Published in final edited form as:

Am J Emerg Med. 2008 May ; 26(4): 473–479. doi:10.1016/j.ajem.2007.05.026.

Assessment of severity measures for acute asthma outcomes: a first step in developing an asthma clinical prediction rule[★]

Donald H. Arnold, MD, MPH^{a,b,*}, Tebeb Gebretsadik, MPH^c, Patricia A. Minton, RN^e, Stanley Higgins, PhD^{d,e}, and Tina V. Hartert, MD, MPH^{d,e,f}

^aDepartment of Emergency Medicine, Vanderbilt University School of Medicine, Nashville, TN 37232-4700, USA

^bDepartment of Pediatrics, Vanderbilt University School of Medicine, Nashville, TN 37232-4700, USA

^cDepartment of Biostatistics, Vanderbilt University School of Medicine, Nashville, TN 37232-4700, USA

^dDivision of Allergy, Pulmonary and Critical Care Medicine, Vanderbilt University School of Medicine, Nashville, TN 37232-4700, USA

^eDepartment of Medicine, Vanderbilt University School of Medicine, Nashville, TN 37232-4700, USA

^fCenter for Health Services Research, Vanderbilt University School of Medicine, Nashville, TN 37232-4700, USA

Abstract

Objective—As a first step in the development of an asthma prediction rule, our primary objective was to assess the association of 8 candidate predictor variables with 2 clinically relevant asthma outcomes.

Methods—Among a cohort of 125 adults hospitalized with an asthma exacerbation, we examined models to identify clinical variables associated with length of stay (LOS) and clinically significant asthma exacerbations within 3 months after hospitalization (3-month exacerbation). Eight candidate predictor variables were chosen, including age, sex, race, pulsus paradoxus, prior endotracheal intubation for asthma, hospitalization within 5 years for asthma, and 2 chronic asthma severity scores.

Results—We found independent associations between LOS and pulsus paradoxus ($P = .005$), prior intubation ($P = .03$), sex ($P = .03$), and prior hospitalization ($P = .019$). Among men, 52% had a 3-month exacerbation in comparison with 25% of women; and in multivariable analysis, male sex was independently associated with 3-month exacerbation (adjusted odds ratio = 5.1; 95% confidence interval = 1.37–18.9; $P = .015$). Participants with 3-month exacerbation had higher Johns Hopkins Allergy and Asthma Composite (JHAAC) chronic severity scores (median = 77; interquartile range = 57–91) than those who did not (median = 54; interquartile range = 35–69; $P < .001$) (for 40-unit increase, adjusted OR for 3-month exacerbation = 1.54; 95% confidence interval = 1.16–2.03; $P = .003$). In multivariable analysis, male sex and the JHAAC severity score were independently associated with 3-month exacerbation.

[★]Funding source: National Institutes of Health KO8 AI001582 to TVH; American Lung Association Clinical Research Grant to TVH.

© 2008 Elsevier Inc. All rights reserved.

* Corresponding author. Department of Emergency Medicine, Vanderbilt University Medical Center, Nashville, TN 37232-4700, USA. Tel.: +1 615 936 0095; fax: +1 615 936 1316. don.arnold@vanderbilt.edu (D.H. Arnold).

Conclusions—Elevated pulsus paradoxus, prior intubation for asthma, and 5-year asthma hospitalization are independently associated with LOS. Race, 5-year asthma hospitalization, and JHAAC score predict 3-month asthma exacerbation. These variables warrant consideration for use in the development of an asthma prediction rule.

1. Introduction

1.1. Background

Asthma is one of the most frequent acute conditions that emergency medicine physicians are called upon to evaluate and manage [1-4]. However, assessment of acute asthma severity continues to be difficult and imprecise, in part because of a lack of available objective measures of disease severity and the variability in how individual patients manifest signs and symptoms [5]. Needed are objective, validated, reliable, and practical measures with which clinicians at the bedside can quickly predict acute disease severity, therapeutic response, and relevant outcomes of acute asthma exacerbations.

A clinical prediction rule is a decision-making tool that uses available history, physical examination, and diagnostic tests to reduce the inherent variability in diagnosis and prediction of response to treatment [6-8]. Clinical and biostatistical standards for prediction rule development have been established [6,8,9].

A first step in the development of an asthma clinical prediction rule (APR) is the selection of appropriate outcome variables. The outcomes to be predicted must be both clinically important and clearly defined [6,10]. Although the most definitive, objective asthma outcome is death from respiratory failure, deaths from asthma are too infrequent to be of use as an outcome measure for developing an APR. Admission to the hospital or ICU is a relevant surrogate outcome measure [11-13]. However, these admission decisions are frequently influenced by situational and subjective factors and are not appropriate outcome measures for modeling an APR [10].

Hospital length of stay (LOS) may be a more appropriate outcome measure and indicator of severity of illness [14]. In addition, 3-month exacerbation after emergency department (ED) or hospital care is a surrogate outcome variable pertinent to ED management.

Predictor variables must be well defined, biologically plausible, and available in the clinical setting, and should enter the scoring system consistent with the manner in which each predictor becomes available clinically [15-17]. Models with too many predictors lead to overfitting of data and poor performance in different populations [18]. Furthermore, clinicians are most likely to use a simple prediction rule that follows the principle of parsimony: simpler models are not only easier to use in the acute care setting but are also more likely to represent reality than more complex models [18].

The primary objective of this study was to identify and assess the association of select candidate predictor variables with 2 clinically relevant outcome measures for future modeling of an APR. To do so, we considered 2 models to identify variables capable of predicting LOS and the occurrence of an asthma exacerbation requiring ED care or hospitalization within 3 months of hospital discharge (3-month exacerbation).

2. Methods

2.1. Setting and selection of participants

The “Bronchopulmonary Response During Episodes of Asthma and the Treatment and History of Exacerbations” cohort is a prospective study of participants 18 years and older

recruited from patients with asthma exacerbations admitted to a tertiary university teaching hospital. The study's database includes demographic, historical, environmental, physical examination, and laboratory variables.

Each weekday and every third weekend during the hours of 8:00 AM to 4:00 PM, between December 1999 and March 2006, all adult patients hospitalized with the diagnosis of acute asthma were approached for study inclusion. Charts on participants were reviewed to ensure that the hospital admission was for asthma. Patients were excluded if they had other chronic pulmonary diseases or other conditions that could account for the acute illness or if they were previously enrolled in the study. The study was approved by the institutional review board, and written informed consent was obtained from each participant.

2.2. Data collection and processing

Our trained study nurses completed a standardized form including medical and social history and clinical symptoms. The study nurses also measured vital signs and performed a physical assessment. We evaluated participants daily during hospitalization and collected clinical data at admission, 24 hours after admission, at discharge, and 3 months after discharge.

2.3. Predictor and outcome measures

Predictor variables to be included in the models were chosen from the data set of recorded variables in accordance with the principles of predictor variable selection [6,16,17]. As such, we chose a priori 8 variables for inclusion based upon their being available at the bedside, objective and well-defined, biologically and physiologically plausible, and likely to contribute meaningfully to a simple predictive model.

The 8 variables included *age* at time of hospitalization, *sex*, and self-reported *race* as well as those defined as follows. Chronic asthma disease severity during the previous 1-year period was measured using the Johns Hopkins Allergy and Asthma Composite (JHAAC) score in which lower values indicate milder disease [19]. The JHAAC is a research instrument developed and internally validated to assess asthma severity and control over the prior 1-year period. The score captures the frequency of signs, symptoms, impact on daily activities, use of emergency facilities, lifetime and recent hospitalizations, and use of inhaled bronchodilator and oral steroid medications.

A simpler composite score of chronic disease severity and control over the previous 1-month period was also recorded, based upon the Tayside Asthma Stamp [20]. This *Tayside composite score* consisted of 3 questions: (1) How many days in the last month have you had your usual asthma symptoms during the day? (2) How many days in the last month has your asthma interfered with usual activities? (3) How many nights in the last month have you had difficulty sleeping because of asthma symptoms? We created a scoring system whereby each question was scored as 1 (no events), 2 (1-2 times per month), 3 (1-2 times per week), or 4 (daily/nightly), with the sum total comprising the composite score. *Pulsus paradoxus* was defined as the maximal millimeters of mercury difference in systolic blood pressure between inspiration and expiration, measured manually with a sphygmomanometer. Normal physiologic levels of pulsus paradoxus are <10 mm Hg [21-23]. The variables *prior endotracheal intubation for asthma* and *hospitalized for asthma within past 5 years* were categorized as yes/no by self-report.

The 2 outcome measures for this study were LOS and 3-month exacerbation. *Length of stay* was defined as total length of hospital admission in half-day increments. A *3-month exacerbation* was defined as an ED visit or hospitalization for asthma in the 3 months after hospital discharge as determined at the 3-month follow-up visit.

2.4. Data analysis

Descriptive characteristics of the study participants are expressed as median and interquartile range (IQR) or mean and standard deviations (SDs) for continuous variables and as frequencies and proportions for categorical variables. Candidate predictor variables chosen for the models included continuous (age, pulsus paradoxus), ordinal (JHAAC and Tayside composite scores), and dichotomous variables (sex, race, previous endotracheal intubation for respiratory failure, hospitalization within 5 years for asthma). The correlation between LOS and continuous clinical characteristics was assessed using the Spearman rank correlation coefficient (ρ). Wilcoxon rank-sum tests were used to compare the distributions of LOS and categorical candidate predictor variables. For the outcome of 3-month exacerbation, continuous candidate predictor variables were compared using Wilcoxon rank-sum tests and categorical candidate predictor variables by χ^2 tests. Multiple linear regression was used to assess the independent associations of candidate predictor variables and LOS. Logarithmic transformation of LOS was applied to achieve normality of the residuals.

Logistic regression models were used to calculate adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for candidate predictor variables and the outcome of 3-month exacerbation. The maximum number of candidate predictor variables to be included in each model was determined based upon the 10-events-per-variable rule to minimize overfitting [24]. The frequency of the outcome variable, 3-month exacerbation, would thus limit the number of predictor variables in each regression model. Age and sex were chosen a priori for adjustment in assessing the effect of each predictor variable on the outcome of 3-month exacerbation.

R-software version 2.11 (www.r-project.org) and SAS version 9.0 (SAS Institute, Cary, NC) were used for data analysis. A 2-sided 5% significance level was used for all statistical inferences.

3. Results

During daytime screening hours, we approached for enrollment 136 of the 235 unique eligible patients admitted during the entire study period. Of these, 125 agreed to participate, resulting in a recruitment rate of 92% among those approached for enrollment during study hours and 53% of eligible patients overall. Demographic and asthma characteristics of the participants are included in Table 1. Most participants were female, and most were white. There was representation of both commercial insurance coverage and Tennessee Medicaid. Most participants received their outpatient care from a primary care physician alone, and most were either current or past smokers.

The mean age of asthma onset was 21 years. Inhaled corticosteroids had been prescribed to 67% of participants, and 35% of these participants did not use this medication. Fifty-four percent had been admitted to the hospital within 5 years, 38% had been admitted to an ICU for asthma, and 20% had previously undergone endotracheal intubation for respiratory failure.

Mean pulsus paradoxus was 17.4 mm Hg at the time of hospital admission. The median LOS for our cohort was 2.5 days (IQR = 2.0-3.5). Thirty-one percent of subjects who completed 3-month phone follow-up ($n = 97$) experienced a 3-month exacerbation.

Median LOS was 2.5 (IQR = 2.0-3.5) days. Longer LOS was associated with participants having a history of endotracheal intubation for respiratory failure (median LOS = 3.5; IQR = 3-4) than those who did not (median LOS = 2.5; IQR = 2-3.5; $P = .0009$) (Table 2 and Fig.

1). Those hospitalized for asthma in the past 5 years also had longer LOS (median = 3; IQR = 2-4) than those who did not (median = 2.5; IQR = 2-3; $P = .013$). Pulsus paradoxus was associated with longer LOS ($\rho = 0.33$; $P = .0002$). The associations between longer LOS and pulsus paradoxus ($P = .005$), prior intubation ($P = .030$), sex ($P = .030$), and prior hospitalization ($P = .019$) remained after adjustment.

Participants who had 3-month exacerbations (Table 3 and Fig. 1) were younger (mean = 38.7 years; SD = 11.3) than those who did not (mean = 44 years; SD = 12.6; $P = .05$). Among men, 52% had a 3-month exacerbation in comparison with 25% of women; and in multivariable analysis, male sex was independently associated with this outcome (adjusted OR = 5.1; 95% CI = 1.37-18.9; $P = .015$).

Thirty participants had a 3-month exacerbation. In accordance with the 10-events-per-variable rule, each logistic regression model included one predictor variable in addition to age and sex (Table 3) [24]. This analysis provides ORs for 3-month exacerbation adjusted for age and sex. Fifty-three percent of African Americans had a 3-month exacerbation vs 24% of other participants (adjusted OR = 1.84; 95% CI = 0.69-4.94; $P = .22$). Participants with a 3-month exacerbation had higher JHAAC severity scores (median = 77; IQR = 57-91) than those who did not (median = 54; IQR = 35-69; $P < .001$), and JHAAC severity scores were independently associated with this outcome (for a 40-unit increase in JHAAC severity score, adjusted OR = 1.54; 95% CI = 1.16-2.03; $P = .003$).

4. Discussion

The objective of this study was to identify the strength of association of candidate predictor variables for future use in the development of an asthma prediction rule, using data from a prospective cohort of adults hospitalized for an asthma exacerbation and followed up at 3 months after hospital discharge. Eight candidate predictor variables were considered based upon accepted criteria for predictor variable selection [6,15-17]. To evaluate the ability of these predictor variables to provide clinically meaningful information, 2 outcome measures based upon appropriate criteria were used [6,10].

Elevated pulsus paradoxus at the time of admission, a history of endotracheal intubation for asthma, and asthma hospitalization within 5 years each were independently associated with LOS. This finding is consistent with a previous investigation of adults with severe asthma and affirms the role of LOS as an important outcome measure and a surrogate for asthma severity [14]. The ability to predict LOS is thus clinically useful to the emergency medicine physician in determining the need for hospital or ICU admission or appropriate outpatient management and disposition.

The 3-month exacerbation rate in this group was high; and race, 5-year asthma hospitalization, and JHAAC severity score predicted this outcome. This is an important outcome for intervening and preventing disease exacerbations in at-risk or susceptible groups. The associations we found between 3-month exacerbation and male sex and the JHAAC severity score are plausible because they may each reflect chronic disease severity and medication compliance.

Our findings pertain to a single, prospective convenience sample of adults presenting with acute asthma exacerbations and admitted to the hospital. The demographics of this cohort are not much different from other hospitalized cohorts, including the percentages of women, those with suboptimally controlled asthma at baseline, and those with prior endotracheal intubation for respiratory failure [14,25,26]. Further development of an asthma prediction rule will nonetheless necessitate continued internal and external validation in different populations. As such, the predictive value of the identified candidate predictor variables is

not presented as a clinical prediction rule, but rather to identify candidate predictors for consideration in the development of an APR.

A strength of the study was our trained study nurses with expertise in patient assessment and measurement of pulsus paradoxus. The recruitment rate of 92% among those approached for enrollment served to minimize selection bias in our sample. An additional strength was the prospective manner of data acquisition, providing a comprehensive database of relevant variables.

A potential limitation is the exclusion of patients evaluated, treated, and discharged from the ED or out-patient setting for an asthma exacerbation; these patients were not included in this cohort. Exclusion of patients discharged from the ED may have introduced spectrum bias. Some of these patients may have subsequently sought care in our ED or another facility and may have been admitted to the hospital. However, extensive data collection over multiple, clinically relevant time points was accomplished with each participant; and this comprehensive evaluation was facilitated by recruitment of hospitalized patients. Our objective was to identify candidate predictor variables that are associated with the need for admission to the hospital (ie, LOS) and the likelihood of clinically significant disease exacerbations after hospital admission (ie, 3-month exacerbation). As such, the population of interest for this study was those patients perceived to be sufficiently ill to warrant hospital admission. In retrospect, our study might be strengthened if we had recorded specific date of readmission to the ED or hospital at the 3-month follow-up visit for each participant experiencing this event. This would have enabled a time-to-event analysis and calculation of hazard ratios for 3-month exacerbation. An additional limitation is the use of the Tayside composite score. This instrument has not been validated as a metric of asthma severity.

In summary, a necessary first step in developing an asthma prediction rule is the selection of outcomes that fulfill the standards discussed previously. The 2 outcomes chosen for this study meet these standards and are clinically relevant in the ED environment. Length of stay is a surrogate for disease severity [14]. In addition, clinical features that identify the patient likely to experience clinically significant exacerbations after ED or hospital care may facilitate identification of those who might benefit from more intensive disease management.

A second step is the compilation of a list of candidate predictors for the outcome of interest [7]. We have investigated 8 variables as candidate predictor variables from a large number of variables recorded as part of this prospective, hospitalized adult cohort. These candidate predictor variables might be considered in the development of an asthma prediction rule, a necessary next step in advancing the care of patients with asthma evaluated and managed in the ED.

References

1. Mannino DM, Homa DM, Akinbami LJ, et al. Surveillance for asthma—United States, 1980-1999. *MMWR Surveill Summ.* 2002; 51:1–13.
2. Asthma prevalence and control characteristics by race/ethnicity—United States, 2002. *MMWR Morb Mortal Wkly Rep.* 2004; 53:145–8. [PubMed: 14985651]
3. Akinbami LJ, Schoendorf KC. Trends in childhood asthma: prevalence, health care utilization, and mortality. *Pediatrics.* 2002; 110:315–22. [PubMed: 12165584]
4. Yawn BP, Wollan P, Kurland M, et al. A longitudinal study of the prevalence of asthma in a community population of school-age children. *J Pediatr.* 2002; 140:576–81. [PubMed: 12032525]
5. McFadden ER Jr. Acute severe asthma. *Am J Respir Crit Care Med.* 2003; 168:740–59. [PubMed: 14522812]

6. Laupacis A, Sekar N, Stiell IG. Clinical prediction rules. A review and suggested modifications of methodological standards. *JAMA*. 1997; 277:488–94. [PubMed: 9020274]
7. McGinn TG, Guyatt GH, Wyer PC, et al. Users' guides to the medical literature: XXII: how to use articles about clinical decision rules. Evidence-Based Medicine Working Group. *JAMA*. 2000; 284:79–84. [PubMed: 10872017]
8. Wasson JH, Sox HC, Neff RK, et al. Clinical prediction rules. Applications and methodological standards. *N Engl J Med*. 1985; 313:793–9. [PubMed: 3897864]
9. Harrell FE. Regression modeling strategies. New York: Springer. 2001
10. Stiell IG, Wells GA. Methodologic standards for the development of clinical decision rules in emergency medicine. *Ann Emerg Med*. 1999; 33:437–47. [PubMed: 10092723]
11. Turner MO, Noertjojo K, Vedal S, et al. Risk factors for near-fatal asthma. A case-control study in hospitalized patients with asthma. *Am J Respir Crit Care Med*. 1998; 157:1804–9. [PubMed: 9620909]
12. Magadle R, Berar-Yanay N, Weiner P. The risk of hospitalization and near-fatal and fatal asthma in relation to the perception of dyspnea. *Chest*. 2002; 121:329–33. [PubMed: 11834639]
13. Story RE, Greenberger PA. Potentially fatal asthma. *Allergy Asthma Proc*. 2004; 25:S29–30. [PubMed: 15515372]
14. Gupta D, Keogh B, Chung KF, et al. Characteristics and outcome for admissions to adult, general critical care units with acute severe asthma: a secondary analysis of the ICNARC Case Mix Programme Database. *Crit Care*. 2004; 8:R112–21. [PubMed: 15025785]
15. Moons, KG. Erasmus Universiteit Rotterdam; The Netherlands: Diagnostic research. Theory and application. 10-30-1996..
16. Harrell Jr FE, Lee KL, Mark DB. Multivariable prognostic models: issues in developing models, evaluating assumptions and adequacy, and measuring and reducing errors. *Stat Med*. 1996; 15:361–87. [PubMed: 8668867]
17. Stiell, IG. The development of clinical decision rules for injury care.. In: Rivara, FP., editor. *Injury control: research and program evaluation*. Cambridge University Press; Cambridge (UK): 2001. p. 217-35.
18. Steyerberg, EW. Theory and applications. Erasmus University Rotterdam; The Netherlands: 1996. Prognostic modeling for clinical decision making.; p. 1-197.
19. Togias A, Horowitz E, Joyner D, et al. Evaluating the factors that relate to asthma severity in adolescents. *Int Arch Allergy Immunol*. 1997; 113:87–95. [PubMed: 9130491]
20. British Thoracic Society. The BTS/SIGN British guidelines in the management of asthma. World wide web. 9-22-2006. 9-22-2006.
21. Seidel, HM., editor. *Mosby's guide to physical examination*. St. Louis; Mosby: 2003. Blood vessels examination and findings.; p. 481
22. National Heart, Lung, and Blood Institute, National Asthma Education and Prevention Program.. National Asthma Education and Prevention Program (Publication no. 97-4051). US Department of Health and Human Services, National Institutes of Health; Bethesda (Md): 1997. Expert panel report 2: guidelines for the diagnosis and management of asthma..
23. Bilchick KC, Wise RA. Paradoxical physical findings described by Kussmaul: pulsus paradoxus and Kussmaul's sign. *Lancet*. 2002; 359:1940–2. [PubMed: 12057571]
24. Peduzzi P, Concato J, Kemper E, et al. A simulation study of the number of events per variable in logistic regression analysis. *J Clin Epidemiol*. 1996; 49:1373–9. [PubMed: 8970487]
25. Dhuper S, Maggiore D, Chung V, et al. Profile of near-fatal asthma in an inner-city hospital. *Chest*. 2003; 124:1880–4. [PubMed: 14605063]
26. Wisnivesky JP, Leventhal H, Halm EA. Predictors of asthma-related health care utilization and quality of life among inner-city patients with asthma. *J Allergy Clin Immunol*. 2005; 116:636–42. [PubMed: 16159636]

Fig. 1.

Multivariable analysis of candidate predictor variables with LOS (multiple linear regression model). Vertical bars, effect (increase or decrease) in LOS; horizontal bars, 95% CIs. ¹JHAAC score of disease severity over the previous 1-year period. Lower score indicates milder severity. ²Tayside composite score of chronic disease severity and control over the previous 1-month period. Lower score indicates milder severity and better control.

Table 1

Demographic and asthma characteristics of 125 adult patients with exacerbations requiring hospital admission

	n ^a	Mean ± SD or %
Age	125	42 ± 12.4 y
Female	100	80%
Race		
White	66	53%
African American	56	45%
Other	3	2%
Insurance		
TennCare	53	42%
Commercial	49	39%
Other	23	18%
Type of physician providing outpatient care		
PCP	73	58%
Pulmonologist	40	32%
Allergist	3	2%
PCP with pulmonologist or allergist	5	5%
Other	4	3%
Cigarette smoking		
Never smoked	43	34%
Current, former, or second-hand smoker	82	66%
Smoking pack years	60	18.5 ± 25.4
Known earliest age of asthma	125	21 ± 17.8
Participant monitors PEFR at home	123	42%
Hospitalized for asthma within past 5 y	124	54%
Admitted to ICU during lifetime	125	38%
Intubated for asthma during lifetime	122	20%
JHAAC score (mean)	122	64.6 ± 41.4
Tayside composite severity score	122	8.84 ± 2.09
Respiratory rate	123	23.2 ± 4.54
Accessory muscle use	123	15%
Pulsus paradoxus (mm Hg)	119	17.4 ± 7.87

PCP indicates primary care physician; PEFR, peak expiratory flow rate.

^aNumber of nonmissing values.

Table 2

Length of stay among 125 adults hospitalized for an acute asthma exacerbation by demographic and clinical characteristics

Categorical variables	n ^a	LOS median (IQR)	p ^b
Sex			
Male	25	2.5 (2-3)	.24
Female	100	2.5 (2-3.5)	
Race			
African American	56	2.5 (2-3.5)	.83
Other ^c	69	2.5 (2-3.5)	
Prior endotracheal intubation for asthma			
No	97	2.5 (2-3.5)	.0009
Yes	25	3.5 (3-4)	
Hospitalized for asthma within past 5 y			
No	57	2.5 (2-3)	.013
Yes	67	3 (2-4)	
Continuous variables		Spearman ρ	
Age	125	0.0005	1.0
Pulsus paradoxus	119	0.33	.0002
JHAAC score	122	-0.014	.88
Tayside composite severity score	122	0.024	.79

^aNumber of nonmissing values.

^bUnadjusted *P* values obtained with Wilcoxon rank-sum tests for categorical variables and Spearman correlation coefficients tests for continuous variables.

^cWhite (66), Hispanic (2), Asian (1).

Table 3

Association of predictor variables with asthma exacerbations after hospitalization among 97 adults returning for 3-month follow-up

	No relapse	Relapse	Unadjusted OR ^a (95% CI) ^b	Adjusted OR ^a (95%CI) ^c
n ^d (%)	67 (69%)	30 (31%)		
Variable				
Age, mean (SD)	44 (±12.6)	38.7 (±11.3)	0.96 (0.93-1.00)	–
Female sex, %	85	63	0.30 (0.11-0.82)	–
African American, %	33	53	2.34 (0.96-5.64)	1.84 (0.69-4.94)
Previous intubation, %	16	32	2.41 (0.86-6.71).	2.24 (0.74-6.75)
Hospitalized for asthma within past 5 y, %	53	60	1.33 (0.55-3.19)	1.64 (0.63-4.22)
Pulsus paradoxus (IQR)	16 (12-22)	18 (14-22)	1.15 (0.86-1.55)	1.07 (0.78-1.47)
Tayside composite severity score (IQR)	9 (7-10)	9 (8-11)	1.49 (0.64-3.46)	1.41 (0.56-3.60)
JHAAC (IQR)	54 (35-69)	77 (57-91)	1.50 (1.15-1.94)	1.54 (1.16-2.03)

Emergency department visit or hospitalization for asthma 3 months after hospital discharge. χ^2 test for categorical variables and Wilcoxon rank-sum test for continuous variables.

^aOdds ratios calculated based on the following: pulsus paradoxus, >20 mm Hg by 5-mm increments; Tayside score, >6 by 4-point increments; JHAAC, >40 points by 20-point increments.

^bLogistic regression was applied.

^cMultivariable logistic regression adjusted for age and sex.

^dNumber of nonmissing values.