

Early Administration of Systemic Corticosteroids Reduces Hospital Admission Rates for Children With Moderate and Severe Asthma Exacerbation

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Study objective: The variable effectiveness of clinical asthma pathways to reduce hospital admissions may be explained in part by the timing of systemic corticosteroid administration. We examine the effect of early (within 60 minutes [SD 15 minutes] of triage) versus delayed (>75 minutes) administration of systemic corticosteroids on health outcomes.

Methods: We conducted a prospective observational cohort of children aged 2 to 17 years presenting to the emergency department with moderate or severe asthma, defined as a Pediatric Respiratory Assessment Measure (PRAM) score of 5 to 12. The outcomes were hospital admission, relapse, and length of active treatment; they were analyzed with multivariate logistic and linear regressions adjusted for covariates and potential confounders.

Results: Among the 406 eligible children, 88% had moderate asthma; 22%, severe asthma. The median age was 4 years (interquartile range 3 to 8 years); 64% were male patients. Fifty percent of patients received systemic corticosteroids early; in 33%, it was delayed; 17% of children failed to receive any. Overall, 36% of patients were admitted to the hospital. Compared with delayed administration, early administration reduced the odds of admission by 0.4 (95% confidence interval 0.2 to 0.7) and the length of active treatment by 0.7 hours (95% confidence interval -1.3 to -0.8 hours), with no significant effect on relapse. Delayed administration was positively associated with triage priority and negatively with PRAM score.

Conclusion: In this study of children with moderate or severe asthma, administration of systemic corticosteroids within 75 minutes of triage decreased hospital admission rate and length of active treatment, suggesting that early administration of systemic corticosteroids may allow for optimal effectiveness. [Ann Emerg Med. 2012;xx:xxx.]

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INTRODUCTION

In children and adults with moderate or severe asthma exacerbations, the administration of systemic corticosteroids in the emergency department (ED) is associated with a 25% reduction in hospital admission rates.¹ Clinical asthma pathways, which outline the sequence of evaluation and interventions for patients, have generally advocated the administration of systemic corticosteroids for children presenting with acute moderate or severe asthma. Yet the effectiveness of clinical pathways to reduce hospital admissions for asthma is variable.²⁻⁴

The discrepancy between the efficacy of systemic corticosteroids documented in randomized controlled trials¹ and the variable effectiveness observed in actual settings²⁻⁴ could be explained in part by the timing of systemic corticosteroid administration. Indeed, there exists an inverse relationship between the risk of admission and the time elapsed between the intake of systemic corticosteroids and the decision to admit or discharge (disposition), supporting a clinical onset of action within 3 to 4 hours of corticosteroid intake.¹ Consequently, in the ED in which the disposition decision is made within 4 to 5 hours of triage, early and aggressive treatment in the first hour

Editor's Capsule Summary*What is already known on this topic*

Although corticosteroids are standard therapy for asthma in the emergency department, their optimal timing of administration is not clear.

What question this study addressed

Does early corticosteroid administration decrease hospital admissions?

What this study adds to our knowledge

In this observational study of 406 children with moderate to severe asthma, those who received steroids within 75 minutes after triage were significantly less likely to be admitted than those who received them later.

How this is relevant to clinical practice

This study found that early corticosteroid administration for children with moderate to severe asthma was associated with reduced hospital admissions.

of triage is probably crucial to prevent hospital admission. However, most clinical pathways have not stressed the importance of timing of systemic corticosteroid intake.⁵⁻⁷ In the few pathways that insisted on corticosteroid administration within 60 minutes, adherence to this recommendation is approximately only 40% of targeted children.^{8,9} Because patients with moderate to severe asthma account for the majority of potentially preventable hospital admissions,^{10,11} the effect of, and factors associated with, delayed administration of systemic corticosteroids must be specifically explored in these 2 severity groups.

The primary objective of this study was to explore in children with moderate and severe asthma the effect of adherence to the recommendation of early administration of systemic corticosteroids on patient health outcomes in the actual setting of a busy pediatric ED. Moreover, we wished to identify patient-, physician- and setting-related factors associated with delayed or nonadministration of systemic corticosteroids.

MATERIALS AND METHODS**Study Design**

We conducted a prospective observational cohort study of children presenting to the ED with an asthma exacerbation between September and December 2006. The study was approved by the scientific review committee and the institutional review board of the Montreal Children's Hospital of the McGill University Health Centre, a tertiary care academic pediatric hospital. Because of the quality control

nature of the study using chart audit, no patient or physician consent was deemed required.

Selection of Participants

Patients were eligible if they were aged 2 to 17 years, had received a diagnosis of an acute exacerbation treated with 1 or more albuterol nebulizations in the ED, and had moderate or severe obstruction as documented by a baseline Pediatric Respiratory Assessment Measure (PRAM)¹² score of 5 to 12. Children were excluded if they presented with a chronic illness (eg, cystic fibrosis, bronchopulmonary dysplasia, cardiac or renal diseases), an acute illness for which the administration of systemic corticosteroid was indicated (eg, croup) or contraindicated (eg, varicella), and ongoing oral corticosteroids use on presentation. In case of multiple visits, only the first acute care visit was included to avoid nonindependence of subjects.

The acute asthma severity-specific pathway in use since 2003 at the Montreal Children's Hospital was derived from evidence-based guidelines.¹³⁻¹⁵ The pathway was embedded in the ED order sheet, serving both as a written and unavoidable reminder of guidelines.⁹ Baseline severity was measured at triage with the 12-point PRAM and was repeated throughout the ED stay.^{12,16} Briefly, this clinical score validated in children comprised 5 elements, namely, scalene muscle contraction, suprasternal muscle contraction, air entry, wheezing, and oxygen saturation.¹⁶ At the study, PRAM scores of 5 to 8 and 9 to 12 were deemed indicative of moderate and severe exacerbations, respectively, whereas scores of 0 to 4 signaled mild asthma. A change in PRAM of 3 points or greater between 2 assessments corresponded to a 25% change in respiratory resistance, indicative of a clinically meaningful improvement.¹⁶ For the initial 75 minutes (60 minutes with 15 minutes' leeway),⁹ the care outlined by the clinical care pathway for moderate asthma included 1 or more nebulizations of albuterol (0.03 mL/kg of 5% albuterol solution; GlaxoWellcome, Mississauga, Canada) and a dose of prednisone or prednisolone (1 mg/kg; maximum 50 mg); and for severe asthma, 3 nebulizations of 0.03 mL/kg of albuterol and 1 mL of 250 µg ipratropium bromide (Boehringer Ingelheim, Burlington, Canada) and a dose of systemic corticosteroids (predominantly 1 mg/kg of prednisone or prednisolone, although 4 to 8 mg/kg of intravenous hydrocortisone was occasionally administered).

The exposure of interest was the administration of systemic corticosteroids. Three groups were a priori defined, namely, patients who received early administration of systemic corticosteroid within 75 minutes of triage (60 minutes as specified in the pathway, with a 15-minute leeway to account for anticipated delays in a busy ED), those with delayed administration (beyond 75 minutes of triage), and those who received no systemic corticosteroids during the ED stay.

The main outcome was admission, defined as a hospital admission or an elapsed time of greater than 6 hours between triage and the decision to admit or discharge. The 6-hour delay was determined a priori, recognizing that in our center, a

decision to admit or discharge is recommended to be taken within 5 hours of treatment. Secondary outcomes included length of active treatment, that is, the time between first and last nebulization of albuterol in the ED to avoid noise related to nonmedical reasons for prolonged stay in ED (such as waiting for pickup), and relapse, defined as a return visit to the Montreal Children's Hospital ED for acute asthma within 72 hours of discharge. The secondary outcomes were chosen because they contributed to ED crowding (length of active treatment) or may reflect an inadequate decision to discharge (relapse).

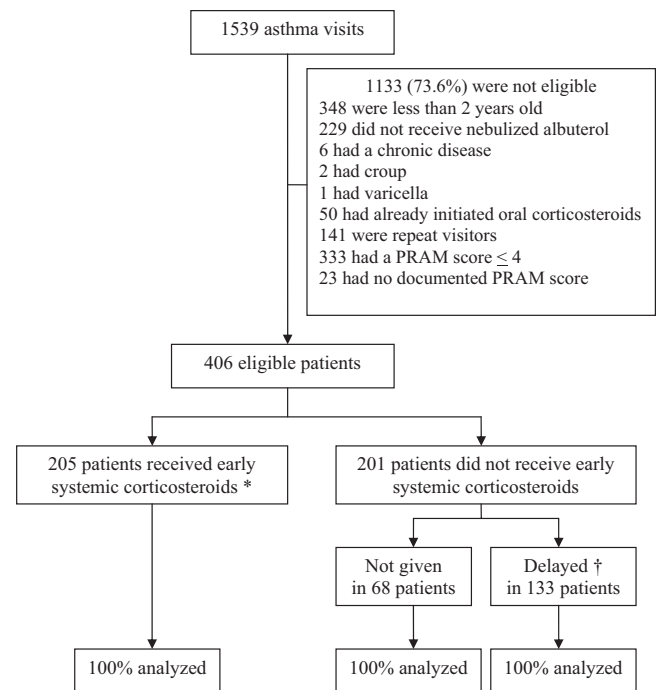
Data Collection and Processing

The charts of all patients presenting to the ED were reviewed within 24 hours of registration to ascertain eligibility, extract data, and document disposition and length of active stay by a research assistant. Patients discharged home were monitored for 72 hours to ascertain relapse at our institution, using the computerized ED database. Health care professionals were unaware of the ongoing study. The computerized ED database that logged all registered patients was reviewed daily to ensure that no patient was missed. Duplicate data extractions were conducted for all eligible charts before electronic data scanning, using Teleform software (version 7; Cardiff Software, Inc., Vista, CA).

Potential factors of corticosteroid administration were obtained from one of 3 data sources. First, child's age, sex, triage category,¹⁷ PRAM severity score,¹² diagnosis, medication and disposition, and the time of each step in the process of care (ie, triage, baseline PRAM, physician examination, and systemic corticosteroid prescribed, administered, and retained) were obtained from the medical charts. As per regulations, nurses were required to clearly record the dose and time of administration of each medication in the medical records. Nurses were also required to record whether oral systemic corticosteroids needed to be readministered because of vomiting of the preparation. In the case of multiple administrations of oral corticosteroids because of vomiting, time of final retention of the steroid preparation was taken as time of administration. Second, the attending physician documented in the medical chart and ED log was then linked to a database containing key physician characteristics. If more than 1 physician attended to a child, the one responsible for the child in the initial hour was documented. Finally, shift periods and congestion at presentation were obtained from the computerized log of all ED visits. ED congestion was operationally defined for this study as the ratio of the number of patients registered in the ED in the hour before the child's presentation over the number of available ED beds; it was calculated for each visit.

Primary Data Analysis

According to a previous study, we expected 400 eligible patients during the 12-week study period, of whom 40% would receive early administration of systemic corticosteroids.¹⁸ With 406 patients with moderate or severe asthma, our study was



* Administered within 60 ($\pm$ 15) minutes of triage

† Administered beyond 75 minutes of triage

Figure 1. Patient flow chart.

powered at 80% to detect an absolute group difference in hospital admission of 15% between the early and delayed administration groups, at a 2-tailed α of .05.

Multivariate logistic regression by generalized estimating equations was used to examine the odds of admission and relapse and to identify factors associated with the absence and delayed administration of systemic corticosteroids. A multiple linear regression served to compare the length of active treatment. Analyses of the main outcome examined the effect of timing of systemic corticosteroids in 30-minute increments. Two post hoc analyses were conducted: one analyzed hospital admission as admission to the hospital without the 6-hour time constraint between triage and disposition, and the other compared the effect of preschool versus school age on the odds of admission. Candidate variables for all multivariate models included age, sex, and baseline PRAM, baseline variables that were unbalanced between the groups, and confounders that changed the effect estimate by 10% or more. Statistical tests were carried out as 2-tailed tests, at $\alpha = .05$. Data were analyzed with SAS (version 9.1; SAS Institute, Inc., Cary, NC).

RESULTS

Of 1,539 visits for asthma, 1,133 (74%) were not eligible, primarily because of age younger than 2 years (31%), no administration of nebulized albuterol (20%), repeated visits (12%), and PRAM score of less than 5 (29%) (Figure 1).

Twenty-three patients (2%) were excluded because no PRAM score was documented at triage; they experienced a mean admission rate of 4%.

The median age of the 406 eligible patients was 4 (interquartile range [IQR] 3 to 8) years. Most patients presented with a median baseline PRAM score of 6 (IQR 5 to 7), indicating moderate severity. Fifty-nine physicians with full-time, part-time, and occasional shift coverage attended to 57%, 12%, and 31% of these 406 children, respectively (Table E1, available online at <http://www.annemergmed.com>). At patient presentation, the ED was operating at a median capacity of 91% (IQR 64% to 127%). Two hundred five (50%) patients received systemic corticosteroids early; 201 did not. The 2 groups differ on several patient- and physician-related factors, with no significant group difference in setting-related variables (Table 1). There were no group differences in asthma medications taken before arrival. Patients who failed to receive early systemic corticosteroids included 133 (33%) who received them beyond 75 minutes of triage and 68 (17%) who failed to receive any during the course of the ED stay (Table E2, available online at <http://www.annemergmed.com>). The average delay between the administration of systemic corticosteroid and the decision to admit or discharge was 3.3 hours (SD 1.1 hours) for timely treated patients and only 2 hours (SD 2.4 hours) for those with delayed treatment.

Overall, 145 (35.7%) patients were admitted to the hospital (or had a length of stay in the ED greater than 6 hours) and 25 (6%) relapsed; the average length of active ED treatment was 3.6 hours (SD 2.5 hours). Early administration of systemic corticosteroids was associated with significantly decreased rates of admission (Figure 2). This association remained significant even when the 6-hour time constraint between triage and disposition was not taken into account (odds ratio [OR] 0.07; 95% confidence interval [CI] 0.1 to 0.53). In fact, for every 30-minute delay in administering systemic corticosteroid from triage, the odds of hospital admission increased by 1.23 (95% CI 1.09 to 1.39) (Table 2). Early administration was also associated with a shorter duration of active ED treatment, with no significant effect on relapse compared with that of children with delayed administration. Indeed, for every 30-minute delay in administering systemic corticosteroids from triage, the duration of active treatment increased by 60 minutes (95% CI 41 to 80 minutes), with no significant effect of relapse (OR 1.06; 95% CI 0.89 to 1.27). The 17% of patients who received no systemic corticosteroids had significantly lower rates of admission and shorter duration of active treatment compared with those who received delayed systemic corticosteroid (Figure E1, available online at <http://www.annemergmed.com>), although significance in lower admission rates was lost when the cutoff time of 6 hour between triage and disposition was not taken into account (OR 0.66; 95% CI 0.37 to 1.27). This group of patients, however, exhibited a nonsignificant trend toward 2-fold higher relapse rate. Preschoolers did not have

Table 1. Characteristics of patients, physicians, and the ED.

Characteristics	Administration of Systemic Corticosteroids, No. (%) [*]	
	Early, N=205	Not Early, N=201
Patient		
Demographics		
Age, y		
2–6	129 (62.9)	147 (71.0)
7–12	57 (27.8)	41 (20.4)
13–17	19 (9.2)	13 (6.5)
Sex (male)	126 (61.5)	131 (65.5)
Severity		
Triage category [†]		
1	2 (1)	1 (0.5)
2	108 (52.7)	28 (13.9)
3	95 (46.6)	172 (85.6)
Baseline PRAM score[‡]		
5	44 (21.5)	82 (40.8)
6	46 (22.4)	81 (40.3)
7	37 (18.5)	31 (15.4)
8	32 (15.6)	3 (1.5)
9	23 (11.2)	1 (0.5)
10	14 (6.8)	0
11	9 (4.4)	3 (1.5)
12	0	0
Change in PRAM postbronchodilation[§]		
Clinical meaningful deterioration	0	0
No change	104 (65)	97 (78.9)
Clinical meaningful improvement	56 (35)	22 (21.1)
Occurrences in the ED		
Vomiting of oral corticosteroid	17 (8.3)	13 (6.5)
Physician		
Sex (% male)	72 (35.1)	75 (37.3)
Years since graduation		
<10	44 (31.5)	47 (23.4)
10–20	105 (51.2)	72 (35.8)
>20	56 (27.3)	82 (40.8)
Physician shift coverage		
Full time	117 (57.1)	90 (44.8)
Part time	25 (12.2)	45 (22.4)
Occasional	63 (30.7)	66 (32.8)
Physician specialty		
Pediatric specialist	20 (9.8)	30 (14.9)
General pediatrician	4 (2)	4 (2)
Pediatric emergency physician	142 (69.3)	109 (54.2)
Adult emergency physician	23 (11.2)	24 (11.9)
General practitioner	16 (7.8)	34 (16.9)
Setting		
Time of presentation		
Night (12:01 AM to 8 AM)	34 (16.6)	28 (13.9)
Day (8:01 AM to 4 PM)	97 (47.3)	97 (48.3)
Evening (4:01 PM to midnight)	74 (36.1)	76 (37.8)
ED congestion, quartile[¶]		
First (lowest)	53 (25.9)	44 (21.9)
Second	108 (52.7)	93 (46.3)
Third	35 (17.1)	53 (26.4)
Fourth (highest)	9 (4.4)	11 (5.5)
Trainee involved in care management		
None	141 (68.8)	134 (66.7)
Resident	51 (24.9)	45 (22.4)

Continued.

Table 1. (Continued)

Characteristics	Administration of Systemic Corticosteroids, No. (%) [*]	
	Early, N=201	Not Early, N=205
Emergency fellow	13 (6.3)	18 (9)
Medical student	0	4 (2)

^{*}“Early” refers to administration of systemic corticosteroids within 60 minutes (SD 15 minutes) of triage and “not early” refers to delayed (beyond 60 minutes [SD 15 minutes] of triage) or nonadministration of systemic corticosteroids.

[†]Triage categories were defined according to the Canadian Paediatric Emergency Triage and Acuity Scale,¹⁵ in which patients in triage priorities 1, 2, and 3 were recommended to be seen within 15, 30, and 60 minutes, respectively.

[‡]PRAM is a 12-point validated clinical severity score.

[§]Clinically meaningful deterioration, no change, and clinically meaningful improvement in severity correspond to a change in PRAM score after first bronchodilator of greater than or equal to 3, −2 to +2, and greater than or equal to 3 points, respectively. The clinically meaningful change of the PRAM is based on concordance with 25% change in respiratory resistance.¹⁴

^{||}In a 4-week block, full-time coverage involves approximately 8 to 14 shifts, part-time coverage involves approximately 6 to 13 shifts, and occasional coverage involves 5 or fewer shifts per block. Physicians with full-time, part-time, and occasional shift coverage attended to 57%, 12%, and 31% of patients with acute asthma, respectively.

[¶]First, second, third, and fourth quartiles correspond to congestion rates of less than 60%, 61% to 120%, 121% to 180%, and greater than 181%, respectively.

significantly higher odds of hospital admission compared with older children (OR 0.67; 95% CI 0.42 to 1.08).

Two factors related to patient severity were associated with delayed administration of systemic corticosteroids: triage category and PRAM. Delayed administration was significantly more likely to occur in patients with a lower triage priority and less likely in those with a severe PRAM score (Table 3). The following factors were not associated with a delayed administration of systemic corticosteroids: β_2 -agonist or inhaled corticosteroids on arrival, vomiting the oral corticosteroid preparation (which occurred in 7.4% of all children), time of presentation, and ED congestion. No physician characteristics were identified as important predictors of timing of corticosteroid administration.

Several factors were significantly associated with not receiving systemic corticosteroids: patient-related factors, namely, preschool age, lower triage priority, and PRAM score; and physician-related factors, including graduation more than 20 years ago, adult emergency specialty or general practitioner, and involvement of an emergency fellow (Table 4). Because physician subspecialty was strongly associated with shift coverage ($r=0.66$; $P<.001$), shift coverage could not simultaneously be included in the model. When shift coverage was included in lieu of physician specialty, nonadministration was more likely to occur among physicians covering only occasional ED shifts (OR 5.13; 95% CI 1.4 to 7.0) compared with those with full-time coverage.

LIMITATIONS

Our study was an observational study of a busy ED, strengthened by the accuracy of data, which was ensured

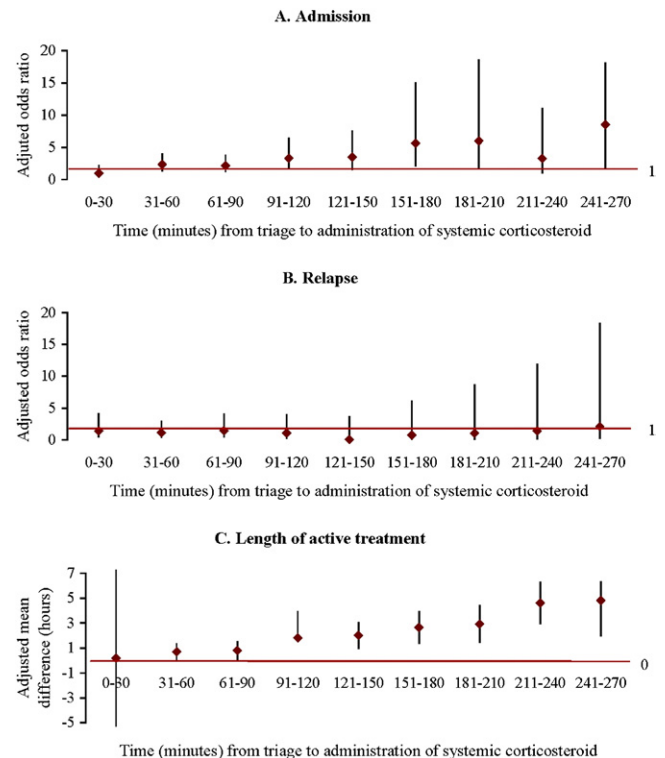


Figure 2. Point estimates of the relative effectiveness of systemic corticosteroids on A, admission; B, relapse, defined as a return visit to the Montreal Children's Hospital ED for acute asthma within 72 hours of discharge; and C, length of active treatment, defined as the time between first and last nebulization of albuterol in the ED. Admission and relapse are presented as adjusted OR (95% CI), and length of active stay is presented as adjusted difference in means (95% CI). Admission was adjusted for age, sex, and baseline PRAM score. Relapse was adjusted for age and sex. Length of active treatment was adjusted for age, sex, and PRAM score after first nebulization of albuterol in the ED. The width of the vertical line represents the 95% CI around the point estimate (red diamond). The horizontal line is the line of no effect; with 1.0 and 0.0 representing no effect for OR and difference in means, respectively.

through duplicate data extraction and electronic data entry. Because health care professionals were unaware of the monitoring, they were unlikely to have modified their behavior during the study period. Because of the ED electronic log and mandatory recording of treatment and timing of administration in medical records, we had complete data. The results should be interpreted in the light of several limitations. First, it appeared unethical to randomize children to receiving timely or delayed corticosteroids. Yet, in absence of randomization, the study results may have been distorted by confounding by indication with regard to the timing and administration of systemic corticosteroids. This bias was partially addressed by the exclusion of children with mild asthma (PRAM score less than

Table 2. Effect of timing in the administration of systemic corticosteroid on admission.

Variable	Adjusted OR (95% CI)*
Time	
30-min interval from triage	1.19 (1.09–1.35)
PRAM[†]	
1-point increase	1.41 (1.38–1.75)
Triage category[†]	
≤2	1.0
≥3	0.41 (0.20–0.84)
Age, y	
2–6	1.0
7–12	1.40 (0.76–2.57)
13–17	2.36 (0.95–1.73)

*OR represents the odds of delayed administration and was calculated with the generalized estimating equation approach, accounting for possible patient clustering by physician and adjusted for patient age. The intercorrelation coefficient between physician clusters and adherence to the pathway was 0.05. Reference categories were set to 1.

[†]PRAM is a 12-point validated clinical severity score.¹⁰

*Triage categories were defined according to the Canadian Paediatric Emergency Triage and Acuity Scale,¹⁵ in which patients in triage priorities 1, 2, and 3 were recommended to be seen within 15, 30, and 60 minutes, respectively.

Table 3. Factors associated with delayed administration of systemic corticosteroids.

Variable	Adjusted OR (95% CI)*
Patient factors	
Triage category[†]	
≤2	1.0
≥3	2.83 (1.41–5.68)
Baseline PRAM score[†]	
5	1.0
6	0.88 (0.49–1.60)
7	0.78 (0.38–1.59)
≥8	0.17 (0.06–0.49)

*OR represents the odds of delayed administration and was calculated with the generalized estimating equation approach, accounting for possible patient clustering by physician and adjusted for patient age. No physician characteristics were identified as important predictors of timing of corticosteroid administration. The intercorrelation coefficient between physician clusters and adherence to the pathway was 0.05. Reference categories were set to 1.

[†]Triage categories were defined according to the Canadian Paediatric Emergency Triage and Acuity Scale,¹⁵ in which patients in triage priorities 1, 2, and 3 were recommended to be seen within 15, 30, and 60 minutes, respectively.

[†]PRAM is a 12-point validated clinical severity score.¹⁰

5) and the adjustment for severity and other confounders in all analyses. We acknowledge the possibility of residual confounding, suggested by baseline group differences in severity and improved outcomes in those who failed to receive corticosteroids. We recognize that the use of a standardized clinical score does not preclude the possibility of misclassification. We acknowledge that the exclusion of repeated visits was a conservative approach to avoid nonindependence. Factors associated with delayed and no administration of systemic corticosteroids may be specific to our institution and not be generalizable to other settings. Finally, these factors raise interesting hypotheses about physicians' knowledge, beliefs, and attitudes toward the administration and the timing of systemic corticosteroids in children with moderate and severe acute asthma.

DISCUSSION

The early administration of systemic corticosteroids, ie, within 60 minutes (SD 15 minutes) of triage in the ED, was associated with a significant reduction in the rate of hospital admission and in the length of active treatment. Delayed administration was associated with lower triage priority and prevented by a higher PRAM score, suggesting that children at the lower end of moderate severity may be at higher risk of delayed administration. The few children who did not receive systemic corticosteroids in the ED had lower admission rates and shorter length of active treatment but a clinically important trend toward higher relapse rates. Several patient- and physician-related factors were associated with failure to provide systemic corticosteroids.

We observed a 15% relative reduction in the odds of hospital admission in children who received systemic corticosteroids within 75 minutes of triage compared with those delayed, a

finding entirely concordant with a Cochrane review of randomized controlled trials.¹ The most important factor to prevent admission appears the delay between corticosteroids and the decision to admit or discharge. Indeed, our children with early intake received oral corticosteroids on average 3.3 hours before disposition, within the clinical onset of action established at 3 to 4 hours by Rowe et al.¹ In contrast, for children with delayed intake, systemic corticosteroids were received barely 2 hours before disposition. The critical delay between corticosteroids and disposition would explain why several studies, in which disposition could occur up to 8 to 12 hours after triage, showed significant reductions in admissions without improving corticosteroid administration in the initial hour of ED treatment.^{5,6} Conversely, most pathways may have failed to reduce admissions and length of stay because of the insufficient delay between systemic corticosteroid and the disposition decision.^{9,19} Clearly, the timing of triage, systemic corticosteroids, and disposition must be carefully documented in future studies assessing clinical care asthma pathways.

Only 2 factors were associated with delayed systemic corticosteroid administration; both suggested that children perceived at the lowest end of the moderate obstruction range were at higher risk of delay. Indeed, lower triage priority resulted in delayed physician visit. The appropriate integration of the PRAM score in the triage prioritization may have allowed for an early medical assessment. Alternatively, several hospitals have endorsed a medical directive allowing the nurse or respiratory therapist to administer oral corticosteroids before the physician's visit (personal communication D. Johnson, Calgary Children's Hospital, August 2009; personal communication, Roger Zemek, Children's Hospital of Eastern Ontario, August 2010; personal communication, David McGillivray, Montreal Children's Hospital, September 2010).

Table 4. Factors associated with no administration of systemic corticosteroids.

Variable	Adjusted OR* (95% CI)
Patient factors	
Age, y	
13–17	1
7–12	0.56 (0.12–2.7)
2–6	2.5 (1.61–10.24)
Triage category[†]	
≤2	1.0
3	11.26 (4.10–30.89)
Baseline PRAM score[‡]	
5	1.0
6	2.93 (1.34–6.41)
7	1.34 (0.43–4.13)
Physician factors	
Years since graduation	
<10	1.0
10–20	0.86 (0.32–2.31)
>20	3.32 (1.17–9.46)
Physician subspecialty	
Pediatric emergency	1.0
Adult emergency	3.33 (1.06–10.48)
Pediatric specialist	2.53 (0.92–7.02)
General pediatrician	2.04 (0.24–16.42)
General practitioner	4.82 (1.81–12.82)
Setting factors	
Trainee	
None	1.0
Residency	1.36 (0.50–3.69)
Emergency fellow	12.28 (3.73–40.43)

*OR represents the odds of not receiving systemic corticosteroids. ORs were calculated with the generalized estimating equation approach, accounting for possible patient clustering by physician. The intercorrelation coefficient between physician clusters and adherence to the pathway was 0.05. Reference categories were set to 1.

[†]Triage categories were defined according to the Canadian Paediatric Emergency Triage and Acuity Scale,¹⁵ in which patients in triage priorities 1, 2, and 3 were recommended to be seen within 15, 30, and 60 minutes, respectively.

[‡]PRAM is a 12-point validated clinical severity score.¹⁰

Seventeen percent of our patients failed to receive any systemic corticosteroids during the ED stay. In this small group of patients, we observed a significant reduction in admission compared with that of patients who receive timely or delayed corticosteroids. Although the decision not to administer systemic corticosteroids may appear appropriate because of the lower admission rates in the group, the trend toward a 2-fold increase in relapse would suggest otherwise.

Several factors were associated with no ED administration of systemic corticosteroids. Regarding the failure to administer systemic corticosteroid to preschoolers,^{20,21} one possible explanation is the uncertainty about its effectiveness in this age group.²² In our study, however, preschoolers appeared to benefit from early systemic corticosteroid administration. Failure to administer systemic corticosteroids among children with a triage priority of 3 or more and at the lower end of the moderate severity cutoff may be because these children displayed a marked response to bronchodilator or their baseline

severity was not deemed sufficient to warrant corticosteroid. The omission to prescribe systemic corticosteroid among adult emergency physicians and general practitioners suggests significant practice variation depending on medical training.^{23,24} Likewise, senior physicians were significantly less likely to prescribe systemic corticosteroid,²⁵ perhaps because of their greater reliance on clinical experience than on clinical care pathways or the use of older guidelines recommending administration for children with incomplete response to initial bronchodilator.^{26,27} The greater likelihood of not prescribing systemic corticosteroid among physicians with occasional ED shift coverage is meaningful because they cared for 30% of all asthma patients. Finally, the greater likelihood of not receiving corticosteroid when treatment was managed by emergency fellows, who usually manage asthma cases without staff involvement, suggests a need for improved monitoring. Clearly, reasons for not administering systemic corticosteroid across seniority, specialties, shift coverage, and trainees must be better understood to correct this.^{28,29}

In the actual setting of a busy ED, early administration of systemic corticosteroids to children with moderate and severe asthma significantly decreases admissions and shortens the length of active treatment, suggesting that it may allow optimal effectiveness. Yet, despite a clinical pathway specifically recommending systemic corticosteroids within 60 minutes (SD 15 minutes) of triage, optimal timing was met in only half of children. In the future, delays between triage, systemic corticosteroids administration, and disposition should be carefully monitored and reported because they may significantly potentiate or negate the expected benefits of clinical asthma pathways. Incorporating the PRAM in the triage assessment or adopting a medical directive permitting nurses to administer corticosteroids at triage appears a promising approach to be tested.

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Table E1. Characteristics of attending physicians.

Demographics	N=59	%
Sex (% male)	27	45.8
Years since graduation		
<10	10	17
10–20	22	37.3
>20	27	45.7
Physician shift coverage*		
Full time	13	22
Part time	16	27.1
Occasional	30	50.9
Physician specialty		
Pediatric subspecialist	15	25.4
General pediatricians	15	25.4
Pediatric emergency physician	14	23.7
Adult emergency physician	10	17

*In a 4-week block, full-time coverage involves approximately 8 to 14 shifts, part-time coverage involves approximately 6 to 13 shifts, and occasional coverage involves 5 or fewer shifts.

Table E2. Characteristics of patients, physicians, and the ED among patients who did not receive early systemic corticosteroid.*

Patient Demographics	Not Given, No. (%) ^a , N=68	Delayed, No. (%), N=133
Age, y		
2–6	53 (77.9)	94 (70.7)
7–12	11 (16.2)	30 (22.5)
13–17	4 (5.9)	9 (6.8)
Sex (male)	44 (64.7)	87 (65.4)
Severity		
Triage category[†]		
1	0	1 (0.8)
2	8 (11.8)	20 (15)
3	60 (88.2)	112 (84.2)
Baseline PRAM score		
5	25 (36.8)	57 (42.9)
6	36 (52.9)	45 (33.8)
7	7 (10.29)	24 (18.1)
8	0	3 (2.3)
9	0	1 (0.8)
10	0	0
11	0	3 (2.3)
12	0	0
Change in PRAM postbronchodilation[†]	n=30	n=93
Clinical meaningful deterioration	0	0
No change	19 (63.3)	78 (83.9)
Clinical meaningful improvement	11 (36.7)	15 (16.1)
Medications on arrival		
β-2 Agonist	44 (64.7)	86 (64.7)
Inhaled corticosteroids	35 (51.5)	67 (50.4)
Antibiotics	0	3 (2.3)
Occurrences in the ED		
Vomiting of systemic corticosteroid preparation	0	13 (9.8)
Physician		
Sex (% male)	24 (35.3)	51 (38.4)
Years since graduation		
<10	12 (17.6)	35 (26.3)
10–20	21 (30.9)	51 (38.4)
>20	35 (51.5)	47 (35.3)
Physician shift coverage[§]		
Full time	24 (35.3)	66 (49.6)
Part time	19 (27.9)	26 (19.6)
Occasional	25 (36.8)	41 (30.8)
Physician specialty		
Pediatric specialist	12 (17.6)	18 (13.5)
General pediatricians	2 (2.9)	2 (1.5)
Pediatric emergency physician	25 (36.8)	84 (63.2)
Adult emergency physician	8 (11.8)	16 (12)
General practitioners	21 (30.9)	13 (9.8)
Setting Time of presentation		
Night (12:01 AM to 8 AM)	7 (10.3)	21 (15.8)
Day (8:01 AM to 4 PM)	32 (47.1)	65 (48.9)
Evening (4:01 PM to midnight)	29 (42.6)	47 (35.3)
ED congestion, quartile		
First (lowest)	12 (17.7)	32 (24.1)
Second	35 (51.5)	58 (43.6)
Third	18 (26.5)	35 (26.3)
Fourth (highest)	3 (4.4)	8 (6)
Trainee involved in care management		
None	46 (67.7)	88 (66.2)
Resident	3 (4.4)	1 (0.8)

Continued.

Table E2. (Continued).

Patient Demographics	Not Given, No. (%), N=68	Delayed, No. (%), N=133
Emergency fellow	9 (13.2)	36 (27)
Medical student	10 (14.7)	8 (6)

*N for not given, and delayed is 68 and 133, respectively, except where indicated.

[†]Triage categories were defined according to the Canadian Paediatric Emergency Triage and Acuity Scale, in which patients in triage categories 1, 2, and 3 should be seen within 15, 30, and 60 minutes, respectively.

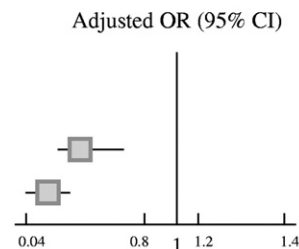
[‡]Clinically meaningful deterioration, no change, and clinically meaningful improvement in severity correspond to a change in PRAM score after first bronchodilator of greater than or equal to 3, -2 to +2, and greater than or equal to 3 points, respectively. Clinically meaningful change is based on concordance with 25% change in respiratory resistance.

[§]Full-time coverage involves approximately 8 to 14 shifts in a 4-week block, part-time coverage involves approximately 6 to 13 shifts in a 4-week block, and occasional coverage involves 5 or fewer shifts per block. Physicians with full-time, part-time, and occasional shift coverage attended to 57%, 12%, and 31% of patients with acute asthma, respectively.

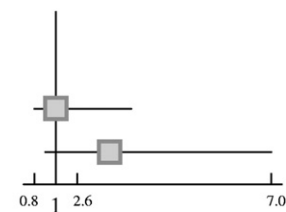
^{||}First, second, third, and fourth quartiles correspond to congestion rates of less than 60%, 61% to 120%, 121% to 180%, and greater than 181%, respectively.

A. Admission

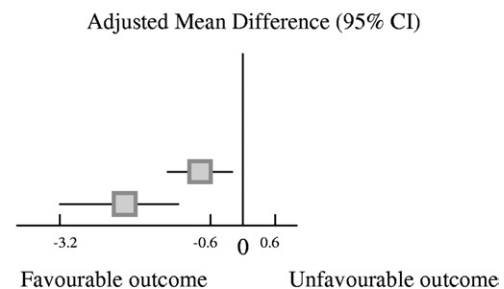
	n/N	%	OR (95% CI)
Delayed	61/133	45.9	Reference
Early	79/205	38.5	0.4 (0.2, 0.7)
Not Given	9/68	7.4	0.1 (0.04, 0.3)

**B. Relapse**

Delayed	7/133	5.3	Reference
Early	10/205	4.9	1.0 (0.4, 3.0)
Not Given	10/68	11.8	2.4 (0.8, 7.0)

**C. Length of active treatment, hours**

	N	Mean (SD)	Mean difference (95% CI)
Delayed	133	4.4 (2.6)	Reference
Early	205	3.7 (2.4)	-0.7 (-1.3, -0.1)
Not Given	68	1.7 (1.6)	-2.2 (-3.2, -1.2)

**Figure E1.** Impact of systemic corticosteroids on admission, relapse, and length of active stay.