

care clinics, and hospitalizations. In a recent population-based study, Guttman and colleagues³ found that over 9% of children with asthma in Ontario, Canada had at least 1 ED visit for asthma over a 2-year period and that asthma accounted for 3% of all pediatric ED visits. Factors predictive of such adverse asthma events (such as acute asthma episodes and ED visits) may help identify high-risk patients to be targeted for interventions to improve outcomes, especially in those who already have experienced adverse events. A number of prospective studies have examined outcomes in children after visiting the ED for asthma.^{3–10} Predictors of repeat acute care visits identified at the patient level included female gender, young age, previous hospitalization or ED visit for asthma, increased number of acute asthma episodes or use of oral corticosteroid in the past year, having planned visits to the primary care provider in past 6 months, acuity of index visit, suboptimal treatment during ED stay or hospital admission at the index visit, maternal smoking, and exposure to cigarette smoke. However, most of these studies were limited to short-term follow-up (<8 weeks)^{3–8,10} and provide little information on outcomes beyond.⁹

To improve patient outcomes after receiving acute care for asthma, the Canadian Asthma Consensus Guidelines^{11–13} recommend that inhaled corticosteroids be prescribed to almost all children at discharge from ED. Observational studies showed that inhaled corticosteroid

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therapy was associated with a significant decrease in the risk of repeat ED visits for asthma in both the short-term and long-term.^{8,14} Nevertheless, despite widespread availability, inhaled corticosteroids are underutilized in children with asthma in Canada.^{14–16} This situation may stem in part from inadequate drug insurance coverage and cost sharing, which is known to influence access to and use of inhaled corticosteroids in children with asthma,^{17–19} especially in provinces (such as Ontario) without universal insurance for medications. Given these observations, it is logical to conclude that insurance coverage for asthma medications has an important role in determining patient outcomes in children who have visited the ED for acute care for asthma. However, to date, no study has examined this association directly.

We conducted a prospective observational study to identify risk factors for long-term adverse outcomes in children who visited the ED of a tertiary children's hospital for asthma.

METHODS

Study Design and Procedure

Three hundred fifty children with acute asthma visiting the ED of The Hospital for Sick Children in Toronto, Canada between January 2003 and June 2004 were approached for the study. Informed consent was obtained from patients 16 years of age or older; patients between the ages of 7 to 15 years provided patient assent while their parent or guardian provided proxy consent. For patients under 7 years of age, parental or guardian consent alone was obtained. Of patients approached, 269 (76.9%) were recruited. Those who refused to participate in the study did not significantly differ from the participants in age and gender. The study was approved by the Research Ethics Board at The Hospital for Sick Children. In 2003, recruitment was slow due to low ED patient volume after the outbreak of severe acute respiratory syndrome (SARS).

A prospective observational design was used in this study. Two research assistants who worked in the ED on rotating schedules approached eligible parents/children visiting the ED for respiratory problems for the consent process. Consented patients were interviewed at the time of their visit at ED (baseline) and were followed at 1 and 6 months by telephone. Medical charts of recruited patients were reviewed by a trained chart abstractor to assess acute asthma management in the ED. Asthma education may be provided to asthma patients by the ED staff at discretion of clinical judgment prior to ED discharge and may include dissemination of a standardized asthma information package, teaching on inhalation equipment and technique, and review of asthma triggers and medications. No additional material was given to the patients by the research team.

Study Population

This study included children with acute asthma aged 2 to 17 years (inclusive) visiting the ED with their primary caregiver, who was able to speak English. An acute asthma episode was defined as the sudden worsening of symptoms,

resulting in difficulty in breathing that often required taking extra medicine to relieve asthma symptoms, with or without an unscheduled ED or doctor visit.²⁰ The final diagnosis of asthma was determined by the attending physician at the ED. Eligible children were included regardless of disposition of the ED visit (admitted or discharged).

Children were excluded if they had an unclear diagnosis of asthma (eg, children with a first-time wheeze and without a strong family history of asthma), a primary diagnosis of pneumonia, significant comorbid conditions (eg, foreign body airway obstruction, congenital heart disease, bronchopulmonary dysplasia, significant neurological impairment), or severe respiratory distress with altered mental status or respiratory acidosis.

Outcome Measures

Patient outcomes were measured by self-reported adverse asthma events at 1- and 6-month follow-ups: acute asthma episodes, ED visits, and urgent care visits (any ED visit, walk-in clinic visit or admission). These measures were treated as binary outcomes (yes/no) to minimize the impact of recall bias. Because patients may choose to visit a different hospital for urgent care of asthma after discharge, and documentation of walk-in clinic visits is usually not captured in hospital charts, self-reported data rather than chart review data were used to solicit patient outcomes. The level of adverse asthma events at 1- and 6-months post-ED discharge was compared with that reported at baseline.

Independent Factors

Sociodemographic information, such as age, sex, parental education, single-parent status, employment, family income, and drug insurance coverage, was collected at baseline. Drug insurance coverage was identified by the question "Do you or members of your family have a drug plan that pays for all or a part of your child's asthma medications?" In Ontario, medications are not covered by the universal health care system. Private insurance plans (third party insurance) provide coverage for medications used outside the hospital. These plans vary considerably with regards to which medications they cover and the amount of deductibles and copays the beneficiary pays. Low socioeconomic status was defined as having a family income below the low-income cutoff established by Statistics Canada.²¹

Children/parents were asked about self-rated health and activity level, asthma control, and asthma self-management at baseline. Asthma control was measured by 1) asthma symptoms (ie, wheeze, shortness of breath, chest tightness, cough, and night-time symptoms) in the last 4 weeks, 2) school/work absenteeism in the last 4 weeks, and 3) acute asthma episodes and acute health services use (ie, hospitalization, ED, and walk-in clinic visits) in the last 6 months. Asthma self-management factors assessed included routine visits to health care providers for asthma (yes/no), asthma medication use, and asthma education received (yes/no) in the last 6 months. Questions were also asked about asthma triggers, adverse home

environment factors (eg, furry animals, carpets), bedroom environment control measures (eg, washing bed linens in hot water weekly), parental smoking status, and child's exposure to secondhand smoke at baseline.

Characteristics of the baseline acute asthma episode were obtained from chart review, including arterial oxygen saturation (SaO₂) recorded by pulse oximetry, the need for hospital admission, the length of stay at the ED, and discharge instructions (ie, prescriptions of asthma medications and advice on follow-up). The season of the baseline acute asthma episode was assigned according to the date of the ED visit.

Statistical Analysis

Study population characteristics at baseline were summarized and compared between those with drug insurance coverage and those without using the chi-square test for nominal data and the Student *t* test for continuous variables. Time trends in adverse asthma events and asthma self-management factors were assessed using a generalized estimating equations method for longitudinal analysis while adjusting for covariates, and results were stratified by the status of drug insurance coverage. Multiple conditional logistic regressions were used to model patient outcomes during follow-up. Specifically, the impact of drug insurance coverage was examined while adjusting for confounders. Because adverse asthma events at 1 month were rare, only patient outcomes at 6 months were examined in the logistic regressions analysis. Since analyses of ED visits and urgent care visits yielded almost identical results, only those of ED visits were presented. SAS version 9.1 (SAS Institute Inc, Cary, NC) was used to conduct all analyses.

RESULTS

Study Population

Of 269 children recruited, 247 (91.8%) completed 1-month follow-up and 220 (81.8%) completed 6-month follow-up. One of 10 (11.6%) children presented to the ED with severe acute asthma episodes (initial SaO₂ ≤ 91%), whereas 30.1% required transfer to the observation unit in ED or admission to inpatient units.

Table 1 shows the demographic characteristics of the study population reported at baseline. The majority of the study population were younger than 7 years (70%) and 59% were male. Overall, 71% of the primary caregivers had drug insurance coverage and half of them had a university degree. Patients without drug insurance coverage were more likely to come from low-income families (52.5% vs 27.5%; *P* < .001) and identify cold air as a trigger for asthma (67.9% vs 53.7%; *P* = .04) but less likely to have furry animals at home (33.2% vs 15.4%; *P* < .003). Compared with children who completed both follow-up interviews, those lost to follow-up were less likely to have parents with a university degree (54.5% vs 30.6%; *P* < .003) or experience night-time symptoms in the 4 weeks prior to baseline visit (75.5% vs 87.2%; *P* = .05), but

were more likely to identify weather changes as a trigger for asthma (68.2% vs 83.7%; *P* = .04).

At baseline (Table 2), the majority of children reported having at least 1 asthma symptom in the last 4 weeks (wheeze 86.6%, shortness of breath 81.7%, chest tightness 70.5%, cough 96.6%, night-time symptoms 85.1%). When interviewed at follow-ups, night-time symptoms (in the last 4 weeks) resolved in approximately half of the children at 1 month, and the level of asthma symptoms (in the last 4 weeks) remained stable at 6 months compared with 1-month postdischarge.

Overall, a significant decreasing trend was observed in ED visits (39.4% at baseline vs 26.8% at 6 months; *P* < .001) and urgent care visits (53.7% at baseline vs 31.0% at 6 months; *P* < .0001). However, the level of acute care episodes remained unchanged (Table 3). Similarly, the percentage distribution of asthma self-management factors remained stable during the study period. At 1 month post-ED discharge, less than half (45.7%) of the children had scheduled visits to their health care providers for asthma. This increased to 57.5% by 6 months post-ED discharge. The majority of these children had used inhaled corticosteroids to some extent in the last 6 months at baseline (78.1%) and at 6 months (80.9%), whereas only 1 of 4 children had been given instructions in the last 6 months to use inhaled corticosteroids daily when interviewed at baseline and at 6 months (24.9% and 29.5%, respectively).

Adjusted Risk of Acute Asthma Episode and ED Visit by Logistic Regression

Table 4 shows that previous history of acute asthma episodes (in the 6 months prior to baseline) was associated with a 4.7-fold (adjusted odds ratio [AOR] = 4.73; 95% CI, 2.25–9.97; *P* < .0001) risk of having acute asthma episodes at 6 months post-ED discharge. In contrast, having drug insurance coverage (AOR = 0.36; 95% CI, 0.15–0.85; *P* = .02) and washing bed linens in hot water weekly (AOR = 0.29; 95% CI, 0.12–0.66; *P* < .004) were protective against subsequent acute asthma episodes.

The risk of having subsequent ED visits for asthma at 6-month follow-up was substantially lower in children with drug insurance coverage (AOR = 0.45; 95% CI, 0.20–0.99; *P* = .05). As expected, having ED visits in the 12 months prior to baseline was highly associated with having repeat ED visits at 6 months post-ED discharge (AOR = 6.27; 95% CI, 1.54–7.12; *P* < .0001).

Adverse Asthma Events and Self-Management Factors by Drug Insurance Coverage

Table 5 shows that during the study period, the proportion of children with acute asthma episodes in the last 6 months decreased in those with drug insurance coverage (71.1% at baseline vs 62.9% at 6 months; *P* = .13) but increased in those without (66.7% at baseline vs 73.3% at 6 months; *P* = .15). Although the change over time within groups was not statistically different, the difference between groups was significant (*P* = .05). Similarly, the decreasing trend in urgent care use was significantly less

Table 1. Study Population Characteristics*

| Characteristics at Baseline | No. (N = 269) | % |
|---|------------------|------|
| Demographics | | |
| <7 y | 188 | 69.9 |
| Female | 109 | 40.5 |
| Parental education ≥ university graduate | 135 | 50.2 |
| Full-time employment | 119 | 44.2 |
| Single parent status | 71 | 26.4 |
| Family income below low-income cutoff† | 83 | 35.0 |
| Drug insurance coverage | 190 | 70.9 |
| Season at recruitment | | |
| Spring/fall | 133 | 49.4 |
| Time first started to have breathing problems | | |
| Within last 12 mo | 46 | 17.1 |
| Health status‡ | | |
| Fair/poor health rating | 52 | 19.5 |
| Less active than average | 40 | 14.9 |
| Asthma control | | |
| Symptoms (last 4 wk, including current visit) | | |
| Wheeze | 232 | 86.6 |
| Shortness of breath | 219 | 81.7 |
| Chest tightness | 189 | 70.5 |
| Cough | 259 | 96.6 |
| Night-time symptoms | 228 | 85.1 |
| Acute asthma episodes (last 6 mo) | 188 | 69.9 |
| Health services use (last 6 mo) | | |
| ED§ visit | 97 | 39.4 |
| Walk-in clinic visit | 76 | 30.9 |
| Hospital admission | 23 | 9.3 |
| Urgent visit (any ED visit, walk-in clinic visit, or admission) | 131 | 53.3 |
| School/work absenteeism (last 4 wk) | | |
| Missed school | 166 | 78.3 |
| Missed work (parent) | 129 | 63.5 |
| Environment | | |
| Have furry animals/birds at home | 75 | 27.9 |
| Sleep in basement | 10 | 3.7 |
| Have harmful factors in bedroom (eg, carpets, stuffed animals) | 243 | 90.3 |
| Have protective factors in bedroom (eg, air tight pillow case/mattress) | 198 | 73.6 |
| Triggers (top 5) | | |
| Colds/sinus infection | 240 | 89.2 |
| Weather changes | 191 | 71.0 |
| Seasons | 167 | 62.1 |
| Cold air | 156 | 58.0 |
| Dust | 152 | 56.5 |
| Smoking | | |
| Parental smoking | 40 | 15.7 |
| Secondhand smoke exposure | 22 | 8.2 |
| Asthma self-management | | |
| Routine visit in last 6 mo | 153 | 56.9 |
| Had spirometry done ever | 48 | 38.1 |
| Medication use | | |
| Prescribed any asthma medications in last 6 mo | 212 | 78.8 |
| Used any asthma medications in last 4 wk | 227 | 84.4 |
| Used any asthma medications in last 6 mo | 249 | 92.6 |
| Used inhaled bronchodilator and inhaled corticosteroids in last 6 mo | 200 | 74.3 |
| Instructions given on daily inhaled corticosteroids use in last 6 mo | 67 | 24.9 |
| Asthma education | | |
| Received asthma education in last 6 mo | 63 | 23.4 |
| Ever been given an action plan | 76 | 28.6 |
| Inhaler/nebulizer use demonstrated by health care provider to patient | 238 | 88.5 |

(Continued)

Table 1. (Continued)

| Characteristics at Baseline | No. (N = 269) | % |
|---|------------------|------|
| Inhaler/nebulizer use demonstrated by patient to health care provider | 139 | 60.2 |
| Peak flow meter use demonstrated by health care provider to patient | 41 | 31.3 |
| Peak flow meter use demonstrated by patient to health care provider | 32 | 80.0 |
| Used peak flow meter to monitor asthma | 16 | 12.2 |
| Severity of baseline acute asthma episode | | |
| Initial SaO ₂ ≤ 91% | 30 | 11.6 |
| Admitted (including transfer to ED observation unit) | 81 | 30.1 |
| Length of ED stay, mean ± SD, h | 9.2 ± 7.4 | |
| Length of ED stay (median, maximum-minimum), h | 7, 1–52 | |
| ED discharge instructions | | |
| Received asthma education (eg, equipment, triggers) | 84 | 31.2 |
| Prescribed bronchodilator | 203 | 75.5 |
| Prescribed oral corticosteroids | 162 | 60.2 |
| Prescribed inhaled corticosteroids | 148 | 55.0 |
| Advised on follow-up visit to primary care provider | 163 | 60.6 |

*All percentages were adjusted for missing data.

†The low-income cutoffs were established by Statistics Canada based on the 1992 Family Expenditure Survey. A low-income cutoff is an income threshold below which a family will likely devote a larger share of its income on the necessities of food, shelter, and clothing than the average family.²¹

‡Health status is self-reported health rating and activity levels.

§ED indicates emergency department.

pronounced ($P = .01$) in children without drug insurance coverage (50.0% at baseline vs 41.7% at 6 months) compared with those with coverage (54.4% at baseline vs 26.4% at 6 months).

DISCUSSION

Our prospective follow-up study showed significant improvements in long-term outcomes in a cohort of children after receiving treatments for acute asthma at the ED of a tertiary children's hospital. At 6 months post-ED discharge, there was a significant drop in asthma symptoms and acute health care use for asthma compared with the reported levels at baseline, although there was a trend toward deterioration compared with those at 1 month. Though part

Table 2. Level of Asthma Symptoms Over Time*

| Asthma Symptoms 4 Weeks Prior to Interview | Baseline (N = 269) | | 1 month (n = 247) | | 6 months (n = 220) | |
|--|-----------------------|------|----------------------|------|-----------------------|------|
| | No. | % | No. | %† | No. | %† |
| Wheeze | 232 | 86.6 | 96 | 38.9 | 91 | 41.4 |
| Shortness of breath | 219 | 81.7 | 82 | 33.2 | 73 | 33.2 |
| Chest tightness | 189 | 70.5 | 67 | 27.1 | 54 | 24.5 |
| Cough | 259 | 96.6 | 135 | 54.7 | 138 | 62.7 |
| Night-time symptoms | 228 | 85.1 | 115 | 47.9 | 122 | 55.5 |

*All percentages were adjusted for missing data.

† $P < .0001$ compared to baseline.

Table 3. Trends in Adverse Asthma Events and Asthma Self-Management Over Time†

| | Baseline (N = 269), % | 1-month follow-up‡ (n = 247), % | 6-month follow-up§ (n = 220), % | Ratio of proportion at 6 months vs baseline |
|-------------------------------------|-----------------------|---------------------------------|---------------------------------|---|
| Adverse asthma events | | | | |
| Acute asthma episode | 69.9 | 35.2 | 65.9 | 0.94 |
| ED¶ visit | 39.4 | 6.1 | 26.8 | 0.68* |
| Urgent care visits | 53.7 | 10.3 | 31.0 | 0.58** |
| Asthma self-management | | | | |
| Routine provider visit | 56.9 | 45.7 | 57.7 | 1.01 |
| Used ICS†† | 78.1 | 74.1 | 80.9 | 1.04 |
| Given instructions to use ICS daily | 24.9 | 35.2 | 29.5 | 1.19 |

*P < .01.

**P < .0001.

†All percentages were adjusted for missing data.

‡In 4 weeks prior to interview.

§In 6 months prior to interview.

||Test for trend was obtained using generalized estimating equations adjusting for age group, gender, socioeconomic status, and drug insurance coverage.

¶ED indicates emergency department.

††ICS indicates inhaled corticosteroids.

of the changes over time could be due to regression toward the mean, our relatively long observation window (last 6 months) at both baseline and follow-up and the >30% decrease in repeat ED visit rate suggest that the trend may be truly significant. Future studies with an appropriate control group and follow-ups beyond 6 months post-ED discharge would provide a more accurate estimate of the trend.

Table 4. Adjusted Risks of Patient Outcomes at 6-Month Follow-up†

| Risk Factors at Baseline | OR‡ | 95% CI§ |
|--|------|--------------|
| Outcome: acute asthma episode (n = 193) | | |
| With drug insurance coverage <7 y | 0.36 | 0.15–0.85* |
| Female sex | 2.03 | 0.95–4.34 |
| Socioeconomic status (below low-income cutoff) | 1.39 | 0.66–2.92 |
| Had acute asthma episodes in last 6 mo | 0.51 | 0.24–1.11 |
| Wash bed linens in hot water weekly | 4.73 | 2.25–9.97*** |
| Colds/sinus infection as asthma trigger | 0.29 | 0.12–0.66** |
| Had walk-in clinic visit in past year | 3.04 | 1.03–8.95* |
| Had walk-in clinic visit in past year | 2.37 | 1.09–5.11* |
| Outcome: ED¶¶ visit (n = 194)¶¶ | | |
| With drug insurance coverage <7 y | 0.45 | 0.20–0.99* |
| Female sex | 1.34 | 0.56–3.21 |
| Socioeconomic status (below low-income cutoff) | 0.97 | 0.47–2.00 |
| Received education in last 6 mo | 1.01 | 0.47–2.21 |
| ED visits in last 12 mo | 3.31 | 2.52–15.60** |
| ED visits in last 12 mo | 6.27 | 1.54–7.12*** |

*P < .05.

**P < .01.

***P < .0001.

†From logistic regression models; the final models included independent variables shown in the table only. Other independent variables were excluded due to lack of statistical significance.

‡OR indicates odds ratio.

§CI indicates confidence interval.

||Model significance was measured by the Hosmer-Lemeshow test: chi-square = 6.1; df = 8; P = .63.

¶¶Model significance was measured by the Hosmer-Lemeshow test: chi-square = 5.0; df = 9; P = .84.

††ED indicates emergency department.

It is generally accepted that asthma is an ambulatory care-sensitive condition, and appropriate outpatient management results in decreased urgent health care use.²² However, previous studies^{3–10} conducted under both private and public health care systems showed that outcomes of children attending an ED for asthma were far from ideal. For example, Spurrier and colleagues⁹ followed children with asthma for 6 months after attending an ED and found that 37% had at least 1 unplanned subsequent visit to the ED. In the current study, the incidence of repeat ED visits was 6.1% and 26.8% at 1 and 6 months, respectively. Though still concerning, the rates were lower than those reported by most others. Possible explanations for this difference may lie in the asthma education given to children/family in the ED and the emphasis of the use of inhaled corticosteroids after ED discharge. Our data showed that inhaled corticosteroids were used to some extent—although it may not be consistent with guideline recommendations—in about three fourths of our study population over the study period. This percentage was substantially higher than that reported in most previous studies^{4,6–8} and may explain the better asthma control in our study population, even at baseline compared with other studies.

One of the most significant findings in the current study is that having drug insurance coverage was a significant protective factor against adverse asthma events at 6-month follow-up. This indicates that the affordability and accessibility of asthma medications may still be major barriers to long-term asthma control in children, even under a public health care system. Recently, the development of better drug benefit plans has been recognized as one of the key challenges, if addressed, that would make the biggest impact on improving access to the medications and education that Canadian children need for optimal asthma control.²³ In the United States, a multicenter study found that medical care insurance status had no impact on quality of care and short-term outcomes in children with acute asthma

Table 5. Trends in Adverse Asthma Events and Asthma Self-Management Over Time†

| | With Drug Insurance Coverage (n = 190) | | | | Without Drug Insurance Coverage (n = 78) | | | |
|-------------------------------------|--|-----------------------|-----------------------|---|--|----------------------|----------------------|---|
| | Baseline, % | 1-month follow-up, %‡ | 6-month follow-up, %§ | Ratio of proportion at 6 months vs baseline | Baseline, % | 1-month follow-up, % | 6-month follow-up, % | Ratio of proportion at 6 months vs baseline |
| Adverse asthma events | | | | | | | | |
| Acute asthma episode | 71.1 | 34.5 | 62.9 | 0.89 | 66.7 | 37.7 | 73.3 | 1.10 |
| ED¶ visit | 39.1 | 5.1 | 23.9 | 0.61* | 40.8 | 8.7 | 33.3 | 0.82 |
| Urgent care visits | 54.4 | 9.6 | 26.4 | 0.49** | 50.0 | 14.5 | 41.7 | 0.83 |
| Asthma self-management | | | | | | | | |
| Routine provider visit | 54.7 | 48.0 | 59.1 | 1.08 | 61.5 | 40.6 | 53.3 | 0.87 |
| Used ICS†† | 77.4 | 77.8 | 82.4 | 1.06 | 79.5 | 73.9 | 76.7 | 0.96 |
| Given instructions to use ICS daily | 24.2 | 33.9 | 31.4 | 1.30 | 26.9 | 40.6 | 25.0 | 0.93 |

* $P < .01$.** $P < .0001$.

†By drug insurance coverage. All percentages were adjusted for missing data.

‡In 4 weeks prior to interview.

§In 6 months prior to interview.

||Test for trend was obtained using generalized estimating equations adjusting for age group, gender, and socioeconomic status.

¶ED indicates emergency department.

††ICS indicates inhaled corticosteroids.

presenting to 36 EDs.¹⁰ This suggests that other risk factors such as affordability and accessibility of medications may play a more important role in determining outcomes of children with asthma in privately insured health care systems. Therefore, improving the affordability and accessibility of asthma medications—maybe through public health policies and interventions—should be considered a priority target for future efforts to improve outcomes in children with asthma.

Besides drug insurance coverage, we also identified other potentially modifiable factors associated with repeat ED visits that could be used to target interventions to achieve good asthma control. Similar to previous studies, we found that environment control measures (eg, washing bed linens in hot water weekly) were associated with a significantly lower risk of subsequent acute asthma episodes. Current guidelines endorsed reducing exposure to allergens in asthma patients as the tertiary prevention strategy for asthma.^{11–13} Some researchers recommended that clinicians provide education regarding effective environmental measures for all families with potentially modifiable asthma triggers,²⁴ although the optimal location, content, and duration of the delivery of such asthma education remain an ongoing debate.²⁵ Although some have advocated that education for asthma patients should be initiated in the ED, many barriers exist that make it difficult to implement. These include the allocation of adequate staff time for patient education, adjustment of content to meet individual patients' needs, and the assessment of learners' comprehension.²⁶ Our study suggested that providing patient education in the ED may contribute to improved long-term outcomes in children with asthma. Further studies that assess the cost-effectiveness of allocating an asthma educator in the ED would be informative to guide future policy changes and resource allocation.

In this study, we also observed relatively high levels of asthma symptoms at follow-ups, which could be partially explained by suboptimal self-management patterns post-

ED visits. At 1 month, only one third of the study population, either with or without drug insurance coverage, were given instructions to use inhaled corticosteroids on a daily basis. Furthermore, in contrast to recommendations in national guidelines, less than half of these children had scheduled visits to health care providers for asthma within 1 month after ED discharge. Education of both health care providers and patients on better asthma self-management strategies may help improve asthma control.

This study has several limitations. Firstly, the measures on symptoms, acute asthma events, and health services use were based on patients' self-report. There could be a potential bias in overrecalling at the baseline ED visit and underreporting at follow-ups on asthma symptoms, events, and medication use. However, a recent study showed that agreement between health administrative data and respondent reports was moderate for ED visits in the past year, and the agreement was significantly higher for children who had an asthma attack in the past 6 months.²⁰ In addition, the time windows (4 weeks or 6 months) adopted in our questionnaire were much shorter than those applied in national population-based health surveys (12 months),^{27,28} which would help reduce the risk of underreporting as children recovered over time.

Secondly, this study lacks detailed information on medication use post-ED discharge, such as whether prescriptions were filled and whether medications were taken as instructed. Future research that collects detailed data on medication use is needed to explore the mechanisms through which drug insurance coverage is linked to adverse asthma events in children. This will guide the development of policies/interventions to reduce the negative impact of inadequate drug insurance coverage on patient outcomes in children with asthma.

Thirdly, the current study focused on objective health outcomes (eg, repeat ED visits) and individual asthma symptoms rather than composite functional outcome or health status measures. The latter could be of interest if the quality of

care that children with asthma receive is of concern, or if one is interested in measuring the performance of the health care system in caring for children with special needs.²⁹ However, limitations of existing health status measures have long been noted,³⁰ and new measures (eg, the Children's Health Survey for Asthma) are still being tested to be used in longitudinal analysis.²⁹ Future studies on outcomes in children with asthma should include composite health status measures whenever possible.

Finally, our study cohort was a nonrandom sample that attended the ED of a tertiary children's hospital. Therefore, our findings may not be generalizable to children with mild or moderate asthma who are primarily managed in community settings. However, since those attending the ED of a tertiary hospital may represent difficult asthma or poorly controlled asthma, our results hold clinical relevance to practitioners who are providing continuous care to these children after they are discharged into the community.

In summary, our study demonstrated significant improvements in long-term outcomes in a cohort of children who have received acute care for asthma at the ED. Future efforts remain in targeting the sustainability of improved outcomes beyond 6 months. Risk factors identified in this study can help target vulnerable-children populations (such as those with previous adverse events or without drug insurance coverage) for proper interventions to reduce adverse outcomes, especially acute asthma episodes and the need for acute health care use. Such interventions may include efforts to maximize insurance coverage for asthma medications, as well as strategies to improve asthma self-management, likely through patient and provider education.

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REFERENCES

1. Millar WJ, Hill GB. Childhood asthma. *Health Rep.* 1998;10(3):9-21.
2. To T, Dell S, Dick P, et al. *Burden of childhood asthma*. Institute for Clin Evaluative Sciences Available at: <http://www.ices.on.ca/file/ACF77.pdf>. Accessed March 17, 2008
3. Guttman A, Zagorski B, Austin P, et al. Effectiveness of emergency department asthma management strategies on return visits in children: a population-based study. *Pediatrics.* 2007;120:e1402-e1410.
4. Butz AM, Eggleston P, Alexander C, Rosenstein BJ. Outcomes of emergency room treatment of children with asthma. *J Asthma.* 1991;28:255-264.
5. Ducharme FM, Kramer MS. Relapse following emergency treatment for acute asthma: can it be predicted or prevented? *J Clin Epidemiol.* 1993;46:1395-1402.
6. Stevens MW, Gorelick MH. Short-term outcomes after acute treatment of pediatric asthma. *Pediatrics.* 2001;107:1357-1362.
7. Emerman CL, Cydulka RK, Crain EF, et al. Prospective multicenter study of relapse after treatment for acute asthma among children presenting to the emergency department. *J Pediatr.* 2001;138:318-324.
8. Benito-Fernandez J, Onis-Gonzalez E, Alvarez-Pitti J, et al. Factors associated with short-term clinical outcomes after acute treatment of asthma in a pediatric emergency department. *Pediatr Pulmonol.* 2004;38:123-128.
9. Spurrier NJ, Staugas R, Sawyer MG, et al. Health-service use by children with asthma over a 6-month period. *J Paediatr Child Health.* 2003;39:15-21.
10. Ferris TG, Crain EF, Oken E, et al. Insurance and quality of care for children with acute asthma. *Ambul Pediatr.* 2001;1:267-274.
11. Boulet LP, Becker A, Bérubé D, et al. Canadian asthma consensus report, 1999. *Can Med Assoc J.* 1999;161(11 suppl):S1-S62.
12. Boulet LP, Bai T, Becker A, et al. What is new since the last (1999) Canadian Asthma Consensus Guidelines? *Can Respir J.* 2001;8(suppl A):5A-27A.
13. Becker A, Lemiere C, Berube D, et al. Summary of recommendations from the Canadian Asthma Consensus Guidelines, 2003. *Can Med Assoc J.* 2005;173(6 suppl):S3-S11.
14. Sin DD, Man SF. Low-dose inhaled corticosteroid therapy and risk of emergency department visits for asthma. *Arch Intern Med.* 2002;162:1591-1595.
15. Anis AH, Lynd LD, Wang XH, et al. Double trouble: impact of inappropriate use of asthma medication on the use of health care resources. *Can Med Assoc J.* 2001;164:625-631.
16. Blais L, Beauchesne MF. Use of inhaled corticosteroids following discharge from an emergency department for an acute exacerbation of asthma. *Thorax.* 2004;59:943-947.
17. Ungar W, Ariely R. Health insurance, access to prescription medicines and health outcomes in children. *Expert Rev Pharmacoecon Outcomes Res.* 2005;5(2):1-11.
18. Kozyrskyj AL, Mustard CA, Simons FE. Socioeconomic status, drug insurance benefits, and new prescriptions for inhaled corticosteroids in schoolchildren with asthma. *Arch Pediatr Adolesc Med.* 2001;155:1219-1224.
19. Ungar WJ, Kozyrskyj A, Paterson M, Ahmad F. Effect of cost-sharing on use of asthma medication in children. *Arch Pediatr Adolesc Med.* 2008;162:104-110.
20. Ungar WJ, Davidson-Grimwood SR, Cousins M. Parents were accurate proxy reporters of urgent pediatric asthma health services: a retrospective agreement analysis. *J Clin Epidemiol.* 2007;60:1176-1183.
21. Statistics Canada. *Low Income Cut-Offs*. Ottawa, Ontario: Statistics Canada; 1996.
22. Dell S. Tackling paediatric asthma—the time has come. *Paediatr Child Health.* 2004;9:659-660.
23. Ungar W. Improving drug benefits for children with asthma: building a research agenda. AllerGen NCE Inc Web site. Available at: <http://www.allergen-nce.ca/documents/UngarReport.pdf>. Accessed April 17, 2008.
24. Cabana MD, Slish KK, Lewis TC, et al. Parental management of asthma triggers within a child's environment. *J Allergy Clin Immunol.* 2004;114:352-357.
25. Rowe BH, Majumdar SR. Improving quality of asthma care after emergency department discharge: evidence before action. *Ann Emerg Med.* 2005;45:299-301.
26. Singer AJ, Camargo CA Jr, Lampell M, et al. A call for expanding the role of the emergency physician in the care of patients with asthma. *Ann Emerg Med.* 2005;45:295-298.
27. Statistics Canada and Human Resources Development Canada. National Longitudinal Survey of Children and Youth, cycle 6 survey instruments 2004/2005, book 1-parent, child & youth. Available at: http://www.statcan.ca/english/sdds/instrument/4450_Q2_V5_E.pdf. Accessed April 17, 2008.
28. Statistics Canada. Canadian Community Health Survey, cycle 3.1, final questionnaire. Available at: www.statcan.ca/english/sdds/instrument/3226_Q1_V3_E.pdf. Accessed April 17, 2008.
29. Asmussen L, Olson LM, Grant EN, et al. Reliability and validity of the Children's Health Survey for Asthma. *Pediatrics.* 1999;104:e71.
30. Olson LM, Asmussen L. Current methods in measuring health-related quality of life in children with asthma. In: Weiss KB, Buist AS, Sullivan SD, eds. *Social and Economic Impact of Asthma*. New York, NY: Marcel Dekker, Inc; 1999:99-126.