# Quality of care for acute asthma in 63 US emergency departments

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**Background: Little is known about the quality of acute asthma care in the emergency department (ED).**
**Objectives: We sought to determine the concordance of ED management of acute asthma with National Institutes of Health asthma guidelines, to identify ED characteristics predictive of higher guideline concordance, and to assess whether guideline concordance was associated with hospital admission.**
**Methods: We conducted a retrospective chart review study of acute asthma as part of the National Emergency Department Safety Study. Using a principal diagnosis of asthma, we identified ED visits for acute asthma in 63 urban EDs in 23 US states between 2003 and 2006. Concordance with guideline recommendations was evaluated by using item-by-item quality measures and composite concordance scores both at the patient and ED level. These scores ranged from 0 to 100, with 100 indicating perfect concordance.**
**Results: The cohort consisted of 4,053 subjects; their median age was 34 years, and 64% were women. The overall patient guideline concordance score was 67 (interquartile range, 63-83), and the ED concordance score was 71 (SD, 7). Multivariable analysis showed southern EDs were associated with lower ED concordance scores (β-coefficient, −8.2; 95% CI, −13.8 to −2.7) compared with northeastern EDs. After adjustment for the severity on ED presentation, patients who received all recommended treatments had a 46% reduction in the risk of hospital admission compared with others.**
**Conclusions: Concordance with treatment recommendations in the National Institutes of Health asthma guidelines was moderate. Significant variations in ED quality of asthma care were found, and geographic differences existed. Greater concordance with guideline-recommended treatments might reduce hospitalizations. (J Allergy Clin Immunol 2009;123:354-61.)**

***Key words:*** *Acute asthma, emergency department, guidelines, quality of care*

Asthma is an important public health problem in the United States. In 2005, an estimated 7.7% of Americans (22 million) had asthma.[1] Acute asthma accounts for approximately 2 million emergency department (ED) visits and 500,000 hospitalizations each year.[2,3] Despite the significant morbidity associated with acute asthma, little is known about the quality of acute asthma care in the nation's EDs. A key objective for asthma outlined in "Healthy People 2010"[4] is to improve the quality of care by "increasing the proportion of persons with asthma who receive appropriate asthma care according to the guidelines."

The National Institutes of Health (NIH) published the first asthma guidelines in 1991, and updates were made in 1997, 2002, and 2007.[5-8] These guidelines all share a common goal of translating research findings into clinical practice and thereby improving asthma care. However, the extent to which actual ED management of acute asthma is concordant with guideline recommendations remains largely unknown. Assessment of concordance with evidence-based guideline recommendations is commonly used to evaluate quality in health care and help identify targets for quality improvement efforts.[9] Compared with other emergency conditions, such as acute myocardial infarction and pneumonia,[10,11] research on quality of care for acute asthma has received disproportionately less attention. Most studies have focused on quality of care for patients with chronic asthma[12-16] or for patients hospitalized for asthma.[17]

To address these gaps in the current knowledge of acute asthma management, we analyzed data from the asthma component of the National Emergency Department Safety Study (NEDSS). The 3 objectives of this study were (1) to evaluate concordance of ED

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*Abbreviations used*
ED: Emergency department
EMNet: Emergency Medicine Network
ICD-9-CM: International Classification of Disease, Ninth Revision, Clinical Modification
ICU: Intensive care unit
IQR: Interquartile range
NEDSS: National Emergency Department Safety Study
NIH: National Institutes of Health
OR: Odds ratio
PEF: Peak expiratory flow

management of acute asthma with recommendations in the NIH guidelines at both the patient and ED level, (2) to identify ED characteristics predictive of higher ED guideline concordance, and (3) to assess whether guideline concordance was associated with patient outcomes (ie, hospital admission).

# METHODS

## Study design and setting

This retrospective cohort study was part of the NEDSS. Details of the study design and data collection have been published previously.[18] In brief, the NEDSS was a large multicenter study that sought to characterize organizational- and clinician-related factors associated with the occurrence of errors in EDs. NEDSS was coordinated by the Emergency Medicine Network (EMNet; www.emnet-usa.org). We recruited EDs mainly by inviting sites affiliated with the EMNet. Because most EMNet sites are affiliated with an emergency medicine residency program (ie, academic EDs), we made additional efforts to recruit nonacademic and other EDs not affiliated with EMNet through postings on emergency medicine listservs, by contacting sites directly, and through presentations at emergency medicine meetings. We excluded military hospitals, Veterans Administration hospitals, children's hospitals, and hospitals in US territories. A total of 63 US EDs in 23 US states completed the asthma component of the NEDSS. The institutional review boards at all participating hospitals approved the study.

## Study population

By using the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)[19] codes 493.xx, each site identified all charts with a principal ED or hospital discharge diagnosis of asthma from hospital administrative records during a 12-month period. Inclusion criteria were (1) visits made by patients aged 14 to 54 years and (2) a history of asthma before the index visit. We excluded (1) visits made by patients with a history of chronic obstructive pulmonary disease, emphysema, or chronic bronchitis; (2) transfer visits; (3) repeat visits by the same subject; or (4) visits not prompted largely by asthma exacerbation.

In the case of repeat visits, only the first ED visit was included.

## Chart abstraction

Onsite chart abstractors reviewed 70 ED charts randomly selected by the project director (AFS). Sites with less than 70 charts in the preceding 12-month period reviewed all eligible charts. Chart abstractors all had some medical training, with the majority being physicians, nurses, residents, and medical students. Abstractors were trained by the authors (AFS, CAC, RK), and then the abstractors completed practice charts, which were assessed versus a "criterion standard." If an abstractor's accuracy was less than 80% per chart, the individual was retrained. Both computerized tools and paper forms were available for abstractors. Before data collection, the abstraction protocol was tested at 4 EDs. Data from the test sites were used to adjust the abstraction forms but not included in the final data set.

## ED-level information

We distributed a key informant survey at each site to collect data on ED characteristics, such as number of beds in the ED, annual asthma visit volume, region, and affiliation with an emergency medicine residency program. Geographic regions (Northeast, South, Midwest, and West) were defined according to Census Bureau boundaries.[20] Rural and urban distinctions were made according to the Office of Management and Budget's designation of metropolitan statistical area.[21] Information on the presence of an emergency medicine residency program was collected from the Web site of the Society for Academic Emergency Medicine.[22]

## Patient-level information

Data abstracted included baseline patient characteristics, past asthma history, and current asthma medications. ED presentation, treatments (in the ED or at discharge), and disposition also were abstracted. The timing of ED arrival and ED treatments also were collected from charts. Peak expiratory flow (PEF) was recorded in liters per minute and expressed as the absolute value; no predicted values are presented because of lack of patients' height data. Severity of acute asthma was classified according to the initial PEF as follows: mild, 300 L/min or greater for women and 400 L/min or greater for men; moderate, 200 to 299 L/min for women and 250 to 399 L/min for men; severe, 120 to 199 L/min for women and 150 to 249 L/min for men; and very severe, less than 120 L/min for women and less than 150 L/min for men. The absolute PEF values represented approximately 70%, 40%, and 25% of predicted value, respectively, for a typical adult woman and man.[5,8,23]

## Concordance with guidelines: Quality measures

**Process measures.** On the basis of common recommendations contained in the 1997 and 2007 NIH asthma guidelines[6,8] and in the consensus view of the EMNet Steering Committee, we defined *a priori* 12 process measures among patients eligible to receive these treatments, which included 5 level A and 5 level B evidence-based treatments according to the NIH guidelines (Table I). Level A evidence requires substantial numbers of randomized controlled trials involving substantial numbers of participants, and level B requires fewer randomized controlled trials involving fewer numbers of participants.[8] ED treatments with magnesium sulfate, heliox, and inhaled corticosteroids at discharge were excluded because these are relatively new recommendations in the 2007 NIH guidelines, which might not be appropriate measures for our study of asthmatic patients presenting to the ED between 2003 and 2006. We also summarized the 10 evidence-based process measures (levels A and B) by using a patient composite concordance score, which was calculated as the sum of guideline-concordant care provided from the patient's total number of eligible opportunities.[24] These scores were then averaged across patients at the ED level to obtain ED composite scores.[25] These scores ranged from 0 to 100, with a score of 100 indicating perfect concordance. To assess whether the concordance varied by strength of evidence, we computed the scores for level A evidence-based measures separately.

**Outcomes measure.** The primary outcome measure was hospital admission, which was defined as admission to an inpatient unit, observation unit, or intensive care unit (ICU).

## Statistical analysis

Summary statistics at both the patient and ED levels are presented as proportions (with 95% CIs), means (with SDs), or medians (with IQRs) after assessing the data for normality. Bivariate associations were examined by using Student *t* tests, Wilcoxon rank sum tests, and $\chi^2$ tests, as appropriate.

**ED-level analysis.** Associations between ED characteristics and ED composite concordance scores were assessed by using multivariable linear regression, adjusting for aggregate patient mix (age, sex, race, oxygen saturation, respiratory rate, and initial peak flow at ED presentation) at the ED level.

**Patient-level analysis.** To assess the associations between the composite concordance scores and risk of hospital admission, we performed

**TABLE I.** Description of quality measures for acute asthma care

| Measure | Numerator | Denominator | Level of evidence according to NAEPP EPR-3 |
|---|---|---|---|
| Process measure | | | |
| Treatment with inhaled β-agonists in ED | Inhaled β-agonist given in ED | Patients presenting to the ED with an asthma exacerbation | A |
| Treatment with inhaled anticholinergics in ED | Inhaled anticholinergics given in ED | Patients presenting to the ED with a severe asthma exacerbation, which is defined as any of the following criteria: (1) admitted to hospital, ICU, or observation unit; (2) PEF <200 L/min for women and <250 L/min for men Exclusion: the mildest exacerbations (oxygen saturation = 100% and RR <18) | A |
| Treatment with systemic corticosteroids in ED | Systemic corticosteroids given in ED | Patients presenting to the ED with a moderate-to-severe asthma exacerbation, which is defined as any of the following criteria: (1) taking oral corticosteroids at time of ED visit; (2) admitted to hospital, ICU, or observation unit; (3) PEF <300 L/min for women and <400 L/min for men Exclusion: the mildest exacerbations (oxygen saturation = 100% and RR <18) | A |
| Treatment with methylxanthines in ED | Not given methylxanthines in ED | Patients presenting to the ED with an asthma exacerbation | A |
| Treatment with oral corticosteroids at discharge | Oral corticosteroids given in ED | Asthmatic patients who meet the criteria to receive systemic corticosteroids in the ED (see above) and are discharged home | A |
| Treatment with antibiotics in ED | Not given antibiotics in ED | Patients present to the ED with an asthma exacerbation Exclusion: infections that are generally of bacterial origin* | B |
| Treatment with oral antibiotics at discharge | Not given oral antibiotics at discharge | Asthmatic patients who meet the criteria to receive antibiotics in the ED (see above) and are discharged home | B |
| Assessment of airflow limitation | At least 1 PEF measured in ED | Patients presenting to the ED with an asthma exacerbation Exclusion: respiratory extremis (oxygen saturation <90% or RR ≥30) | B |
| Timeliness measure | | | |
| Assessment of airflow limitation | Initial PEF checked within 30 min of arrival | Patients who present to the ED with an asthma exacerbation and have at least 1 PEF measured Exclusion: respiratory extremis (oxygen saturation <90% or RR ≥30) | B |
| Posttreatment assessment of airflow limitation | A posttreatment PEF checked within 30-90 min of first β-agonist treatment† | Patients presenting to the ED with an asthma exacerbation Exclusion: respiratory extremis (oxygen saturation <90% or RR ≥30) | B |
| Treatment with inhaled β-agonists in ED | Inhaled β-agonists given within 15 min of arrival | Patients who present to the ED with an asthma exacerbation and are given β-agonists | – |
| Treatment with systemic corticosteroids in ED | Systemic corticosteroids given within 75 min of ED arrival | ED asthmatic patients who meet the criteria to receive systemic corticosteroids (see above) | – |

*NAEPP EPR-3*, National Asthma Education and Prevention Program Expert Panel Report 3; *RR*, respiratory rate.
*Including pneumonia, cellulitis, urinary tract infection, otitis media, pharyngitis, and sinusitis.
†If time of first β-agonist treatment was not recorded but patients were given at least 1 treatment in the first hour, the time of first β-agonist treatment was set to be 30 minutes after arrival to the ED.

multivariable logistic regression, adjusting for important ED and patient factors that have been shown to predict admission.[26,27] These factors included age, sex, race/ethnicity, duration of symptoms, history of intubation for asthma, chronic use of oral corticosteroids, upper respiratory tract infection, respiratory rate, oxygen saturation, initial PEF, and change in PEF. Variables with substantial missing data (race/ethnicity and PEF) were dummy coded by using the missing indicator method.[28] Several important ED characteristics also were included in the model, including number of beds in the ED, annual asthma visit volume, region, and affiliation with an emergency medicine residency program. The patient composite concordance scores were treated as a dichotomous independent variable because of highly skewed distribution. Dichotomizing concordance into 100% concordance versus other also allowed us to evaluate how results differed using all-or-none quality metric.[29] For the model of hospital admission, only level A guideline-recommended care in the ED was used for calculating the composite scores (ie, inhaled β-agonists, inhaled anticholinergics, systemic corticosteroids, and not receiving methylxanthines) to give more weight to the treatments that have been shown to reduce hospitalizations.[8,30] The multivariable model was fit by using generalized estimating equations to account for the effects of clustering of patients within EDs.[31] The discrimination and calibration of the model was determined by using the c-statistic and Hosmer-Lemeshow test, respectively.[32]

A series of sensitivity analyses were performed to assess the robustness of our findings. First, the ED-level composite concordance scores were generated by using the "opportunity-based" method (ie, the patient-level composite scores were summated at the ED level).[13,25] Second, the hierarchic generalized linear model with binomial response was fit for the admission model to assess the effect of different model-fitting methods.[33] Finally, to address the possibility of reverse causation in the association between guideline concordance and hospitalizations (ie, sicker patients were admitted quickly and thus did not receive treatments in the ED), we refit the admission model by

**TABLE II.** Patient and ED characteristics

| | |
|---|---|
| ED characteristics (n = 63) | |
| No. of ED visits per year, median (IQR) | 58,215 (43,000-75,000) |
| No. of ED visits for asthma per year, median (IQR) | 1,011 (511-1,767) |
| No. of ED beds, median (IQR) | 39 (27-50) |
| Residency affiliated (%) | 76 |
| Census region (%) | |
| Northeast | 44 |
| Midwest | 24 |
| South | 13 |
| West | 19 |
| Urban location (%) | 100 |
| Electronic ED visit notes (%) | 78 |
| Patient characteristics (n = 4,053) | |
| Demographic factors | |
| Age (y), median (IQR) | 34 (24-43) |
| Female sex (%) | 64 |
| Race/ethnicity (%)* | |
| White | 33 |
| Black | 47 |
| Hispanic | 18 |
| Other | 2 |
| Chronic asthma factors (%) | |
| Admitted for asthma in past year | 9 |
| ED visit for asthma in past year | 23 |
| Ever intubated or ventilated for asthma | 9 |
| ED presentation | |
| Initial respiratory rate (breaths/min), median (IQR) | 20 (18-24) |
| Initial oxygen saturation (%), median (IQR)† | 97 (95-99) |
| Initial PEF (L/min), median (IQR)‡ | 240 (170-300) |
| Severity based on initial PEF (%) | |
| Mild | 23 |
| Moderate | 39 |
| Severe | 28 |
| Very severe | 10 |
| Concomitant bacterial infection diagnosis (%) | |
| Pneumonia | 3 |
| Sinusitis | 1 |
| ED disposition (%) | |
| Sent home | 79 |
| Admission (hospital ward/observation unit) | 16 |
| ICU admission | 2 |
| Other (eg, left against medical advice) | 2 |

*Documented for 2,629 patients.
†Documented for 3,970 patients.
‡Documented for 1,877 patients.

excluding patients admitted to the ICU or admitted within 1 hour of ED arrival. All odds ratios (ORs) and β-coefficients are presented with 95% CIs. All analyses were performed with Stata 10.0 software (StataCorp, College Station, Tex). All *P* values are 2-sided, with a *P* value of less than .05 considered statistically significant.

## RESULTS

A total of 6,065 visits with a principal diagnosis of asthma were identified on the basis of ICD-9-CM codes, and the charts were reviewed. A total of 2,015 visits were excluded because of age of 13 years or less (n = 712), age of 55 years or greater (n = 490), history of chronic obstructive pulmonary disease (n = 177), no history of chronic asthma (n = 377), visits not prompted by asthma exacerbation (n = 289), and missing information on inclusion/exclusion criteria (n = 7). The final cohort comprised 4,053 patients who presented to 63 EDs between 2003 and 2006, with 88% of the visits made in 2004. The median number of patients treated per ED was 69 (IQR, 64-70). Participating EDs had high annual visit volumes and cared for high numbers of asthmatic patients annually (Table II). Seventy-six percent were affiliated with an emergency medicine residency program (ie, academic EDs). Participating EDs were all urban but located in different geographic regions of the country. Seventy-eight percent of the EDs used electronic ED visit notes.

The median age of the patients was 34 years (IQR, 24-43 years); 64% were women, and 47% were black. Disease burden was high, with 9% admitted for asthma in the previous year. Nine percent of the patients had been intubated for asthma, and 23% visited the ED for acute asthma in the previous year. On presentation to the ED, the median respiratory rate was 20 breaths/min, oxygen saturation was 97%, and initial PEF was 240 L/min. On the basis of initial PEF results, the majority of patients (77%) were classified as having at least a moderate exacerbation. Concomitant bacterial infections were rare; only 3% had pneumonia. Most patients (79%) were discharged from the ED. Sixteen percent were admitted to the ward or observation unit, and 2% were admitted to the ICU.

Table III shows the item-by-item guideline-recommended treatments prescribed to the patients, as well as the overall concordance scores. At the patient level, the overall concordance with guideline recommendations was moderate, with a median score of 67 (IQR, 63-83; Fig 1). The level of concordance varied considerably by quality measure. By using 70% as a criterion, the asthma care was suboptimal in several areas: PEF assessment (52%), prescription of oral corticosteroid at discharge (66%), and timeliness-related measures (all <70%). The level of concordance also differed by the strength of evidence outlined in the NIH guidelines. The concordance was significantly higher with level A recommendations than with level A and B recommendations (100% vs 67%, $P < .001$).

At the ED level, the number of EDs included for each quality measure ranged from 61 to 63. Similar to the findings at the patient level, the overall ED concordance with guideline recommendations was moderate, with a mean ED composite score of 71 (SD, 7; Fig 2). The quality of care delivered in the ED also varied considerably. The best-performing ED scored 90, whereas the worst-performing ED scored 53. Item-by-item measures revealed that the variation in ED performance was greatest in the following areas: PEF assessment (SD, 24), inhaled anticholinergics (SD, 22), oral corticosteroids at discharge (SD, 19), oral antibiotics at discharge (SD, 14), and all timeliness-related measures (all SDs >10). The composite concordance was significantly higher with level A recommendations than with level A and B recommendations (89% vs 71%, $P < .001$).

### ED-level analysis

The ED characteristics associated with ED-level guideline concordance are shown in Table IV. Although EDs with higher asthma volume and those affiliated with an emergency medicine residency program tended to have higher unadjusted composite concordance scores, the only significant finding on multivariable analysis was that southern EDs were less likely to deliver guideline-concordant care compared with northeastern EDs (β-coefficient, −8.2; 95% CI, −13.8 to −2.7). Further adjustment for aggregate patient mix, including racial composition, reduced

**TABLE III.** Performance on quality measures both at the patient and ED level

| Quality measure | No. of patients eligible | No. of times care was delivered | Percentage of recommended care patient received (95% CI) | Mean ED performance ± SD |
|---|---|---|---|---|
| Process of care | | | | |
| Prescribed inhaled β-agonists in ED | 4,053 | 3,708 | 91 (91-92) | 91 ± 6 |
| Prescribed inhaled anticholinergics in ED | 1,272 | 981 | 77 (75-79) | 77 ± 22 |
| Prescribed systemic corticosteroids in ED | 2,119 | 1,643 | 78 (76-79) | 77 ± 9 |
| Methylxanthines not prescribed in ED | 4,052 | 4,038 | 99 (99.5-99.8) | 99 ± 1 |
| Prescribed oral corticosteroids at discharge | 1358 | 894 | 66 (63-68) | 67 ± 19 |
| Antibiotics not prescribed in ED | 3,847 | 3,543 | 92 (91-93) | 92 ± 6 |
| Oral antibiotics not prescribed at discharge | 3,147 | 2,063 | 83 (81-84) | 82 ± 14 |
| Assessment of PEF | 3,655 | 1,903 | 52 (50-54) | 51 ± 24 |
| Timeliness measure | | | | |
| Initial PEF ≤30 min of arrival | 1630 | 768 | 47 (45-50) | 41 ± 24 |
| Posttreatment PEF within 30-90 min | 3,845 | 850 | 22 (21-23) | 23 ± 15 |
| Inhaled β-agonists ≤15 min of arrival | 3,467 | 968 | 28 (26-29) | 22 ± 16 |
| Systemic corticosteroids ≤75 min of arrival | 1,549 | 961 | 62 (60-64) | 61 ± 17 |
| Composite score | | | **At the patient level, median score ± IQR** | **At the ED level, mean score ± SD** |
| Composite guideline concordance score (level A + B evidence) | – | – | 67 (63-83) | 71 ± 7 |
| Composite guideline concordance score (level A evidence) | – | – | 100 (75-100) | 89 ± 5 |

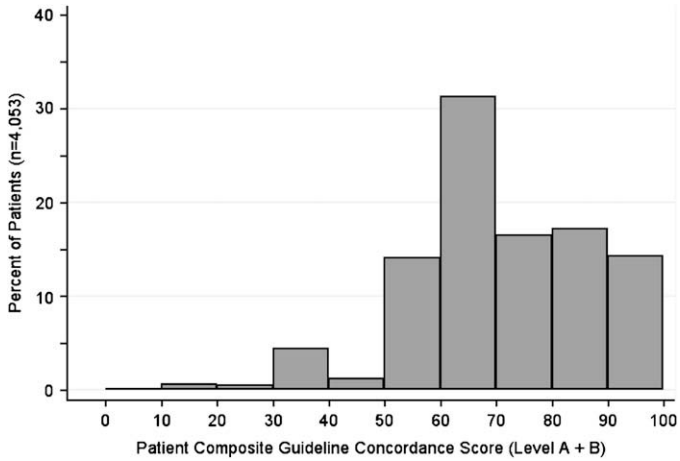


**FIG 1.** Distribution of composite guideline concordance score at the patient level. The scores are slightly negatively skewed, with more extreme values to the left.

the South-Northeast quality gap, but it remained statistically significant (β-coefficient, −6.5; 95% CI, −12.8 to −0.2).

## Patient-level analysis

About three quarters of patients received care that was fully concordant with the 4 level A recommendations in the guidelines (Table V). These patients also had a significantly lower risk of admission compared with others (17% vs 25%, $P < .001$). Multivariable logistic regression was performed to assess the association between concordance with processes of care and patient outcomes (ie, hospital admission). After adjustment for patient and ED characteristics, the risk of admission remained significantly lower (adjusted OR, 0.54; 95% CI, 0.41-0.71; $P < .001$) among patients who received all level A guideline-recommended care in the ED compared with other patients. Also, the risk of admission increased with age ($P < .001$) and was greater in women compared with men ($P = .001$). The c-statistic for the model was 0.81, and the Hosmer-Lemeshow test demonstrated a good fit ($P = .72$).

## Sensitivity analyses

First, using the "opportunity-based" method for the ED-level analysis, southern EDs remained associated with a lower concordance score compared with northeastern EDs after adjusting for patient mix (β-coefficient, −6.4; 95% CI, −12.3 to −0.5). Second, for the admission model, the magnitude of the protective effect of guideline-concordant care on admission was similar by using the hierarchic generalized linear model approach (adjusted OR, 0.50; 95% CI, 0.39-0.65; $P < .001$). Finally, excluding patients admitted to the ICU or admitted within 1 hour of ED arrival (6% of the study population) did not materially change the results (adjusted OR, 0.51; 95% CI, 0.37-0.69; $P < .001$).

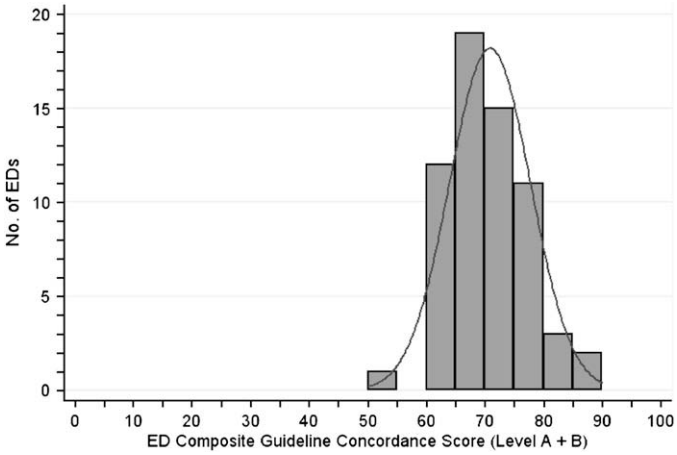


**FIG 2.** Distribution of composite guideline concordance score at the ED level. The scores are normally distributed. The superimposed curve represents the normal curve based on sample mean and SD.

**TABLE IV.** Unadjusted and multivariable predictors of higher ED composite guideline concordance score (level A + B)

| Variable | Unadjusted β- coefficient (95% CI) | Multivariable adjusted β- coefficient (95% CI)* |
|---|---|---|
| No. of ED beds per 10-bed increase | 0.9 (−0.1 to 2.0) | 0.4 (–0.8 to 1.6) |
| Annual ED visits for asthma per 100-visit increase | 0.1 (0.03 to 0.2) | 0.08 (–0.03 to 0.18) |
| Residency affiliated | 4.1 (0.1 to 8.0) | 2.4 (–2.1 to 6.9) |
| Census region | | |
| Northeast | 0 (Reference) | 0 (Reference) |
| Midwest | –2.3 (–6.4 to 1.9) | –2.4 (–6.8 to 2.1) |
| South† | –8.4 (–13.6 to –3.2) | –8.2 (–13.8 to –2.7) |
| West | –3.5 (–8.0 to 1.0) | –3.3 (–8.3 to 1.7) |
| Calendar year per 1-y increase | 0.4 (–6.5 to 7.3) | 0.2 (–6.2 to 6.7) |
| Electronic ED visit notes | 0.009 (–4.2 to 4.2) | 1.6 (–2.9 to 6.1) |

*Model adjusting for all variables shown in the table.
†The South was still associated with lower performance scores (β-coefficient, −6.5; 95% CI, −12.8 to −0.2) compared with the Northeast after adjustment for aggregate patient mix at the ED level, including mean patient age, percentage of male patients, percentage of black patients, mean PEF value, mean oxygen saturation, and mean respiratory rate at ED presentation.

## DISCUSSION

In this study of 4,053 patients presenting to 63 EDs with acute asthma, we found that the overall concordance of emergency care with guideline recommendations was moderate. However, emergency care for asthma was highly concordant with guideline recommendations that are based on the stronger evidence (ie, level A evidence). There were substantial variations in the ED quality of care in different geographic regions, with the widest gap between the South and the Northeast. Our study also showed a strong link between variability in processes of care and patient outcomes.

We identified several opportunities to improve quality of care by addressing problems of underuse and overuse of treatments and by reducing harmful delays in the administration of effective treatments in the ED. More than half of ED patients with acute asthma did not have any PEF measurement throughout their ED stay, and 22% might have benefited from systemic corticosteroid therapy in the ED but did not receive it. A previous study of 12 communities found more underuse of PEF; only 34% of patients presenting to the physician's office with acute asthma had a PEF assessment.[34] With respect to overuse, 17% of patients were started on potentially unnecessary antibiotics at ED discharge. Moreover, all timeliness measures indicated that there was an important delay in delivery of asthma care in the ED. Our data suggested that these should be the priority areas of quality improvement efforts in acute asthma. For example, an ED-based quality improvement program involving provision of peak flowmeters and standard asthma order sheets increased the use of PEF from 20% to 82% and decreased the delays to β-agonist and corticosteroid therapy by 16 minutes.[35] Another ED-based program increased the systemic corticosteroid use from 57% to 68% through implementing an acute-care map.[36]

We also found quality of care for acute asthma varied widely across the 63 EDs. This variation was partly explained by geographic region after controlling for residency affiliation, annual number of ED patients with acute asthma, and patient mix. Therefore geographic differences in quality of care might result from factors other than ED and patient characteristics, such as physicians' practice patterns. Because of the small number of southern EDs in our sample (n = 13), the Northeast-South quality gap requires replications in future studies. Similar to our finding, however, a previous national study of Medicare beneficiaries showed that the Northeast consistently ranked high in quality of care across 6 medical conditions (acute myocardial infarction, breast cancer, diabetes mellitus, heart failure, pneumonia, and stroke), whereas the South consistently ranked low.[37]

Our finding of an association between the use of all evidence-based therapies and reduced hospitalizations supports the use of

**TABLE V.** Univariable and multivariable associations between guideline-concordant care and hospital admission among ED patients with acute asthma

| Guideline-concordant care (all-or-none metric) | Percentage of asthmatic patients (n = 4053) | Percentage of patients in the category admitted | Unadjusted OR* (95% CI) | Adjusted OR* (95% CI) | |
|---|---|---|---|---|---|
| | | | | Model 1† | Model 2‡ |
| Received all 4 types of guideline-recommended care when eligible§ | 76 | 17 | 0.61 (0.48-0.77) | 0.56 (0.43-0.73) | 0.54 (0.41-0.71) |
| Not receiving all 4 types of guideline-recommended care when eligible§ | 24 | 25 | Reference | Reference | Reference |

*Model was fit by using generalized estimating equations to account for the effects of clustering of patients within EDs.
†Multivariable model adjusted for age, sex, race/ethnicity, duration of symptoms, history of intubation for asthma, chronic use of oral corticosteroids, upper respiratory tract infection, respiratory rate, oxygen saturation, initial peak flow, and change in peak flow.
‡Model adjusted for the above patient characteristics plus the following variables of ED characteristics: number of beds in the ED, annual asthma visit volume, region, and affiliation with an emergency medicine residency program.
§The elements of care represented 4 level A guideline-recommended treatments in the ED: inhaled β-agonists, inhaled anticholinergics, systemic corticosteroids, and not receiving methylxanthines.

an all-or-none quality measurement.[29] In addition, our data suggested the magnitude of reduced hospitalizations by complete delivery of a series of effective treatments (all-or-none) was substantial, reducing the odds of admission by half. Using an all-or-none metric raises the bar on performance for health care providers. It certainly represents a tougher task; however, we believe it can advance excellence in patient care, which, in turn, will improve emergency asthma care.

Our study has some potential limitations. First, the study relied on medical record review for quality assessment, and some of the apparent quality deficit might be due to underdocumentation. However, previous studies showed that the rates of ED assessments and treatments for asthma by chart abstraction were similar to those by direct observation, with κ coefficients ranging from 0.6 to 0.9.[38] In addition, underdocumentation cannot explain the considerable overuse of antibiotics we identified.

Second, because most EDs that participated in our study are academic and in urban areas, our results might not be generalizable to other settings.

Third, cases were identified by ICD-9 codes, and differences in coding practices might lead to a different patient mix between the Northeast and the South. This might explain part of the Northeast-South quality gap we observed.

Fourth, the associations of timeliness measures are likely to influence the associations between patient concordance and hospital admission, and more studies are required to delineate these associations.

Finally, as with any observational study, the association between guideline concordance and reduced hospitalizations does not necessarily prove causality and might be confounded by unmeasured factors.

In summary, our study demonstrated 3 key findings, and each finding has important policy and clinical implications. First, even in a sample comprised of mostly academic EDs, concordance with guideline recommendations was moderate. Future quality improvement efforts should be focused on the quality gaps identified. The quality chasm might be bridged through quality improvement efforts or perhaps by providing incentives for improvement (eg, public reporting and pay for performance). Second, significant variations in ED quality of asthma care were found, and geographic difference existed. Therefore quality improvement programs should consider monitoring ED care for this important respiratory condition and identifying the barriers in delivery of high-quality asthma care. Finally, we observed a strong association between perfect compliance with recommended patient care guidelines and reduced hospitalizations. We believe that through greater adherence to asthma guideline recommendations, the ultimate goal of quality improvement, better patient outcomes, will result.

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**Clinical implications: Concordance of emergency asthma care with the NIH guidelines was moderate. Patients who received all recommended treatments had lower risk of admission. Quality improvement efforts aimed at increasing the rate of concordance would likely improve patient outcomes.**

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