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Effectiveness of Emergency Department Asthma Management Strategies on Return Visits in Children: A Population-Based Study

Astrid Guttman, MDCM, MSc^{a,b,c,d,e}, Brandon Zagorski, MSc^a, Peter C. Austin, PhD^{a,d,f}, Michael Schull, MD, MSc^{a,d,g}, Asma Razzaq, MPH^a, Teresa To, PhD^{a,c,d,e,f}, Geoff Anderson, MD, PhD^{a,d}

^aInstitute for Clinical Evaluative Sciences, Toronto, Ontario, Canada; ^bDivisions of Pediatric and Emergency Medicine and ^cChild Health Evaluative Sciences, Research Institute, Hospital for Sick Children, Toronto, Ontario, Canada; ^dDepartment of Pediatrics, Faculty of Medicine, Departments of ^eHealth Policy, Management, and Evaluation and ^fPublic Health Sciences, and ^gDivision of Emergency Medicine, Faculty of Medicine, University of Toronto, Toronto, Ontario, Canada

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ABSTRACT

BACKGROUND. Emergency departments play an important role in the care of children with asthma. Emergency department return-visit rates provide a measure of the quality of acute asthma care.

OBJECTIVE. Our goal was to describe the characteristics of children treated in emergency departments for asthma, the resources and asthma management strategies used by emergency departments, and their effect on return visits within 72 hours.

DESIGN, SETTING, AND PATIENTS. We used a population-based cohort study that incorporated both comprehensive administrative health and survey data from all 152 emergency departments in Ontario, Canada. We studied all 2- to 17-year-old children who had a visit to an emergency department for asthma from April 2003 to March 2005.

RESULTS. A total of 32 996 children (>9% of children with asthma in Ontario) had at least 1 visit to an emergency department for the care of asthma, and most of these visits (68.5%) were triaged as high acuity. The vast majority (148 of 152 [97%]) of emergency departments reported using at least 1 asthma management strategy, and 74% used 3 or more. The overall return-visit rate was 5.6%. Logistic regression models that accounted for the clustering of patients in emergency departments and controlled for patient and emergency department characteristics indicated that preprinted order sheets and access to a pediatrician for consultation were strategies significantly associated with a reduction in return visits. The 11 (17%) emergency departments that used both of these strategies had return visit rates of 4.4% compared with 6.9% in the 95 (63%) that used neither strategy.

CONCLUSIONS. Emergency departments use a range of strategies to manage asthma in children. Preprinted order sheets and access to pediatricians are associated with important reductions in return-visit rates, and more emergency departments should consider using these strategies.

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Key Words

asthma, return visits, emergency department, standardized order sheets, guidelines

Abbreviations

ED—emergency department
OR—odds ratio
CI—confidence interval

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Address correspondence to Astrid Guttman, MDCM, MSc, Institute for Clinical Evaluative Sciences, G Wing, Sunnybrook and Women's College Health Sciences Centre, 2075 Bayview Ave, Toronto, Ontario, Canada M4N 3M5.
E-mail: astrid.guttman@ices.on.ca

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RATES OF CHILDHOOD asthma have risen markedly in the Western world,¹ with current prevalence estimates of 8.9% in the United States² and 12% in Canada.^{3,4} Asthma is exceeded by only injuries and pneumonia as a cause for hospitalization in children⁵ and is estimated to account for ~14 million lost school days per year in the United States.² Acute exacerbations of asthma are often managed in emergency departments (EDs), which in the United States have seen a steady increase of these visits. In 2004, the number of ED visits for children reached >754 000.²

Many national bodies such as the National Institutes of Health have developed ED treatment guidelines for asthma that focus not only on evidence-based pharmacotherapy to relieve the acute symptoms and the underlying inflammation but also on assessments of response to treatment and appropriateness for safe discharge.^{6–10} However, little is known as to whether or how EDs effectively implement these guideline practices.

Although there is great interest in identifying strategies for guideline implementation and quality improvement in all areas of medical practice, a recent review of existing research showed that little is actually known about what works.¹¹ The authors highlighted that there are important limitations to generalizing results from 1 setting to another and that management that requires more complex medical decision-making poses many challenges to the implementation of clinical guidelines. In the case of ED management of childhood asthma, there is some literature on interventions to improve overall care, such as the use of clinical pathways,¹² provider¹³ and patient¹⁴ educational interventions such as innovative decision support tools, to improve acute asthma care for children; however, most were reports from single-center trials, which occur often in the setting of an academic children's hospital and usually find some effect on processes of care but not always on patient outcomes.

The objectives of our study were to (1) describe the current asthma management strategies for children used by EDs in the province of Ontario and (2) test which strategies have an impact on 72-hour return visits by children. Return visits to the ED within a single asthma exacerbation are often used as an end point in clinical trials to measure the effectiveness of ED care¹⁵ and are used as a hospital quality measure in Canada.¹⁶ Expert panels on ED quality have suggested a 72-hour window after the initial ED visit as the most relevant period to assess ED care,^{17,18} with later revisits often serving as a function of issues such as access to follow-up which are not easily within the control of all EDs. The work of Emerman et al and the Multicenter Airway Research Collaboration^{19,20} has shown that for both children and adults, the risk of unscheduled return visits to the ED or another health care provider after an acute asthma exacerbation is high (up to 10% within 14 days in the

largest prospective study in children).²⁰ A number of studies have articulated important patient factors associated with relapse, including age, markers of chronic asthma severity such as a history of admissions and ED use, medication use, and environmental exposures such as cigarette smoke.^{20–22} However, few have identified ED interventions that can be effective in preventing relapse. The results of this study will provide an overview of ED-based asthma care for children and identify which interventions are associated with improved outcomes.

METHODS

Overall Design and Setting

We conducted a retrospective cohort study of all children 2- to 17-years old who were seen for asthma in an ED from April 14, 2003, to March 31, 2005, in Ontario, Canada's largest province (population of 12 million). We linked data from a survey of all EDs to a population-based administrative health database of all ED visits to test the association of different ED strategies on return visits and controlled for patient and institution-level factors. The Research Ethics Board of Sunnybrook Hospital (Toronto, Ontario, Canada) approved this study.

Measures and Data Collection

We surveyed the EDs of all 164 acute care hospitals in Ontario during early 2005. The survey was beta-tested for clarity by a physician in a large academic ED and by a manager of a pediatric ED. Finalized surveys were sent to either the administrative manager or medical chief of the ED, previously identified as the best respondent for other surveys conducted for the Ontario Hospital Report.²³ We asked the physician and manager about general resources such as the presence of a short-stay or observation unit, training of front-line medical staff (pediatric or pediatric emergency medicine), the availability of pediatricians for consultation, and specific questions around strategies for the management of asthma in children. These strategies included those directly recommended in Canadian guidelines (routine use of peak flow monitoring),⁹ others reported in the literature (availability of guidelines, standard order sheets, or personnel trained in asthma education),^{13,24–27} and those known to the authors to be in practice (preprinted discharge instructions or the ability to dispense aerochambers/spacers).

Records for visits to all EDs in Ontario from April 1, 2003, to March 31, 2005, were obtained from the National Ambulatory Care Reporting System, a routinely collected administrative health database. Anonymized unique identifiers allow linkages of records within the database to identify multiple visits by the same individual and can be linked to hospitalization data. Visits with an ED discharge diagnosis of asthma were selected to determine our cohort, the volume of all patients with

asthma at each ED and calculate the propensity of each ED to admit children with asthma.

Our cohort consisted of all children 2- to 17-years old with an ED visit for asthma between April 14, 2003, and March 28, 2005. In the case of multiple visits for asthma, we chose the first visit and looked back to April 1, 2004, to exclude any patient who had a previous ED visit for asthma within the past 2 weeks. We defined an asthma visit as either a primary diagnosis of asthma or status asthmaticus (International Classification of Disease 10CA codes J45 and J46) or as secondary diagnoses with a primary diagnosis of wheeze, dyspnea, cough, or respiratory failure. Our outcome was unplanned (ie, unscheduled) return visits to any ED within 72 hours of the initial visit for patients who had been discharged from the hospital and who had not left the ED before the initial visit was completed.

Patients were allocated to the ED from which they were discharged on the initial visit. We described hospitals as being either academic or community. We categorized the latter group as small- and large-volume hospitals by using the median number of all ED visits by children 0- to 17-years old. We used the National Ambulatory Care Reporting System to assign an overall annual volume of asthma visits for patients of all ages. We excluded EDs with extremely low annual volumes of visits for asthma by children (≤ 10 th percentile).

To control for severity of asthma, we linked patients to the Discharge Abstract Database for Ontario, which contains all hospitalization records, and enumerated those with a previous admission for asthma within the 2 years before the ED visit. We used each child's postal code to describe the mean neighborhood income quintile at the level of dissemination area (average population of 650) based on the 2001 Canadian Census.

Statistical Analyses

To control for the possibility that some hospitals might have a lower threshold of admission, which might have an impact on return visits, we developed a measure of each ED's propensity to admit children with asthma. We used a logistic regression model with admission as the outcome to derive odds ratios (ORs) for all patient factors using the entire sample. We then calculated a rate of observed/expected admissions for each hospital by using the coefficients of this model. This observed/expected ratio was then added as a hospital-level characteristic to the main analyses that modeled return visits (see below).

For our main analyses we used logistic regression after we first developed a "risk-adjustment" model. We modeled the effect of patient factors (age, gender, history of previous admission, and neighborhood income quin-

tile), most of which have been shown to be important in asthma relapse,²⁰ and hospital characteristics (type, annual volume of all patients with asthma, and propensity to admit), which we hypothesized would have an effect on return-visit rates. We then individually added each ED strategy from the survey to this risk-adjustment model to test which strategy decreased the likelihood of return visits. We performed subgroup analyses according to hospital type and according to age for strategies that were relevant to academic hospitals only (front-line staff training in pediatrics or pediatric emergency medicine) and to older children (routine peak flow monitoring). Because patients at the same ED may have correlated outcomes, we adjusted all of our models for clustering of patients within EDs by using generalized estimating equations.²⁸ We used an extension of the Hosmer-Lemeshow goodness-of-fit test to ensure model fit.²⁹

RESULTS

ED Visits for Asthma

Table 1 describes pediatric ED visits for asthma according to hospital group. Over the 2 years studied, there were 32 996 children (of a population of ~ 3 million children of this age in Ontario) who visited 152 EDs for asthma. Overall, there were 49 147 visits for asthma, which represented 3% of the 1 598 915 ED visits for this age group over the study period. There was a preponderance of ED visits for asthma among boys and children in lower-income neighborhoods. Academic and large community hospitals tended to treat younger children, and those of a higher triage score, with overall higher admission rates than those found in small community hospitals. All of these differences across hospital types were statistically significant. Controlling for patient factors, admission rates were not significantly different between hospital types or according to the presence of a short-stay unit in the ED (data not shown). Of the 27 801 children discharged from the hospital after a complete ED visit, 5.6% had a return visit within 72 hours, with the highest rate being in the small community hospitals (7.1%). More than two thirds of the children who returned were triaged as needing urgent or emergent care or resuscitation (using Canadian Triage Assessment scores of 1–3)³⁰, with a subsequent admission rate of 16.6%.

Hospital Survey

We received responses from all 164 EDs that we surveyed. We excluded 12 hospitals with low volumes of asthma visits in patients 2- to 17-years old in 2003–2005 (cutoff: 33 visits). Table 2 describes the asthma care strategies used by the hospitals and available resources such as a short-stay unit and the availability of pediatricians for consultation according to hospital type. Of the

TABLE 1 Characteristics of Children 2- to 17-Years Old Seeking Care for Asthma in EDs, According to Hospital Type: April 2003 to March 2005

Characteristic	Hospital Type, n (%)			Overall (N = 32 996), n (%)
	Academic	Large Community	Small Community	
Male	3418 (61.4)	13 524 (61.3)	3204 (59.5)	20 146 (61.1)
Age, y				
2–7	3623 (65.2)	12 048 (54.6)	2470 (45.9)	18 150 (55.0)
8–12	1215 (21.8)	5719 (25.9)	1559 (29.0)	8493 (25.7)
13–17	722 (13.0)	4279 (19.4)	1352 (25.1)	6353 (19.3)
History of asthma admission	308 (5.5)	1592 (7.2)	193 (3.6)	2093 (6.3)
Neighborhood income quintile				
Missing	116 (2.1)	618 (2.8)	360 (6.7)	1094 (3.3)
1 (lowest)	1478 (26.5)	4506 (20.4)	1256 (23.3)	7240 (21.9)
2	1065 (19.1)	4489 (20.4)	1099 (20.4)	6653 (20.2)
3	989 (17.8)	4478 (20.3)	972 (18.1)	6439 (19.5)
4	979 (17.6)	4385 (19.9)	806 (16.7)	6260 (19.0)
5 (highest)	942 (16.9)	3570 (16.2)	798 (14.8)	5310 (16.1)
Canadian Triage Assessment Score				
1–2 (resuscitation, emergent)	1183 (21.2)	4732 (21.5)	184 (3.4)	6099 (18.5)
3 (urgent)	3088 (55.4)	11 832 (53.7)	1594 (29.6)	16 514 (50.0)
4–5 (semiurgent, nonurgent)	1298 (23.3)	5482 (24.9)	3603 (67.0)	10 383 (31.5)
Disposition				
Admitted	480 (8.6)	2384 (10.8)	167 (3.1)	3031 (9.2)
Discharged	5056 (90.8)	19 374 (87.9)	5119 (95.1)	29 549 (89.6)
Left before visit completed	33 (0.6)	288 (1.3)	95 (1.8)	416 (1.3)
Return visit within 72 h ^a	230 (4.5)	1050 (5.4)	368 (7.1)	1648 (5.6)

All differences in characteristics of children between hospital types are significant at least to $P < .05$.

^a Return-visit rate was calculated for children who were discharged from the ED after a completed visit.

12 academic hospitals, 2 are freestanding children's hospitals and 1 has a separate ED for children. These 3 hospitals are the only ones with a front-line staff of pediatricians (many of whom are certified in pediatric emergency medicine). All of the various asthma care strategies were distributed across the hospital types, although the small community group generally had lower rates of all of these strategies. Only 4 hospitals had adopted no strategies at all, with the majority of all hospitals having between 3 and 4 strategies in place.

Association of Strategies With Return Visits

Table 3 describes the association of patient and hospital factors with return visits. Compared with children 8 to 12

years old, younger children and teenagers were more likely to return, as were those with a history of an asthma admission. Boys had a slightly reduced risk of returning (OR: 0.83; 95% confidence interval: [CI] 0.75–0.91). Neighborhood-income quintile was not associated with the risk of returning. After controlling for patient factors, being seen in a small community hospital was associated with a 62% increased odds of returning within 72 hours. Overall volume of patients with asthma and the propensity-to-admit score was not associated with return visits.

The risk-adjusted model (Table 4) identified 2 strategies that were significantly ($P < .05$ for the nested model) associated with reduced return visits: the avail-

TABLE 2 Distribution of ED Strategies and Resources According to Hospital Type

Strategies/resources available, N (%)	Hospital Type			All (N = 152)
	Academic (N = 12)	Large Community (N = 70)	Small Community (N = 70)	
Short-stay unit	3 (25.0)	17 (24.3)	17 (24.3)	37 (24.3)
Access to a pediatrician for consultation	6 (50.0)	39 (55.7)	3 (4.3)	48 (31.6)
Preprinted discharge instructions	7 (58.3)	36 (51.4)	36 (51.4)	79 (52.0)
Preprinted order sheets	4 (33.3)	17 (24.3)	5 (7.1)	26 (17.1)
Routine use of peak flow testing	2 (16.7)	34 (48.6)	32 (45.7)	68 (44.7)
Trained personnel in asthma teaching	10 (83.3)	57 (81.4)	43 (61.4)	110 (72.4)
Ability to dispense aerochambers	8 (66.7)	53 (75.7)	53 (75.7)	114 (75.0)
Availability of asthma guidelines	6 (50.0)	28 (40.0)	22 (31.4)	56 (36.8)
No. of strategies				
None	0.0	3 (4.3)	1 (1.4)	4 (2.6)
1–2	4 (33.3)	8 (11.0)	23 (32.9)	35 (23.0)
3–4	4 (33.3)	32 (46.0)	33 (47.1)	69 (45.4)
≥5	4 (33.3)	27 (39.0)	23 (32.9)	44 (28.9)

TABLE 3 Unadjusted and Adjusted ORs of Return Visits to the ED According to Patient and Hospital Characteristics (Risk-Adjustment Model)

Patients	No. (%) of Patients	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Male	939 (57.0)	0.85 (0.78–0.94) ^a	0.83 (0.75–0.91) ^a
Age group, y			
2–7	955 (57.9)	1.31 (1.17–1.48) ^a	1.28 (1.13–1.46) ^a
8–12	371 (22.5)	1.00 (ref)	1.00 (ref)
13–17	322 (19.5)	1.10 (0.95–1.27)	1.08 (0.93–1.26)
History of asthma admission	124 (7.5)	1.54 (1.31–1.82) ^a	1.45 (1.21–1.72) ^a
Neighborhood income quintile			
Missing	56 (3.4)	0.96 (0.69–1.32)	0.94 (0.67–1.31)
1 (lowest)	345 (20.9)	0.91 (0.78–1.06)	0.89 (0.75–1.05)
2	331 (20.1)	0.95 (0.81–1.13)	0.95 (0.80–1.13)
3	330 (20.0)	1.00 (ref)	1.00 (ref)
4	332 (20.1)	1.01 (0.86–1.17)	1.01 (0.86–1.19)
5 (highest)	254 (15.4)	0.89 (0.74–1.08)	0.91 (0.74–1.11)
Canadian Triage Assessment score of initial visit			
1–2	274 (16.6)	1.15 (1.01–1.31) ^b	1.17 (1.00–1.36)
3	879 (53.3)	1.00 (ref)	1.00 (ref)
4–5	495 (30.0)	0.75 (0.68–0.83) ^a	0.68 (0.61–0.76) ^a
Hospitals			
Propensity to admit	—	1.05 (0.94–1.18)	1.08 (0.97–1.19)
Hospital type			
Teaching	230 (14.0)	1.00 (ref)	1.00 (ref)
Large community	1050 (63.7)	1.28 (1.01–1.62)	1.25 (0.97–1.61)
Small community	368 (22.3)	1.70 (1.30–2.23) ^a	1.62 (1.20–2.19) ^a
Volume of all asthma patients (per 100 patients)	—	0.97 (0.95–0.99) ^a	1.02 (0.99–1.05)

Ref indicates reference; —, not applicable.

^a $P < .001$.

^b $P < .05$.

ability of a pediatrician for consultation and the use of a standard, preprinted order sheet. Within the academic hospitals there was no significant advantage to being seen directly by a pediatrician/pediatric emergency medicine physician compared with having access to a pediatric consultant (data not shown). Subgroup analysis of children >7 years old did not show any statistically significant benefit for routine peak flow monitoring, which is typically used only for these older children.

Table 5 explores the reduction in return-visit rates according to the number of effective strategies used by hospitals and reiterates that the effect of either strategy, having access to a pediatrician for consultation or using a standard order sheet, is a similar reduction in return-visit rates but that the adoption of both strategies has an additive effect, with a 36% reduction ($P < .001$) in the 11 EDs (including academic EDs) with both strategies as compared with those with neither strategy.

DISCUSSION

In Ontario, EDs play a major role in the acute management of asthma. Data from our study, combined with previous research that showed a 12% prevalence of asthma in children in Ontario,⁴ indicate that ~1 in 10 children with asthma had an ED visit in the study period. Of these children, ~6% returned to the ED within 72 hours, the majority of which had high-acuity triage

scores and many required admission. Although it is not clear how low return-visit rates could be, the analysis shows that there is variation in these rates, after adjustment for patient factors, and that EDs that use specific strategies have substantially lower return-visit rates than those that do not. The survey showed that almost all EDs reported having taken specific steps to try to ensure the delivery of high-quality care for asthma but that no one strategy or combination of strategies seemed to be used by most institutions. This finding may reflect, in part, a lack of shared knowledge about which strategies are effective.

We found that 2 strategies, the use of a standard preprinted order sheet and the ability to access a pediatrician, were associated with a lower risk of return visits. The effect of these 2 strategies seemed to be additive. The study also showed that some strategies, although felt to be effective, did not seem widely used, and they were not associated with better outcomes. For example, although routine peak flow testing is recommended in many guidelines^{6–8} (although there were documented problems in the effective implementation of the tests, even in older children)³¹, we found that less than half of all hospitals, and fewer than 17% of academic hospitals, reported using this assessment tool and that this strategy was not associated with reduced return visits.

TABLE 4 Unadjusted and Adjusted ORs of Return Visits According to Hospital Strategy/Resources

Hospital Strategy/Resources	Unadjusted		Adjusted for Patient Factors		Adjusted for Patient and Hospital Factors	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Short-stay unit	1.07 (0.92–1.24)	.37	1.06 (0.89–1.25)	.53	1.17 (0.99–1.38)	.06
Access to a pediatrician	0.73 (0.63–0.83)	<.001	0.62 (0.53–0.72)	<.001	0.64 (0.52–0.79)	<.001
Preprinted discharge instructions	0.95 (0.81–1.11)	.52	0.93 (0.79–1.11)	.44	0.99 (0.83–1.19)	.95
Preprinted order sheets	0.68 (0.57–0.82)	<.001	0.61 (0.50–0.75)	<.001	0.68 (0.55–0.85)	<.001
Routine use of peak flow testing	0.94 (0.80–1.09)	.39	0.96 (0.81–1.14)	.64	0.93 (0.79–1.10)	.40
Trained personnel in asthma teaching	0.87 (0.73–1.04)	.13	0.85 (0.70–1.03)	.10	0.96 (0.78–1.18)	.68
Ability to dispense aerochambers	0.88 (0.72–1.08)	.22	0.87 (0.69–1.09)	.23	0.87 (0.70–1.08)	.21
Availability of asthma guidelines	0.90 (0.78–1.05)	.19	0.86 (0.73–1.02)	.09	0.96 (0.80–1.16)	.70

Return visits for asthma can reflect a number of problems in management, from inappropriate or delayed medication use³² to underestimation of either the acuity of the asthma exacerbation or the ability of the family to care for the child on discharge. The need for complex and coordinated care may explain why standard order sheets and pediatrician care were found to be associated with better outcomes, whereas individual activities such as aerochamber dispensing were not. When we reviewed the majority of these order sheets, the content and form varied. However, the dosing of bronchodilators (salbutamol and ipratropium bromide) and systemic steroids were documented on a consistent basis. All but 4 forms had criteria for assessment of severity, and 2 had space to document clinical reassessments. Only 3 forms had specific discharge criteria, but all but 4 required documentation of follow-up plans.

This study cannot identify the specific components of these order sheets that account for their effectiveness, but the timely use of evidence-based medications is likely to be an important component, given its consistent appearance in all of them. A previous study of adults with asthma found that the use of a preprinted order sheet in the ED resulted in more timely administration of both oral steroids and bronchodilators, with reduced admission rates but not return visits.²⁵ Other studies on clinical pathways in adults and children have also described improved rates of appropriate steroid use,^{12,33} with no effect on return visits, but the samples were small. It is noteworthy that having asthma management guidelines in the ED did not have the same effect as having a standard order sheet as part of active management. This finding is consistent with what is known from the literature on translating evidence into practice, namely, that guidelines are most effective when embedded in practice.¹¹

Our positive finding for access to a pediatrician for consultation is in line with evidence that more specialized personnel are more likely to be aware of, and compliant with, guideline care for asthma.³⁴ Although not every patient in a hospital with pediatricians would necessarily receive such a consult, the fact that the benefit

was similar to having front-line staff trained in pediatrics or pediatric emergency medicine implies some benefit to being seen by staff with pediatric training. Although it is not feasible for every hospital to have a pediatrician on staff, it would be worthwhile to explore what part of the care is optimized by having this resource and whether this benefit could be translated to other providers. Alternatively, there has also been a move toward access to specialists through telemedicine for other common conditions seen in EDs, such as stroke.³⁵

Although having a pediatrician accessible may be difficult to implement, it is worth noting that a preprinted order sheet (or the equivalent in computerized order entry systems) was equally effective at decreasing return visits but was the least frequently implemented strategy, being used by only 17% of all hospitals (including academic ones) that we studied. These order sheets are inexpensive and likely to be accepted in practice.³⁶ It may be appropriate for national bodies such as the Pediatric Section of the Canadian Association of Emergency Physicians or the American Academy of Pediatrics Committee on Pediatric Emergency Medicine to develop a standard form or its computer entry order system equivalent. Future studies should explore what aspects of care (appropriate medication use, discharge planning, etc) this form improves; this may inform what other types of condi-

TABLE 5 Return-Visit Rates According to Number of Effective Strategies Used

Strategies	Hospitals With the No. of Key Strategies (N = 152), n (%)	Return-Visit Rate, % ^b
Neither	95 (63)	6.9
Pediatrician for consultation only	31 (20)	5.4 ^a
Order sheet only	9 (6)	5.4 ^b
Both	17 (11)	4.4 ^a

Effective strategies included having access to pediatricians and the use of preprinted order sheets.

^a P < .001 compared with no strategies.

^b P < .05 compared with no strategies.

tions seen in EDs could be improved by the use of standard order sheets.

There are a number of limitations of our study. First, the survey data were reported by a single respondent at the hospital. Although these data had been selected previously by the institution as being the most appropriate means of response, we did not verify any of the data from the questionnaires. The administrative data on ED visits had not been independently validated, although hospitals were asked to verify data that were produced as part of the regular hospital reports.

The analysis of the association between reported strategies and observed outcomes was observational and may have been susceptible to selection bias. Although randomized trials may provide the most valid estimates of the impact of specific clinical interventions, they can be difficult to apply to studies of broad organizational interventions, and the results are difficult to generalize. Well-designed observational studies often can provide useful information on real-world effectiveness of interventions to improve the quality of care.³⁷ Our study design allowed us to study interventions as currently practiced in a range of different ED settings for a large number of children.

Although our analysis was at the level of the patient, we also do not know whether every patient received each intervention at a site with the intervention available (peak flow monitoring, a pediatric consult), and there may have been variation in the use of each strategy by different hospitals. In particular, our data set did not allow us to explore at the individual patient level which children were seen in consultation by a pediatrician in those EDs with access to one. In the analysis, we treated all patients in an ED as being exposed to the intervention if the ED reported that they used it, so this approach might underestimate effects if not all patients were actually exposed.

Similarly, the details of strategies such as using order sheets vary, and as such, we were testing a heterogeneous group of interventions under the same strategy category. However, our results reflect real-world implementation and, thus, are likely to be an accurate reflection of the effectiveness of a given strategy.

Finally, we were not able to control for other factors that might have an impact on the recidivism. Although we speculate that the effect of the preprinted order sheet was likely related, at least in part, to use of systemic steroids, we did not have access to any individual-level data about drugs that were administered during the visit or prescribed on discharge. We also do not have data on medication use, such as inhaled corticosteroids, before the initial visit or on follow-up visits after discharge. However, our previous expert panel work^{17,18} suggested that recidivism within 72 hours is directly related to ED management and not to outpatient follow-up care. We

were also limited by our data in terms of how well we could adjust for severity of asthma. Without drug-use data, we were unable to use measures of persistence such as the Health Plan Employer Data and Information Set criteria, although this definition of persistence has been shown to have limitations in reflecting both the persistence³⁸ and severity³⁹ of the disease. As others have done,^{20,40,41} we used a history of previous admission as a marker of severity or poor control, and we controlled for acuity at triage. Many of the criteria used to triage children with asthma such as respiratory rate and oxygen saturation have been shown to predict severity of the acute exacerbation.^{42,43}

CONCLUSIONS

We were able to obtain detailed data on current management strategies for asthma in children from every ED in a large jurisdiction. To the best of our knowledge, this is the first study to assess comprehensive asthma care for children across a range of ED settings and associate currently implemented strategies with improved patient and ED outcomes. We show that acute asthma in children represents a significant proportion of the caseload in Ontario EDs, and the majority of these children are not cared for in children's hospitals, where most trials of interventions are currently conducted. Almost all EDs reported having strategies for enhancing the quality of care for children with asthma. At least 2 strategies were associated with lower rates of 72-hour return visits. Access to a pediatrician is important, but more work should focus on which aspects of this care improve outcomes and translating this knowledge to improve care for children seen in all EDs. Standard preprinted order sheets are the most feasible but are not currently used in many EDs. Our findings build on other work that has demonstrated that tools used to standardize care for acute asthma exacerbations improve care processes. This study suggests that these tools can also improve outcomes.

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Astrid Guttman, Brandon Zagorski, Peter C. Austin, Michael Schull, Asma Razzaq, Teresa To and Geoff Anderson

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