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Emergency Department Crowding and Younger Age are Associated with Delayed Corticosteroid Administration to Children with Acute Asthma

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Abstract

Objective—To identify factors associated with delayed or omission of indicated steroids for children seen in the emergency department (ED) for moderate-severe asthma exacerbation.

Methods—This was a retrospective study of pediatric (age ≤ 21 years) patients treated in a general academic ED January 2006-September 2011 with a primary diagnosis of asthma (ICD-9 code 493.xx) and moderate-severe exacerbations. A moderate-severe exacerbation was defined as requiring ≥2 (or continuous) bronchodilators. We determined the proportion of visits in which steroids were inappropriately omitted or delayed (> 1 hour from arrival). Multivariable logistic regression models were used to identify patient, physician, and system factors associated with delayed or omitted steroids.

Results—Of 1,333 pediatric asthma ED visits, 817 were for moderate-severe exacerbation; 645 (79%) received steroids. Patients <6 years (odds ratio 2.25 [95% confidence interval 1.19–4.24]), requiring more bronchodilators (2.82 [2.10–3.79]), initially hypoxic (2.78 [1.33–5.83]), or tachypneic (1.52 [1.05–2.20]) were more likely to receive steroids. Median time to steroid administration was 108 minutes (IQR: 65–164). Steroid administration was delayed in 502 (78%) visits. Patients with hypoxia (1.91 [1.11–3.27]) or tachypnea (1.82 [1.17–2.84]) were more likely to receive steroids ≤1 hour of arrival whereas children <2 years (0.16 [0.07–0.35]) and those arriving during periods of higher ED volume (0.79 [0.67–0.94]) were less likely to receive timely steroids.

Conclusion—In this ED, steroids were under-prescribed and frequently delayed for pediatric ED patients with moderate-severe asthma exacerbation. Greater ED volume and younger age are associated with delays. Interventions are needed to expedite steroid administration, improving adherence to NIH asthma guidelines.

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Keywords

Systemic corticosteroid; Asthma; Emergency; medicine; Clinical guidelines; Pediatrics; Crowding; Quality of care

INTRODUCTION

Asthma is responsible for approximately 750,000 ED visits and 65,000 hospitalizations for children annually in the U.S.[1–3] For children with an acute exacerbation who fail to respond promptly and completely to inhaled short acting β_2-agonists (up to 3 doses of a bronchodilators in the first hour), the National Institute of Health (NIH) Asthma Guidelines recommend prompt administration of systemic corticosteroids (prednisone, prednisolone, dexamethasone or methylprednisolone).[4] Systemic corticosteroids (hereafter referred to as steroids) are one of the primary evidence-based therapies for acute asthma. [4–7] Cochrane reviews of randomized controlled trials have shown decreased rates of admission (OR=0.40) and ED returns (OR=0.47) associated with receipt of steroids within one hour of ED arrival compared to placebo.[8, 9] Treatment with steroids also reduces hospital length of stay (LOS),[10] improves pulmonary index scores[11, 12] and may improve quality of life for children and their families.[13]

Further, timely treatment with steroids achieves the best outcome for asthma exacerbations.[9–14] While steroids are traditionally thought to exert their anti-inflammatory effect over hours,[15] they may also increase the effectiveness of bronchodilators.[16] Several recent studies have confirmed that timely versus delayed steroid administration is associated with a reduced odds of admission (OR=0.4–0.5)[17–19] and that every 30-minute delay in steroid administration increases the odds of admission by nearly 20%.[18] Accordingly, the proportion of children receiving timely steroids has been used as a surrogate measure of ED quality of care.[20–22]

Despite this evidence and the NIH guidelines, steroids are often under-prescribed for children seen in the ED for acute asthma exacerbations.[3, 13, 21, 23–25] In addition, frequent delays in steroid administration (52–77% of visits) have been reported.[17–19, 25] However, reasons for delayed steroid administration among pediatric ED patients with asthma exacerbations are not well described. Little is known about patient, physician or system factors associated with delayed or omitted steroids for these patients. Our objectives were to determine how often steroids are delayed or omitted and to identify predictors of delayed or omitted steroids among pediatric ED patients with moderate-severe asthma exacerbations. The study results will help direct interventions to improve appropriate and timely steroid administration for children presenting to the ED with asthma exacerbations.

METHODS

In this retrospective cross-sectional study, we analyzed data from the University xx ED from January 1, 2006 to September 1, 2011.

Setting

Our ED has 29 beds and an annual census of approximately 34,000 adult and 6,000 pediatric patients. Pediatric patients are seen by pediatric and emergency medicine residents, supervised 24 hours/7 days a week by attending physicians board eligible/board certified in emergency medicine. At the time of this study, our ED had no specific asthma protocols or pathways.

Study Population

The study population consisted of children ≤21 years of age with a moderate-severe asthma exacerbation. This was defined as a visit where the primary ED diagnosis was asthma (International Statistical Classification of Diseases and Related Health Problems, Coordination and Maintenance (ICD-9-CM) code 493.xx) and the patient required ≥2 (or continuous) bronchodilator treatments (inhaled albuterol, albuterol-ipratropium, levabuterol). The NIH guidelines recommend steroids for all patients with asthma exacerbation except those with mild exacerbations who experience prompt relief with bronchodilator treatment.[4] Therefore, we excluded patient visits requiring 0 or 1 bronchodilator treatments. We also excluded patients who had received steroids within 24 hours prior to their ED visit.

Data Source

During the period of the study, the ED used an internally developed, stand-alone electronic medical record (EMR) for triage information, physician documentation, and billing and charges. Registration time, patient demographics, disposition and hospital LOS (if admitted) were recorded in the hospital's electronic registration database (GE Centricity™). Physician orders and nursing notes (including times of medication administration) were documented on paper.

Data Collection

We identified all patient visits with a diagnosis of asthma (ICD-9-CM code 493.xx) during the study period through an electronic search of the ED's EMR. For each visit identified, we used discrete fields in the ED EMR and the hospital electronic registration databases to obtain time of arrival (time of registration), patient demographics (age, gender, self-determined race and ethnicity, type of insurance), and descriptors of the ED visit (mode of arrival [self vs. ambulance], triage data [presenting vital signs, triage acuity], ED patient volume at hour of arrival). Triage acuity was assigned during the visit by trained triage nursing staff using the Emergency Severity Index (ESI) version 4 which uses a 5-tier scale, 1 being most acute.[26] Information about hospital admission (LOS, ICU [intensive care unit] stay) was extracted from the hospital's electronic registration database. Time of orders was obtained from a paper order form, and time of administration from paper nursing records. In cases where data was missing or showed discrepancies, AB reviewed physician or nursing documentation in the ED's clinical EHR or in scanned documents.

Using a standardized data abstraction tool, two pharmacy students reviewed ED medical records.[27] AB was responsible for training the students and data verification. The students met periodically with AB to resolve data entry discrepancies and review coding rules. The students identified charts for visits that met inclusion criteria. AB reviewed 15% of all charts for visits that did not meet the inclusion criteria with 100% agreement i.e., no charts for visits that met the inclusion criteria were missed by the students. AB then reviewed all the charts from visits that met the inclusion criteria for wait time to be placed in a room, date and time of order and administration of bronchodilators and steroids, time of ED discharge, past medical history of asthma, use of supplemental oxygen, use and initial interpretation of chest radiographs, administration of steroids during a recent clinical (ED or physician's office) encounter, and other tests and medications ordered. Undocumented time entries for care services and other variables not present in the chart were labeled as missing data. AB was blinded to ED volume, race and ethnicity, type of insurance, and hospital LOS data. This information was added after completion of manual data abstraction and verification. SB entered all data into an electronic spreadsheet (Microsoft Excel 2010; Microsoft Corporation, Redmond, WA). The Committee on Human Research at xxxx approved the study.

The primary outcome measures were the factors associated with delayed administration of steroids (>60 minutes). Time to steroid was calculated from the date and time of ED arrival to date and time of first steroid administration. Although there is no standard definition for delayed steroid administration, >60 minutes was chosen based on prior studies and NIH guidelines. [4, 9, 19, 25, 28] Only one study used >75 minutes to define delay to give an extra 15 minutes of leeway.[18] Time from ED arrival to steroid administration was also analyzed as a continuous variable.

Secondary outcome measures were factors associated with omission of indicated steroids. We determined the proportion of patients for whom steroids were omitted and compared this group with patients who received steroids for the predictor variables. We also compared patient outcomes: ED and inpatient LOS and disposition (admission to inpatient bed, admission to ICU, discharge to home). For admitted patients, we calculated inpatient LOS from the date and time of ED admission decision and the date and time of hospital discharge, thereby including any ED boarding time.

Predictor variables for delay and under-prescription of steroids were selected based on clinical experience and results from previous studies evaluating predictors of unequal care in the ED.[3, 25, 29–33] We classified predictor variables as related to the patient, physician, and system. Patient variables were demographics, triage acuity, mode of arrival, past history of asthma, fever (>38.0°C), tachypnea, hypoxia (oxygen saturation < 93%), and secondary diagnosis of pneumonia. Demographic variables were age, gender, race, ethnicity, and insurance. Age was collapsed into a 4-level categorical variable (less than 2 years old, 2–5 years old, 6–12 years old, and 13–21 years old). Race and ethnicity were self-reported and combined to create 5 categories: white (non-Hispanic), black (non-Hispanic), Hispanic, Asian, and other. Insurance was examined in 3 groups: private, Medicaid, and other (e.g., self-pay, no charge/charity). Tachypnea was defined as: >60 breaths per minute (b/min) for ≤1 month old; >50 (b/min) for ≤ 3 months old; >40 (b/min) for ≤6 months old; >33 (b/min) for ≤ 9 months old; >30 (b/min) for ≤4 years old; >25 (b/min) for ≤ 8 years old; and >20 (b/min) for ≤21 years old.[34]

Physician variables were medications ordered (total number and timing of bronchodilators, continuous bronchodilators, supplemental oxygen, antibiotics, intravenous (IV) fluids) and tests ordered (chest radiography, blood tests). Ancillary medications and tests ordered were examined because they may capture more complex or severe patient visits.

System factors included time of day, season, year, waiting time from arrival to ED room placement, time from order to administration of medications, and ED patient volume at hour of arrival (a proxy for ED crowding)[31, 35, 36]. ED patient volume at hour of arrival represented the total number of patients in the treatment area of the ED, including admitted patients waiting for an inpatient bed and those in the waiting room. Time of ED arrival was collapsed into two categories [7am–7pm (day), 7pm–7am (night)], roughly reflecting variations in work shifts. Season of service were divided into December to February, March to May, June to August, and September to November to capture any variations in peaks of asthma exacerbations.

Statistical Analysis

Descriptive statistics were calculated using means, proportions, and medians (when distribution was not normal). For the primary and secondary outcomes, univariate analyses were performed using χ^2 analyses. We developed two multivariable logistic regression models to identify factors associated with delayed and omitted steroids, respectively. Variables were chosen a priori based on prior studies and clinical experience. These included age, ethnicity, triage score, total number of bronchodilators, hypoxia, tachypnea, past history of asthma, chest radiograph, ED patient volume at hour of arrival and year. We avoided using variables that were likely to be co-linear. Multivariable logistic regression models, using generalized estimating equations (GEE, Proc Genmod in SAS), determined the odds ratios (ORs) of each independent variable while controlling for confounding factors. In the models, clustering by medical record number was performed to control for multiple visits by a single patient to avoid non-independence. A 2-tailed P value of <0.05 was considered significant. In patients who received steroids, time from ED arrival to steroid administration was also analyzed as a continuous variable. Additional gamma models (linear GEE models using a gamma distribution and a log link function) were performed to analyze time to steroid administration. Results for binary outcomes are expressed in adjusted ORs and for continuous outcomes, adjusted rate ratios (RRs) with 95% CIs. For the continuous predictor variables of ED volume and number of bronchodilators, ORs were determined for each additional 10 patients or one bronchodilator, respectively. All analyses were performed using SAS statistical software (version 9.2, SAS Institute, Cary, NC).

Results

Patient and Treatment Characteristics

During the study period, there were 2280 ED visits for patients ≤21 years with an ED diagnosis of asthma. Seventy-eight charts (3%) were missing or had missing data, leaving 2202 for review. Of these, 838 had ≥2 (or continuous) doses administered (moderate-severe asthma exacerbation). Twenty one patient visits received steroids within the previous 24 hours, leaving 817 for review. Most of these visits (66%) were by patients under 6 years of age (Table 1). Sixty five percent of visits were by patients who were male, 24% of Black race, 26% of triage acuity 2, and 54% of triage acuity 3.

For all included patients, the mean number of bronchodilators administered within the first hour was one. The mean time from ED arrival to room placement was 31 minutes (SD 43 minutes), from room to bronchodilator order 11 minutes (SD 21 minutes), and from bronchodilator order to administration 12 minutes (SD 14 minutes). Chest radiographs were performed in 43% of visits, with 11% of those having preliminary radiology (i.e. “wet read”) interpretations consistent with pneumonia. For discharged patients, the mean ED LOS was 3.8 hours (SD 1.6 hours). In 13% of visits, patients were hypoxic and required oxygen. Eighteen percent were admitted to the hospital, 1% required ICU admission, and the remaining 81% were discharged home. For admitted patients, the mean hospital LOS was 50 hours (SD 43 hours).

Patients received steroids in 79% of the moderate-severe asthma exacerbation visits and 92% of ED visits that required hospital admission (p<0.01). In 21% of visits where steroids were indicated (n=172), they were not administered. The reason for steroid omission was documented in only two cases (patients’ parents refused steroid administration). In 17 visits, patients were treated for other conditions (bacterial pneumonia, respiratory syncytial virus, sickle cell disease and possible pertussis). In the remaining 153 (19%) visits with a primary diagnosis of asthma, no reason was documented for the steroid omission. For all patients that received steroids, the median time from ED arrival to steroid administration was 108 minutes, (IQR: 65–164, mean 126 minutes, SD 84 minutes). In only 22% of visits were steroids delivered within one hour. For visits with delayed steroid administration (n=502 visits), the mean time from ED arrival to room placement was 36 minutes (SD 43 minutes). Mean time from room to steroid order was 65 minutes (SD 63 minutes), and from steroid order to administration was 48 minutes (SD 36 minutes). Seventy eight percent of patients had a past history of asthma. Of those, only 79% received steroids when they were indicated and only 25% received the steroids within one hour of ED arrival.

Factors associated with steroid administration

Age <6 years (OR 2.25 [95% CI 1.19–4.24]), each additional bronchodilator (2.82 [2.10–3.79]), hypoxia (2.78 [1.33–5.83]), and tachypnea (1.52 [1.05–2.20]) were associated with steroid administration (Table 2). Among those who received steroids, timely administration was associated with hypoxia (1.91 [1.11–3.27]) and tachypnea (1.82 [1.17–2.84]) (Table 3). Patients <2 years of age were less likely to receive steroids within one hour (0.16 [0.07–0.35]). For patients who arrived during a time when ED volume was higher, the odds of receiving timely steroids was lower (0.79 [0.67–0.94]) compared with less crowded times; for every 10 additional patients in the ED, the odds of receiving steroids within 60 minutes of arrival decreased by 21% (Figure 1).

Results were similar when time from ED arrival to steroids was analyzed as a continuous variable. Age <2 years (RR 1.33 [1.04–1.71]) and higher ED volume upon arrival (1.08 [1.03–1.13]) were again associated with longer times to steroid administration (for every 10 additional patients in the ED, time to steroids was prolonged by 8%). Tachypnea (0.80 [0.72–0.89]) and past medical history of asthma (0.83 [0.74–0.93]) were associated with less delay to steroid administration.

The percentage of visits for moderate-severe asthma exacerbations at which patients received steroids within one hour of ED arrival varied from year to year during the study period, falling from 33% in 2006 to 11% in 2009 and rising to 24% in 2011 ($p<0.01$). However, these differences did not reach statistical significance when time from ED arrival to steroid administration was analyzed as a continuous variable.

We did not observe an independent association between delayed or omitted steroids and race and ethnicity, past history of asthma, insurance type, season, time of arrival, mode of arrival, use of continuous bronchodilators or oxygen, fever on presentation, radiographic evidence of pneumonia, receipt of antibiotics, blood tests, or IV fluids.

Discussion

In our study, only one in five children with moderate-severe asthma exacerbation received steroids within 1 hour of ED arrival; on average, administration of steroids took approximately two hours. Older children (≥6 years) and those with less severe presentations were less likely to receive any steroids in the ED. Children <2 years of age, those without a history of asthma, those with less severe presentations, or those who presented at times of higher ED patient volumes were more likely to have their steroids delayed. Most of the delay could be attributed to delayed physician orders rather than delays in room placement or nurse administration of steroids after the order was written.

This study confirms prior reports that steroids are frequently delayed among pediatric ED patients with asthma. The rate of delayed steroid administration is similar to a prior study of patients with moderate-severe exacerbations [20] when all children are included. Studies that excluded children < 2 years of age reported approximately twice as many patients receiving steroids in the first hour of arrival. [17, 18, 25] In our study we found that patients <2 years had a higher risk for delayed steroids than older children. The delay in steroid treatment in this age group may be due to difficulty in differentiating asthma from bronchiolitis, foreign body aspiration and other etiologies of wheezing where steroids are of no benefit. [37] This hypothesis is supported by the fact that another independent risk factor for delayed steroids was lack of a prior history of asthma, suggesting that physicians prefer to observe young children and perhaps obtain ancillary tests before making the diagnosis of asthma.

The NIH guidelines for management of asthma exacerbation do not differentiate patients based on age or prior history of asthma.[4] In addition, the original randomized controlled trials on the use of steroids in asthma exacerbation included patients less than 2 years of age.[11, 12, 14] Young children are at high risk for severe exacerbations [4] and have the highest rate of ED asthma visits. [37] While diagnosis in infants and young children may be challenging, it is important to avoid underdiagnosing asthma, and to provide timely steroids. Therefore, we did not exclude patients less than 2 years of age or without prior history of asthma, but relied on the primary discharge diagnosis of asthma to exclude patients with bronchiolitis.

We found that a higher volume of patients in the ED was associated with delayed administration of steroids for children with moderate-severe asthma exacerbation. Although there is no single accepted definition of ED crowding, ED volume upon patient's arrival is a common method of measurement.[31, 35, 36, 38] Our study adds to the growing literature of the role of ED crowding in diagnostic and treatment delays, reduced quality of care, and poor patient outcomes[31, 39–44] and is one of the first to show the adverse effects of ED crowding on the quality of acute asthma care for pediatric patients. Sills et al. also reported a "dose-related" negative impact of ED crowding on the quality of pediatric asthma care measured by the receipt of steroid in first hour of ED arrival.[22] Others have found associations between ED crowding and delays in antibiotic administration to febrile neonates and in analgesic administration to pediatric patients with sickle cell pain crisis and fractures.[22, 38, 45]

Despite NIH guidelines recommending three bronchodilator treatments in the first hour after arrival, on average, patients received only one treatment in the first hour, beginning 55 minutes after arrival. This likely had a considerable downstream effect of delaying steroid administration because the physician may have waited to see the patient's response to the recommended number of bronchodilator treatments before ordering steroids. While it is reassuring to find that patients with more severe illness were more likely to receive timely steroids, children at the lower end of moderate severity of illness would have also benefitted from timely steroid administration. Studies have shown that even in children with "milder" exacerbations that were not seen in the ED, timely administration of steroids was associated with fewer relapses requiring subsequent ED visits or hospitalizations.[13]

Forty three percent of children with moderate-severe asthma exacerbation received chest radiographs, while only 17% of children were febrile. The high utilization of chest radiographs may have been unnecessary; however, this is not unique to our institution. Among children with asthma, the median rate of chest radiography utilization was 35% (IQR, 31%–42%) across a national sample of pediatric emergency departments. [46] The high utilization of chest radiographs may have also contributed to steroid delays as patients may have physically left the department for the films to be obtained and some physicians may have waited to review the chest radiograph before ordering steroids. This is more likely in visits where the diagnosis of asthma was unclear. In fact, 50% of visits by patients <2 years of age had chest radiography versus 40% of visits by patients ≥2 years of age.

Few studies have reported the reasons for delayed steroid administration. Bhogal et al., the only other pediatric specific study, found that delayed steroid administration was associated with markers of less severe exacerbation (absence of tachypnea, hypoxia, etc.)[18] They did not demonstrate an association between delayed steroid administration and ED crowding. However, the study may have been underpowered to detect the association. Tsai et al. studied adolescent and adult patients only and did find that delayed steroid administration was associated with increased wait times to see a physician.[25]

In addition to the high rate of delayed steroids, we found that steroids were inappropriately omitted in 20% of visits. Failure to provide steroids to children at the lower end of moderate severity of illness has been reported by other studies[18, 25] and may be due to variation in practice, and lack of understanding or knowledge of current NIH guidelines.[3, 13, 47] One study found that physicians practicing for less than 20 years and physicians with subspecialty training in pediatrics were 3–4 times more likely to prescribe steroids.[18] However, our rates of steroid administration were actually higher than the national average (79% vs. 63–69%) [3, 21] and similar to the proportion reported by other single institution studies (83–85%), [18, 48] despite the fact that there were no faculty with pediatric emergency medicine fellowship training in our department at the time of the study.

Understanding factors associated with delayed or omitted steroids can help develop interventions to improve ED adherence to NIH asthma guidelines. Education may be one solution. We did not assess physician knowledge or agreement with the NIH guidelines for asthma; however, this may have been a significant factor in the steroid delay. Our data suggest that failure to deliver the bronchodilators promptly, hesitation about the youngest children, and fewer markers of severity are associated with delays. Yet, younger children have the highest rate of ED asthma visits[37] and were most likely to ultimately receive steroids. Physicians may need to be aware of these findings, along with the evidence for steroid treatment in children presenting at the lower end of moderate severity, in order to feel more comfortable giving steroids earlier in their care.

Clinical pathways have become widespread in the management of pediatric asthma exacerbations in Canada [24] and have been shown to increase appropriate steroid administration, [19, 49] expedite steroid administration, [17, 19, 50] and decrease hospitalization rate, [17, 19, 51] ED LOS, [17, 51–53] cost, [52, 53] prescribing errors [49] and return visits. [54] Our study findings can inform such a pathway by targeting areas where care may be inappropriate and limit unnecessary resource utilization (e.g., chest radiographs). [24] A pathway that prompts immediate and repeated bronchodilator treatments, followed by clear guidelines for steroid administration and obtaining chest radiographs would reduce uncertainty and speed steroid administration. This would be particularly true if triage nurses can initiate treatment before physician assessment to expedite care.[17] Pharmacist involvement in the pathway could help further decrease order to administration time. By improving efficiency, clinical pathways may help preserve quality of care during ED crowding and even reduce ED crowding by expediting care.

Limitations

This study was limited to a single, urban, academic medical center providing tertiary pediatric care in a general ED. Thus, our findings may not be generalizable to other settings such as pediatric, rural or community EDs. However, almost 80% of pediatric patients with asthma receive care in general rather than pediatric EDs [55] and our findings are similar to results of other studies. Second, this was an observational study. In the absence of randomization, results may be biased due to confounding and we can only report on associations between the outcomes and predictor variables (versus cause and effect). We tried to control for severity using several measures such as triage acuity, hypoxia, and tachypnea. Unfortunately, an asthma specific severity score is not routinely recorded in our institution and a peak flow is difficult to obtain in children less than 6 years old (66% of our patient population). Since the NIH guidelines recommend steroids for all patients who fail to respond immediately and completely to bronchodilator treatment, we used the definition of ≥ 2 bronchodilators to determine indication for steroids. In addition, the use of standardized clinical scores does not preclude the possibility of misclassification and is also not specified in the NIH guidelines. Third, this was a retrospective analysis. This introduces the risk of

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measurement error and recording bias. For example, the timing of the steroid administration may not be precise because it may be recorded by nurses after the fact. However, as our results were similar using a continuous outcome as well as the one-hour cut-off, we doubt this would have changed our findings. In addition, 3% of charts had missing information and could not be included in the study. We chose to include patients less than 2 years of age and without prior history of asthma which likely contributed to delays in diagnosis and treatment. The diagnosis of asthma in these children was made clinically and did not rely on responsiveness to bronchodilators since some patients with bronchiolitis also respond to bronchodilators. We did not want to exclude this important group of patients that would benefit from prompt asthma treatment. Lastly, data abstraction from chart review was performed by one abstractor, who was not blinded to the study hypothesis. However, the data abstraction form contained clear definitions and the data required little interpretation.

In conclusion, we found that approximately one-fifth of pediatric patients with moderate-severe asthma exacerbations presenting to a general academic ED did not receive steroids in the ED, and of those who did, approximately 80% did not receive them within one hour of ED arrival. Delays were more pronounced for children who are very young, those without a history of asthma, and during periods of higher ED census. Interventions that improve education and standardize and expedite steroid administration may improve ED adherence to NIH asthma guidelines.

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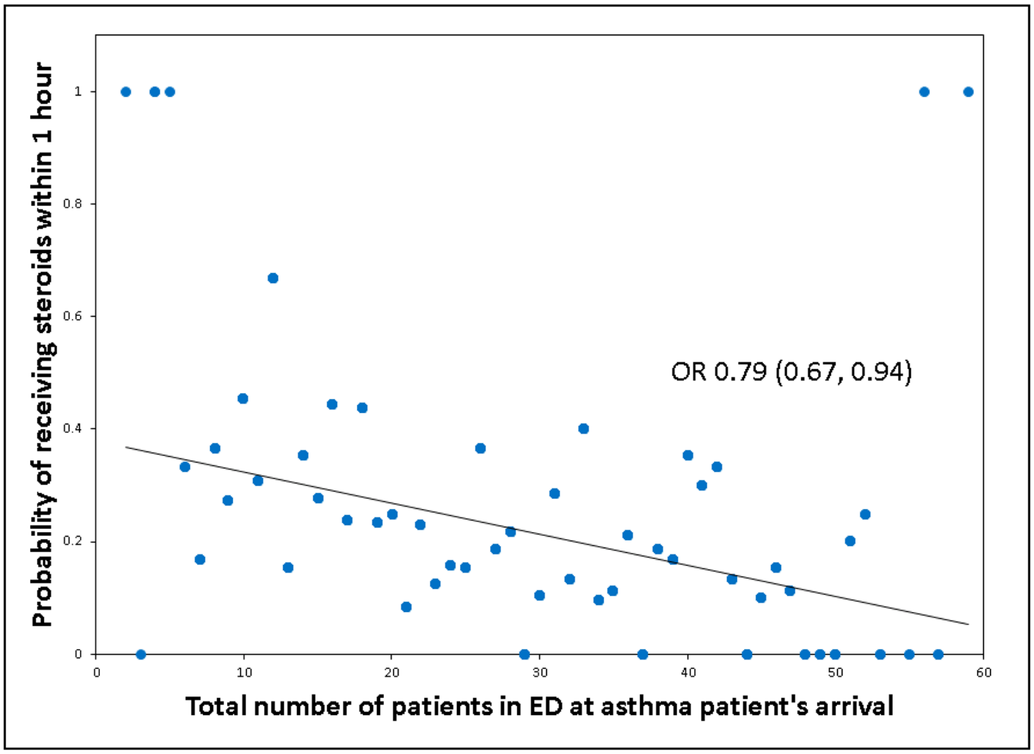

FIGURE 1.

Timely steroid administration versus ED patient volume. Scatter plot of raw proportion of patients with moderate-to-severe asthma exacerbation who received systemic corticosteroids within 1 hour of ED arrival and the number of ED patients at their arrival.

Table 1

Demographic data for patients seen in the ED with moderate-severe asthma exacerbation (n = 817).

	Number (%)	Received steroid (%)
Age		
<24 months	192 (24)	83
2–5 years	340 (42)	84
6–12 years	180 (22)	73
13–21 years	105 (13)	66
Gender		
Male	527 (65)	81
Race/ethnicity		
White	171 (21)	77
Black	197 (24)	77
Hispanic	163 (20)	74
Asian	98 (12)	77
Other	188 (23)	88
Insurance		
Private	393 (48)	80
Medicaid	376 (46)	80
Other	48 (6)	70
Triage		
1	7 (1)	100
2	211 (26)	89
3	443 (54)	77
4/5	156 (19)	72
Arrival by Ambulance	26 (3)	88
Past history of asthma	640 (78)	79
Fever on presentation	140 (17)	82
Tachypnea	471 (58)	83
Hypoxia	109 (13)	93
Pneumonia, secondary diagnosis	39 (5)	77
Receipt of supplemental oxygen	107 (13)	91
Receipt of continuous bronchodilator	65 (8)	82
Receipt of antibiotics	67 (8)	75
Chest x-ray	349 (43)	83
Blood test	49 (6)	82
ED patient volume at hour of arrival (mean)	29	29
Time of arrival		
Day	353 (43)	78
Night	464 (57)	80

	Number (%)	Received steroid (%)
Season of service		
Fall	238 (29)	82
Winter	236 (29)	75
Spring	198 (24)	78
Summer	145 (18)	81
Year of service		
2006	142 (17)	79
2007	125 (15)	74
2008	156 (19)	74
2009	145 (18)	83
2010	171 (21)	79
2011 (January to September)	78 (10)	87

Table 2

Likelihood of receiving systemic corticosteroids in the ED (multivariable regression) (n=817).

	Adjusted Odds Ratio	95% Confidence Interval
Age		
<24 months	2.59	1.29, 5.23
2–5 years	2.25	1.19, 4.24
6–12 years	1.32	0.68, 2.55
13–21 years	Reference	
Hypoxia	2.78	1.33, 5.83
Total number of bronchodilators	2.82	2.10, 3.79
Tachypnea	1.52	1.05, 2.20
Past history of asthma	1.55	0.95, 2.54
ED patient volume at hour of arrival	0.92	0.80, 1.06

Table 3

Likelihood of receiving systemic corticosteroids within one hour of ED arrival (multivariable regression) (n = 645).

	Adjusted Odds Ratio	95% Confidence Interval
Age		
<24 months	0.16	0.07, 0.35
2–5 years	0.59	0.33, 1.03
6–12 years	0.62	0.32, 1.21
13–21 years	Ref	
Hypoxia	1.91	1.11, 3.27
Tachypnea	1.82	1.17, 2.84
Past history of asthma	1.54	0.86, 2.77
ED patient volume at hour of arrival	0.79	0.67, 0.94
Year		0.94, 0.99
2006	Ref	
2007	0.49	0.24, 0.99
2008	0.58	0.32, 1.05
2009	0.26	0.12, 0.53
2010	0.56	0.31, 1.01
2011	0.45	0.21, 0.95