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Can an evidence-based guideline reminder card improve asthma management in the emergency department?

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KEYWORDS

Asthma management guideline;
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Summary

Objective: Asthma is the most common chronic disease in children. Previous studies described significant variations in acute asthma management in children. This study was conducted to examine whether asthma management in the pediatric emergency department (ED) was improved through the use of an evidence-based acute asthma care guideline reminder card.

Methods: The Pediatric Acute Asthma Management Guideline (PAMG) was introduced to the ED of a pediatric tertiary care hospital in Ontario, Canada. Medical charts of 278 retrospective ED visits (January–December 2002) and 154 prospective visits (July 2003–June 2004) were reviewed to assess changes in acute asthma management such as medication treatment, asthma education, and discharge planning. Logistic and linear regressions were used to determine the effect of PAMG on asthma management in the ED. The propensity score method was used to adjust for confounding.

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Results: During the implementation of PAMG, patients who visited the ED were more likely to receive oral corticosteroids (Adjusted Odds Ratio [AOR] = 2.26, 95% CI: 1.63–3.14, $p < 0.0001$) and oxygen saturation reassessment before ED discharge (AOR = 2.02, 95% CI: 1.45–2.82, $p < 0.0001$). They also received 0.23 (95% CI: 0.03–0.44, $p = 0.0283$) more doses of bronchodilator in the first hour of ED stay. Improvements in asthma education and discharge planning were noted, but the changes were not statistically significant.

Conclusions: After the implementation of an evidence-based guideline reminder card, medication treatment for acute asthma in the ED was significantly improved; however, asthma education and discharge planning remained unchanged. Future efforts on promoting guideline-based practice in the ED should focus on these components.

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Introduction

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 Using the health administrative databases in Ontario, To et al. reported a prevalence of 19.6% in children under 10 years of age.² A recent population-based study in Ontario showed that one in ten children with asthma had an ED visit for asthma over a two-year period, and that 5.6% of those discharged from the ED had a return visit within 72 h.³ Although asthma-related deaths have decreased substantially in recent years, emergency department (ED) visits and hospital admissions for asthma remain significant,^{1,3–5} representing a heavy burden of illness in young children and an increasing economic pressure for the health care system.

Several Canadian and US studies have described significant regional variations in hospitalization rates for childhood asthma since the 1990s,^{4,6–13} which are largely influenced by variations in patient characteristics and/or asthma management in emergency departments (EDs).^{12,14} While many guidelines exist for the management of acute asthma in children,^{15–21} substantial practice variations still persist.^{22,23} These findings call for a systematic approach to acute asthma management in order to reduce practice variations and uncertainties in treatment and improve patient outcomes.

The Pediatric Acute Asthma Management Guideline (PAMG) reminder card is an evidence-based management tool based on the Canadian Asthma Consensus Guidelines.^{15–17} The objective of this study was to examine whether asthma management in the ED of a pediatric tertiary care hospital was improved through the use of PAMG.

Methods

Setting

This study was conducted at the Emergency Department (ED) at The Hospital for Sick Children in Toronto, Canada. The Hospital for Sick Children is the primary care pediatric hospital for the downtown core of Toronto and the tertiary pediatric referral centre for the Greater Toronto Area. Its ED provides care to approximately 50,000 children each year, with almost 6000 of those children admitted from the ED to inpatient care. The ED is also a training site for a large number

of medical trainees (over 250 each year); from medical students to fifth year emergency medicine residents.

Evidence-based acute asthma care Guideline reminder card

The Pediatric Acute Asthma Management Guideline (PAMG) was developed by the investigator team consisting of pediatric respirologist, pediatric emergency physicians and nurse practitioners based on Canadian Asthma Consensus Guidelines.^{15–17} It was disseminated in the form of a pocket-size reminder card (Fig. 1), each of which cost approximately 70 cents (CAD) to produce. It includes five sections: initial assessment, medications and tests, reassessment and monitoring, disposition, and education and discharge planning.

PAMG was introduced to all health care providers (including physicians, nurses, residents and respiratory therapists) at the ED of The Hospital for Sick Children in Toronto, Canada after January 2003 through multiple presentations at their rounds and business meetings. Methods of disseminating PAMG included: 1) providing an ample supply of the reminder card for use at the ED; and 2) distributing individual packages (with a short description of the study and the reminder card) to the ED staff in their mailboxes.

Study design and procedure

Medical charts of ED visits for acute asthma before and during the implementation of PAMG were reviewed by one trained chart abstractor using the same chart abstraction form with clear variable definitions and abstraction guidelines. The chart abstractor was a coordinator of the study and was aware of the study hypothesis and the subject status. 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.^{24,25} The final diagnosis of asthma was determined by the attending physician at the ED.

In both retrospective and prospective groups, children were excluded if they had an uncertain diagnosis of asthma (e.g. children with a first time wheeze and without a strong family history of asthma), a primary diagnosis of pneumonia, significant co-morbid conditions (e.g. foreign body airway obstruction, congenital heart disease, bronchopulmonary dysplasia, significant neurologic impairment), or severe respiratory distress with altered mental status or respiratory acidosis. In order to assess asthma education

PEDIATRIC ACUTE ASTHMA MANAGEMENT GUIDELINE
THE HOSPITAL FOR SICK CHILDREN

TORONTO EAST GENERAL HOSPITAL
WILLIAM OSLER HEALTH CENTRE
INITIAL ASSESSMENT

HISTORY: triggers (URI, smoke, weather, pets), duration of episodes, current & prior drug treatments (dosage, delivery, frequency), allergies, previous hospitalizations or ED visits for asthma, family history
PHYSICAL EXAM: nasal flaring, accessory muscles, auscultation, respiratory & pulse rates, hydration status, cyanosis, pulsus paradoxus
INITIAL SaO₂ in room air & **PEF** or **FEV₁** > 5 years of age

MEDICATIONS

OXYGEN: if SaO₂ < 92% give humidified O₂ to maintain SaO₂ > 95% via simple mask / hood / prongs etc.

BRONCHODILATORS:

SALBUTAMOL (VENTOLIN) inhalation solution (5 mg/ml)

0.03 ml (0.15 mg)/kg/dose, [min=0.2 ml (1 mg), max=1 ml (5 mg)]

- Nebulized with 3 ml normal saline: mild to moderate disease: 1-3 doses
severe disease: continuously as improves: Q1-2H

- MDI (100 mcg/puff) with spacer: 1 puff/5kg/dose [min=2 puffs, max=8 puffs]

IPRATROPIUM BROMIDE (ATROVENT) inhalation solution (250 mcg/1ml)

Consider in severe disease (1 ml/dose)

- Nebulized with salbutamol & normal saline: up to 3 doses, then Q2-4H if responding

- MDI (20 mcg/puff) with spacer: 3-6 puffs

STEROIDS:

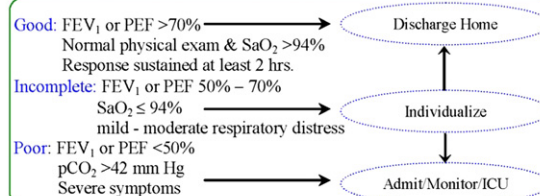
PREDNISONE/ PREDNISOLONE: initially 2 mg/kg/day, then 1 mg/kg/day for 3-5 days [max. 60 mg PO/day]

DEXAMETHASONE: initially 0.3 mg/kg/day, then 0.15 mg/kg/day for 2-4 days [max. 20 mg PO/day]

HYDROCORTISONE: 4-6 mg/kg/dose; Q4-6H IV

REASSESSMENT & MONITORING

- Intermittent or continuous SaO₂ depending on clinical status
- Pulse & respiratory rates
- Respiratory assessment pre and post bronchodilator treatment
- Consider: CXR; blood gas; serum potassium level (especially when >9 total salbutamol doses given)
- If vomiting or unable to tolerate PO meds. consider:
IV hydration → maintenance
IV KCL (if received >9 salbutamol doses and if not contraindicated)
IV hydrocortisone 5mg/kg/dose; Q4-6H

DISPOSITION

EDUCATION & DISCHARGE PLANNING

- Initial assessment & documentation of educational needs
- Asthma information package
- Review home medication regime & triggers
- Address questions/concerns of child & family
- Advise family to make a follow up appointment in 24-48 hrs., or return if deteriorating: indrawing, use of accessory muscles, poor colour, vomiting, speaks in incomplete sentences, ↓ conscious level
- Arrange inhalation equipment (education for use)
- Arrange for patient to obtain discharge meds. if not on drug benefit plan
- Arrange for referral to a specialist if needed

This is a general guideline for use by physicians and staff in the ED. It is part of a project entitled: Pediatric Acute Asthma Management Guideline (PAMG) Project: Development, Implementation, and Outcome, conducted by a team of researchers led by Dr. Teresa To. Copyright © October 2003, Child Health Evaluative Sciences, The Hospital for Sick Children. This guideline may not be reproduced in any form or by any means.

(Front)
(Back)

Figure 1 The Pediatric Acute Asthma Management Guideline Reminder Card.

and discharge planning in the ED, children admitted to the inpatient ward (60 from the prospective group and 29 from the retrospective group) were excluded from the analysis for this paper. In order to minimize the impact of the outbreak of Severe Acute Respiratory Syndrome (SARS) on the study results, children who visited the ED between January and June 2003 were also excluded.

The prospective group consisted of children aged 2–17 years (inclusive) who visited the ED between July 2003 and June 2004. Two research assistants who worked in the ED on rotating schedules approached eligible parents (if child aged 15 years or younger) or children (if child aged 16 years or older) visiting the ED for respiratory problems for the consent process. Once consent was obtained, the research assistants interviewed the parents/children using a standardized survey to collect information on socio-demographic characteristics, asthma control and asthma self-management. Details of the study procedure have been published elsewhere.²⁵ Although a prospective survey was conducted in the prospective group, only chart abstraction data were used for this analysis.

The retrospective group consisted of children who visited the ED for acute asthma at the same institution one year prior to the implementation of PAMG (between January and December 2002). Demographic information of all ED visits for acute asthma (ICD-9 code: 493; ICD-10 codes: J45 and J46) during this period was provided by Health Records. Age- and sex- stratified random sampling of these ED visits were performed to select patients with similar age and sex distribution compared to the prospective group with a ratio of approximately 2:1 (retrospective

vs. prospective). Since one patient could have multiple ED visits, for the purpose of this study only the first ED visit within the retrospective sampling period were used.

A total of 278 retrospective and 154 prospective ED visits were included in the final analysis. A total of 17 charts were abstracted twice by the trained chart abstractor. The intra-rater reliability was 97.5% on all as well as key outcome variables. The study was approved by the Research Ethics Board at The Hospital for Sick Children.

Data collection

Patient data were abstracted from the medical charts. They included age, gender, history of ED visit or hospitalization for asthma, date and time of current ED visit, characteristics of current acute asthma episode (e.g., symptoms, signs, and oxygen saturation [SaO₂] recorded by pulse oximetry at presentation), management of acute asthma in the ED (e.g., oxygen therapy, medications, and laboratory tests), and length of ED stay.

Outcome measures

The primary outcomes of interest for this study were administration of systemic corticosteroids and bronchodilators during ED stay, asthma education (e.g., dissemination of asthma information package, education on use of inhalation equipment, and review of asthma triggers) in the ED, and discharge planning (e.g., instructions on follow-up appointment and prescriptions of oral and inhaled corticosteroids).

Other outcomes, including treatment processes (e.g., time from entry to the ED to bronchodilator treatment) and reassessment of asthma status (i.e., symptoms, signs, and SaO₂) before discharge, were also compared between the retrospective and prospective groups.

Statistical analysis

Patients' age, gender, history of ED visit or hospitalization for asthma, characteristics of the acute asthma episode, and acute asthma management in the ED were compared between the retrospective and prospective groups, using the chi-square test for nominal data and the Student's *t*-test for continuous variables. To examine the stability in clinical practice pattern before the implementation of PAMG, acute asthma management in the ED was analyzed quarterly in the retrospective period (i.e., January–December 2002).

Since univariate analyses showed significant differences in patient characteristics between the retrospective and prospective groups, which can lead to biased estimates of intervention effects, we used the propensity score method to account for potential confounding effects.²⁶ The propensity score, defined as the conditional probability of being treated given the covariates, can be used to balance the covariates in the two groups, and therefore reduce this bias.²⁶ In order to estimate the propensity score, multivariable logistic regressions were used to calculate the conditional probability of a patient being selected for each treatment, given the pre-treatment characteristics including age, gender, history of ED visit/hospitalization for asthma, presence of symptoms and signs, SaO₂ at initial presentation, length of stay, season of ED visit, day of ED

visit, and hour of ED visit. Multivariable logistic and linear regressions were then used to determine the impact of PAMG on acute asthma management in the ED while adjusting for the propensity scores. Statistical Analysis Systems (SAS) software 9.1²⁷ was used to conduct all analyses.

Results

Characteristics of study population

Table 1 showed that the prospective and retrospective groups were not statistically different in demographic characteristics and SaO₂ at presentation (95.5% ± 2.7% versus 95.9% ± 3.4%, *p* = 0.2463). Compared to the retrospective group, patients in the prospective group were more likely to visit the ED on weekdays (90.9% versus 71.2%, *p* < 0.0001) and during day time (68.2% versus 56.8%, *p* = 0.0235), to present with wheeze (91.5% versus 75.4%, *p* < 0.0001) and accessory muscles use (71.9% versus 51.4%, *p* < 0.0001) on physical examination, and to have increased length of ED stay (8.6 ± 7.7 versus 6.6 ± 6.6 h, *p* = 0.0163).

Acute asthma management in ED before and after implementation of PAMG

Table 2 showed that the proportions of patients who received various treatments in the ED were significantly higher in the prospective group. For example, they were more likely to receive supplemental oxygen (9.7% versus 3.2%, *p* = 0.0074), salbutamol (96.8% versus 83.1%, *p* < 0.0001), ipratropium bromide (77.3% versus 66.2%, *p* = 0.0161), and oral

Table 1 Characteristics of study population.

Characteristics	Retrospective N=278		Prospective N=154		p-value
	n	%	n	%	
Age <7 years	186	66.9	107	69.5	0.5930
Male	174	62.6	91	59.1	0.5361
History of ER visit/hospitalization for asthma	74	26.6	49	31.8	0.2668
Visited ED in spring/fall	144	51.8	80	51.9	1.0000
Visited ED on weekdays	198	71.2	140	90.9	< 0.0001
Visited ED during day time (8am-7pm)	158	56.8	105	68.2	0.0235
Length of stay in ED (hours, Mean ± SD)	6.6 ± 6.6		8.6 ± 7.7		0.0163
SaO ₂ at presentation (%)					
Mean ± SD	95.9 ± 3.4		95.5 ± 2.7		0.2463
>95	157	60.4	83	55.0	0.1561
92–95	87	33.5	53	35.1	
<92	16	6.2	15	9.9	
Asthma symptoms at presentation					
Shortness of breath	166	60.4	102	66.7	0.2120
Wheeze	98	35.6	71	46.4	0.0307
Cough	241	87.6	135	88.2	1.0000
Chest Tightness	14	5.1	8	5.2	1.0000
Physical signs at presentation					
Observed difficulty in breathing	35	12.7	30	19.6	0.0673
Use of accessory muscles	142	51.4	110	71.9	<0.0001
Wheeze	208	75.4	140	91.5	<0.0001

Note: All percentages have been adjusted for missing data.

Table 2 Acute asthma management in ED before and after implementation of PAMG.

Asthma Management in ED	Retrospective N=278		Prospective N=154		p-value
	n	%	n	%	
Documentation in Medical Chart					
History of ED visit/hospitalization for asthma	168	60.4	116	75.3	0.0021
SaO ₂ at presentation	260	93.9	151	98.1	0.0559
SaO ₂ reassessment before discharge	141	50.7	110	71.4	< 0.0001
Treatments and Tests in ED					
Oxygen	9	3.2	15	9.7	0.0074
Salbutamol					
Number of doses (Mean ± SD)					
In first hour	2.0 ± 0.9		2.3 ± 0.9		0.0004
In first 4 h	3.1 ± 1.5		3.6 ± 1.4		0.0031
Over ED stay	3.7 ± 2.3		4.6 ± 2.5		0.0005
Any	231	83.1	149	96.8	< 0.0001
Ipratropium bromide					
Number of doses (Mean ± SD)					
In first hour	2.0 ± 1.0		2.3 ± 0.9		0.0035
In first 4 h	2.6 ± 1.0		2.7 ± 0.9		0.3698
Over ED stay	2.7 ± 1.1		2.8 ± 1.1		0.2790
Any	184	66.2	119	77.3	0.0161
Salbutamol combined with ipratropium bromide in patient with initial SaO ₂ ≤ 95%	90	87.4	59	86.8	1.0000
Oral corticosteroids	167	60.1	129	83.8	< 0.0001
Chest x-ray	68	24.5	46	29.9	0.2545
Time between Processes (Minutes, Mean ± SD)					
Entry of ED to bronchodilator treatment	62.9 ± 66.5		78.8 ± 76.0		0.0334
Entry of ED to corticosteroid treatment	142.7 ± 88.6		125.0 ± 87.1		0.0901
Bronchodilator treatment to physical exam reassessment	52.0 ± 40.8		57.1 ± 47.9		0.3162
Bronchodilator to SaO ₂ reassessment	90.7 ± 95.4		94.6 ± 75.1		0.7258
Asthma Education during ED Stay					
Assessed educational needs	18	6.5	3	1.9	0.0370
Addressed questions/concerns of child and family	56	20.1	32	20.8	0.9011
Disseminated asthma information package	53	19.1	28	18.2	0.8978
Educated on use of inhalation equipment	81	29.1	47	30.5	0.8260
Reviewed asthma triggers	11	4.0	6	3.9	1.0000
At least one of above	88	31.9	53	34.4	0.5940
Discharge Conditions					
Good ^a	142	93.4	86	96.6	0.3825
SaO ₂ > 95% at last assessment	99	70.2	74	67.3	0.6806
Discharge planning					
Received instructions on follow-up appointment	196	70.5	121	78.6	0.0705
Received arrangement for referral to specialist	4	1.4	4	2.6	0.4636
Prescribed oral corticosteroids	158	56.8	107	69.5	0.0101
Prescribed inhaled corticosteroids	187	67.3	106	68.8	0.7485

Note: All percentages have been adjusted for missing.

^a As indicated by ED physicians on the medical chart based on overall patient assessment at discharge.

corticosteroids (83.8% versus 60.1%, $p < 0.0001$). They also received more doses of salbutamol during their ED stay (4.6 ± 2.5 versus 3.7 ± 2.3 , $p = 0.0005$). Significant improvements also occurred in the prospective group in the documentation of previous ED visit/hospitalization for asthma (75.3% versus 60.4%, $p = 0.0021$) and reassessment of oxygen saturation before discharge (71.4% versus 50.7%, $p < 0.0001$).

At discharge, oral corticosteroids were more commonly prescribed in the prospective group (69.5% versus 56.8%,

$p = 0.0101$) compared to the retrospective group. However, there was no statistical difference between the two groups in the percentage of patients who received inhaled corticosteroids prescription (68.8% versus 67.3%, $p = 0.7485$), asthma education (34.4% versus 31.9%, $p = 0.5940$), and instruction on follow-up visit (78.6% versus 70.5%, $p = 0.0705$).

Compared to the retrospective group, it took longer for patients in the prospective group to receive bronchodilator treatment (78.8 ± 76.0 versus 62.9 ± 66.5 min, $p = 0.0334$)

after entry to the ED. There was no statistical differences between the timing of receiving oral corticosteroids between the two groups (125.0 ± 87.1 versus 142.7 ± 88.6 min, $p = 0.0901$).

Analyses of acute asthma management on a quarterly basis in the retrospective period showed no obvious changes in clinical practice pattern over time before the implementation of PAMG (data not shown).

Effect of PAMG on acute asthma management in ED

Table 3 showed results of multiple regression models adjusted for the propensity score of a patient being given each treatment. Compared to the retrospective group, patients in the prospective group received an average of 0.23 (95% CI: 0.03–0.44, $p = 0.0283$) more doses of salbutamol in the first hour during the ED stay. Their odds of receiving oral corticosteroids (Adjusted Odds Ratio [AOR] = 2.26, 95% CI: 1.63–3.14, $p < 0.0001$) and SaO₂ reassessment before ED discharge (AOR = 2.02, 95% CI: 1.45–2.82, $p < 0.0001$) were also twice as high compared to the retrospective group. Regression analyses showed that the implementation of PAMG did not affect asthma education, follow-up instructions, or oral corticosteroids prescription at ED discharge (data not shown).

Discussion

Our study showed that disseminating a pocket-size acute asthma care guideline reminder card in the ED of a pediatric tertiary care center can promote guideline-based acute asthma management in children, including more aggressive medication treatment and better documentation of clinical assessments.

One significant gap in acute asthma management in children that has been identified is under-prescription of systemic corticosteroids.^{13,22,28} Guidelines recommend administration of systemic corticosteroids as early as possible during ED encounters for acute asthma to speed the resolution of airflow obstruction and prevent early relapse.^{15,20} Compared to other hospitals in Ontario,²² the use of systematic corticosteroids at our institution was already high in the retrospective group (i.e., pre-intervention period). This is understandable since our hospital is a tertiary care teaching hospital, where more

complicated asthma patients may be referred from community health care providers. Nevertheless, there was still substantial room for improvement compared to guideline recommendations. While the characteristics of asthma exacerbations and ED visits at our institution may be different from other community hospitals and may have changed slightly over time (between the retrospective and prospective groups), results of our adjusted analyses showed that systemic corticosteroids were still administered more often during the ED stay in the prospective group (i.e., after the implementation of PAMG).

In addition to short-term preventive care, significant improvements were also observed in symptomatic care for acute asthma in the prospective group, including more frequent use of bronchodilators in the first hour after entry to the ED. However, the wait time from entry to the ED to bronchodilator treatment was over 60 min in both groups. This delay may be attributable to ED crowding and shortage of ED staff. Therefore, appropriate resource allocation and efforts to improve the functioning of the health care team, such as standing orders that allow nurses to administer the medication without waiting for physicians' instructions, may improve the timing to the first medication treatment at EDs.

While EDs play a major role in managing acute asthma exacerbations, they may also have an important role in bridging the acute and long-term care systems to improve the continuity of care for asthma patients.²⁹ Current guidelines suggest that proper asthma education and discharge planning should be given to patients before ED discharge to reduce short-term readmission rates and improve long-term asthma management.^{15,18,20} Components of asthma education and discharge planning may include review of medications (including inhaler technique) and environmental control measures, review/initiation of an action plan and inhaled corticosteroids, and recommendation on scheduled medical follow-up. However, many barriers, such as the allocation of adequate staff time for patient education, adjustment of content to meet individual patients' needs, and the assessment of learners' comprehension,³⁰ often exist and make it difficult to implement or document asthma education activities. Similar to other studies,^{22,31} our results showed that the majority of patients did not receive asthma education before discharge, and that one in four patients left the ED without instructions on follow-up visit with their primary care provider or prescriptions of oral and inhaled

Table 3 Effect of PAMG (prospective vs. retrospective) on acute asthma management in ED ($N = 309$).

Asthma Management in ED	Unadjusted			Adjusted ^a		
	OR ^b	95% CI	<i>p</i> -value	OR	95% CI	<i>p</i> -value
Logistic Regression						
Systematic corticosteroids given in ED	3.11	1.82–5.30	<0.0001	2.26	1.63–3.14	< 0.0001
SaO ₂ reassessed before discharge	2.14	1.34–3.42	0.0016	2.02	1.45–2.82	< 0.0001
Linear Regression	β^c	95% CI	<i>p</i> -value	β	95% CI	<i>p</i> -value
Number of salbutamol doses given in first hour	0.22	0.07–0.37	0.0410	0.23	0.03–0.44	0.0283

CI: confidence intervals.

^a All models were adjusted for the propensity score (or conditional probability) of a patient being selected for each treatment, given the pre-treatment characteristics including age, gender, history of ED visit/hospitalization for asthma, presence of wheeze, use of accessory muscles, SaO₂ at initial presentation, length of stay, season of ED visit, day of ED visit, and hour of ED visit.

^b OR: Odds ratio (prospective versus retrospective group) was estimated using logistic regression.

^c Regression coefficient β (prospective versus retrospective group) was estimated using linear regression. β equals the average increase in the number of salbutamol doses in the prospective group.

corticosteroids. Using a pre- and post- design, Mackey and colleagues examined the effect of an asthma care map on patient management in the ED and also found inconsistent and infrequent use of the discharge planning section by physicians.²⁸ These findings call for further improvements in providers' efforts on asthma education and discharge planning in the ED.

Several limitations of this study should be noted. First, without a randomized controlled trial, it would be difficult to assess the possible influence of clinical advances or other system changes on the effects we observed. In the current study, it also was possible that physicians in the prospective study period were aware that they were being evaluated and therefore documented clinical processes more vigorously. Second, all medical charts were reviewed by one chart abstractor who was not blinded to the study hypothesis and the subject status. This is the most common limitation in medical record review studies in emergency medicine³² and could have introduced bias to the study results. To minimize this bias, standard chart abstraction form with clear variable definitions and abstraction guideline was used in the current study. Third, our study cohort was a non-random sample of patients who attended the ED of a tertiary children's hospital. So our findings may not be generalizable to patients managed in EDs in community setting. Finally, providers may not document all clinical activities in the medical charts, and therefore discrepancies between medical chart review and clinical care provided to patients may exist and could have influenced the validity of chart abstraction data, especially on asthma educational activities.³³ However, it has been shown that compared to directly observed care, medical chart review was more accurate on certain key aspects of assessment (e.g., oxygen saturation) and treatment (e.g., oral corticosteroids prescribed at discharge) in the ED.³³

Conclusion

This study provides evidence that treatment of acute asthma exacerbations in children in the ED was improved after the implementation of an evidence-based management tool (i.e., a guideline reminder card). Regular updates of the management tool based on the latest guidelines and financial support for its on-going production are key to the sustainability of this strategy. Despite the use of an evidence-based guideline protocol, asthma education and discharge planning at our ED remained unchanged. Strengthening asthma education and discharge planning as suggested by others^{34–36} may improve the low follow-up rates with primary care physicians after ED discharge.^{22,25} Future efforts should focus on promoting and improving evidence-based practice of these components of asthma management in acute care settings.

Conflict of interest statement

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