Variation in Ancillary Testing among Pediatric Asthma Patients Seen in Emergency Departments

Rachel M. Stanley, MD, MHSA, Stephen J. Teach, MD, MPH, N. Clay Mann, PhD, MS, Elizabeth R. Alpern, MD, MSCE, Michael J. Gerardi, MD, Prashant V. Mahajan, MD, MPH, MBA, James M. Chamberlain, MD, the Pediatric Emergency Care Applied Research Network

Abstract

Background: Variation in the management of acute pediatric asthma within emergency departments is largely unexplored.

Objectives: To investigate whether ancillary testing for patients with asthma would be associated with patient, physician, and hospital characteristics.

Methods: The authors performed an analysis of a subset of patients from an extensive retrospective chart review of randomly selected charts at all 25 member emergency departments of the Pediatric Emergency Care Applied Research Network. Patients with a diagnosis of asthma were selected for supplemental review and included in this study. Ancillary tests analyzed were chest radiographs and selected blood tests. Hierarchical analyses were performed to describe the associations between ancillary testing and the variables of interest.

Results: A total of 12,744 chart abstractions were completed, of which 734 (6%) were patients with acute exacerbations of asthma. Overall, 302 patients with asthma (41%) had ancillary testing. Of the 734 patients with asthma, 198 (27%) had chest radiographs and 104 (14%) had blood tests. Chest radiographs were more likely to be ordered in patients with fever. Less blood testing was associated with physician subspecialty training in pediatric emergency medicine, patients treated at children's hospitals, higher patient oxygen saturation, and patient disposition to home.

Conclusions: Ancillary testing occurred in more than one third of children with asthma, with chest radiographs ordered most frequently. Efforts to reduce the use of chest radiographs should target the management of febrile patients with asthma, whereas efforts to reduce blood testing should target providers without subspecialty training in pediatric emergency medicine and patients treated in nonchildren's hospitals who are more ill.

ACADEMIC EMERGENCY MEDICINE 2007; 14:532–538 © 2007 by the Society for Academic Emergency Medicine

Keywords: asthma, pediatric, ancillary testing

From the Department of Emergency Medicine, University of Michigan Health System (RMS), Ann Arbor, MI; Children's National Medical Center (SJT, JMC), Washington, DC; Intermountain Injury Research Center, University of Utah (NCM), Salt Lake City, UT; Children's Hospital of Philadelphia (ERA), Philadelphia, PA; Morristown Memorial Hospital (MJG), Morristown, NJ; and Children's Hospital of Michigan (PVM), Detroit, MI.

Received October 30, 2006; revision received January 17, 2007; accepted January 18, 2007.

Supported in full by grant UO3 MC00003 from the Maternal and Child Health Bureau, Health Resources and Services Administration, Department of Health and Human Services.

Pediatric Emergency Care Applied Research Network members are listed in Appendix A.

Contact for correspondence and reprints: Rachel M. Stanley, MD, MHSA; e-mail: stanleyr@med.umich.edu.

An acute exacerbation of asthma is a clinical diagnosis that usually does not require radiographic or blood tests for appropriate medical management.[1–5] The costs of these radiographs and blood tests are significant; furthermore, chest radiographs expose patients to ionizing radiation and blood tests provoke pain and anxiety in children. Prior studies have shown that chest radiographs are overutilized in children and adults with acute asthma seen in emergency department (ED) settings.[6,7] These studies limited their analyses to chest radiographs and blood gases. To our knowledge, there are no multicenter studies evaluating the use of chest radiographs and blood tests among pediatric patients with acute asthma seen in the ED.

Variation in the care delivered to children in the ED has been associated with patient characteristics, physician

ISSN 1069-6563
PII ISSN 1069-6563583

doi: 10.1197/j.aem.2007.01.016

training, hospital specialization, and differences in regional health systems.[8–17] We performed this multicenter study to examine the prevalence of and the factors associated with variation in the use of chest radiographs and blood testing (ancillary testing) for pediatric patients with asthma presenting to EDs within a research network.

We hypothesized that there would be variations in the use of ED ancillary testing in pediatric asthma, based on specific measurable factors. The documentation of factors associated with variations in ED ancillary testing of children with asthma may help us understand the context in which these tests are performed and identify those factors that may be amenable to intervention, with the ultimate goal of improving the quality and efficiency of care given to children with asthma.

METHODS

Study Design

This was a retrospective study utilizing all 25 member EDs of the Pediatric Emergency Care Applied Research Network (PECARN).[18] The study was approved by the institutional review boards of the participating hospitals and of the PECARN Central Data Monitoring and Coordinating Center at the University of Utah.

Study Setting and Population

Data were obtained by chart review during a 90-day study period in February through April 2003. The Central Data Management and Coordinating Center randomly selected ten days within the study period for data collection. Each site then generated a list of all patients younger than 19 years of age seen on that day, ordered by arrival time. To avoid overrepresentation of large-volume EDs, a random list of 60 visit records was then generated from the Central Data Monitoring and Coordinating Center for each site; if the site saw fewer than 60 patients on the chosen day, all of the patients were included. Standard variables were abstracted for all patient encounters. A standardized supplemental data abstraction form was completed for all patients who met the case definition for an acute exacerbation of asthma.

Pediatric patients in this study were defined as patients aged 1–18 years, inclusive. Patients were included if the primary discharge diagnosis on the chart was asthma, corresponding to the International Classification of Diseases, version 9, Clinical Modification (ICD9-CM) group 493.00–493.99. Asthma as a discharge diagnosis was defined as when written as either the primary discharge diagnosis on the ED record or as the second or third discharge diagnosis when the following were in the top two diagnoses: wheezing, cough, bronchitis, breathing difficulty, pneumonia, respiratory distress, or respiratory difficulty. The following discharge diagnoses were also considered asthma: asthma exacerbation, status asthmaticus, asthma without status asthmaticus, asthmatic bronchitis, extrinsic asthma, bronchial asthma, chronic obstructive asthma, cough variant asthma, allergic asthma, atopic asthma, childhood asthma, hay fever with asthma, and reactive airways disease. When a history of asthma was mentioned in the body of the ED record, the following discharge diagnoses were considered asthma: difficulty breathing, cough, respiratory distress, or bronchitis. To limit the analysis to patients with simple asthma, all patients had their chief complaints and discharge diagnoses reviewed by two authors (RMS and JMC). The reviewing authors were blinded to the hospital and the treating physician of these patients. Patients with significant comorbidities and complex diagnoses (e.g., cystic fibrosis) were excluded from analysis; however, patients with pneumonia were not excluded. In addition, we excluded patients younger than 1 year of age, patients with medical devices (tracheostomy, gastrostomy tubes, ventriculoperitoneal shunts), and patients with a first episode of wheezing.

Study Protocol

A manual of operations was developed and disseminated to all sites. Site investigators attended live training in abstraction procedures, with sham chart review, and research assistants were subsequently trained on-site by the site investigators. Abstractors recorded data onto standardized paper forms and subsequently entered data into a secure Web-based data entry system. Quality assurance measures included double data entry of 10% of charts and chart abstraction by the physician site investigator of approximately 5% of charts to verify research assistant abstractions. Abstractors and site investigators were blinded to the hypothesis of this study.

Outcome Measures

A model that has been used extensively to predict the use of health services is that proposed by Andersen and Aday, in which health care decision making is affected by four sets of characteristics: predisposing, need, enabling, and health system.[19–23] Predisposing variables are patient characteristics that exist before the onset of the illness episode, such as age, gender, race, ethnicity, and health beliefs. Need characteristics refer to illness severity. Enabling characteristics describe the means individuals have available to them for the use of services and can be specific to the patient (health insurance), to the treating physician (physician specialty), or both. Health system variables refer to overall health system characteristics, such as hospital and ED structure and staffing. For the purposes of this study, the predisposing characteristics included were patient age and gender. Need characteristics included the triage status of the patient, as well as the temperature, oxygen saturation, and disposition of the patient. Enabling characteristics encompassed type of health insurance coverage and physician training. Health system characteristics included the following variables: whether the treating ED was part of a freestanding children's hospital or not, whether the treating ED was a high- or low-volume ED, and whether the treating ED was an academic center or not.

The primary outcome measure was the use of ancillary testing for asthma. Ancillary testing was defined as the use of either a blood test (complete blood count, blood culture, C-reactive protein, erythrocyte sedimentation rate, or blood chemistries) or a chest radiograph. We excluded blood gas analysis because this test might provide useful information for patient management, particularly for more severely ill patients. The independent variables tested for association with this outcome based on the conceptual model were predisposing, need, enabling, and health system characteristics, as follows.

Predisposing characteristics included patient age and gender. Need characteristics included triage acuity, temperature, oxygen saturation, and disposition. Triage acuity was recorded for each patient on presentation to the ED, cross-referenced from a site-reported description of triage codes from each hospital, and categorized as nonurgent, urgent, and emergent for the purposes of this study. For temperature and pulse oximetry, we recorded the value in triage, as well as the maximum and minimum during the ED visit. Fever was defined as temperature >38°C recorded at any point during the ED visit. Hypoxia was defined as an oxygen saturation of less than 92% at all sites, except Salt Lake City (89%), at any point during the ED visit. Enabling characteristics included health insurance (none, governmental, private) and treating physician characteristics. Treating physician characteristics included training, categorized as emergency medicine, pediatrics, pediatric emergency medicine (PEM) subspecialty training with any combination of initial training, and "other." Attending physician names were abstracted from the chart and were cross-referenced to a list of physician credentials provided by each site. Health system characteristics included large-volume ED (characterized by an annual pediatric ED volume bifurcated at the network median of 30,000 visits per year), status as a freestanding children's hospital defined as a physically separate structure, and status as an academic hospital defined by presence of resident physicians in the ED. Hospital median volume was obtained from 2002 PECARN electronic ED visit data; the remaining hospital characteristics were obtained from a survey from all sites.[24]

We polled all site primary investigators and confirmed that none of our sites had policies that mandated either triage or admission chest radiographs or blood testing in pediatric patients with asthma.

Data Analysis

A hierarchical multivariate logistic model was applied, using a conceptual model for health care utilization as a framework, to describe the associations between ancillary testing and predisposing, need, enabling, and health system characteristics.[19,21,22] Separate logistic models were applied for chest radiographs and laboratory testing. Before model building, we tested for multicolinearity among dependent variables using a Spearman ρ correlation coefficient, requiring a coefficient <0.4 to demonstrate minimal colinearity. No modeling variables demonstrated significant levels of colinearity (i.e., $\rho \geq 0.4$); thus, modeling techniques often used to describe interrelationships between variables (e.g., nesting) were not applied.

All selected independent variables were introduced into the logistic model using a hierarchical forward stepwise technique. Variables were entered into the model in four blocks, representing the contextual categories of health care utilization described by Andersen and Aday (i.e., predisposing characteristics, need characteristics, enabling characteristics, and health system characteristics).[19,21,22] The appropriateness of the resulting model was assessed using Hosmer and Lemeshow's goodness-of-fit statistic.[25,26] Several variables (i.e., age, respiratory rate, and O_2 saturation) entered the model as continuous variables to maximize their potential to explain variance. Because patient fever and hypoxia might significantly alter physician practice, we performed post hoc analyses of overall ancillary testing in patients without either fever or hypoxia. All analyses were conducted using SPSS version 13.0.0 statistical software (SPSS Inc., Chicago, IL).[27]

RESULTS

The characteristics of the participating hospitals and attending physicians are depicted in Table 1. Over the 90-day study period, the sites registered 210,249 patient visits. During the ten days randomly selected for chart abstraction, 12,744 patient visits were abstracted, of which 820 (6%) were visits with acute exacerbations of asthma. After reviewing these cases, 86 were excluded because of complex diagnoses, medical devices, patient age younger than 1 year, or first episode of wheezing, leaving 734 patients with uncomplicated asthma. All hospitals in the network contributed patients to the study, ranging from 2 to 54 patients per site.

The patient characteristics are described in Table 2. Overall, 302 of 734 (41%) of all pediatric asthma encounters included ancillary testing; of these, 198 (27%) had chest radiographs and 104 (14%) had blood testing. When patients with fever, hypoxia, or both were excluded, 161 of 502 (32%) were subjected to ancillary testing.

Table 3 details the results of the hierarchical logistic analysis of variables associated with chest radiographs; the only factor significantly associated with the use of chest radiographs was fever. Table 4 details the results of the hierarchical logistic analysis of variables associated with blood testing. The factors that were significantly associated with less blood testing included older age and male gender (predisposing), discharge home and higher oxygen saturation (need), physician subspecialty training in PEM (enabling), and freestanding children's hospital (health system). When patients with fever and/or hypoxia

Table 1
Characteristics of 25 Participating Pediatric Emergency Care Applied Research Network Hospitals and Treating Physicians

Characteristics	Total No. (%)
Hospital characteristics	
Total annual pediatric ED visits	808,454
Median volume of ED visits	30,000
Freestanding children's hospital	9 (36)
Teaching hospital	20 (80)
Emergency medicine residency	17 (68)
Pediatric residency	20 (80)
Pediatric emergency medicine fellowship	12 (48)
Treating physician characteristics	
General emergency medicine	79 (14)
General pediatrics	205 (36)
Pediatric emergency medicine subspecialty trained	218 (38)
Other	14 (2)
Missing	50 (9)

Table 2
Characteristics of 734 Patient Encounters with Acute Exacerbations of Asthma

Variable	
Age (yr), mean ± SD	6.3 ± 4.6
Treated at high pediatric volume hospitals	509 (69)
Treated at children's hospitals	325 (44)
Treated at academic/teaching hospitals	623 (85)
Triage category	
Nonurgent	177 (25)
Urgent	407 (55)
Emergent	95 (13)
Missing	55 (7)
Oxygen saturation documented in medical record	574 (78)
Insurance status	
Commercial	257 (35)
Governmental	372 (51)
None	39 (5)
Missing	66 (9)
Any ancillary testing	302 (41)
Any ancillary testing among nonfebrile, nonhypoxic patients with asthma (n = 502)	161 (32)
Patients with chest radiographs	198 (27)
Patients with laboratory testing (excluding blood gas analysis)	104 (14)

All values are expressed as number (%) except where noted.

were excluded, post hoc analyses revealed that less overall ancillary testing was associated with discharged patients and physician training in pediatrics and subspecialty training in PEM.

Of note, 218 patients (30%) were excluded from the logistic model because of missing variables important to the analysis (triage code, oxygen saturation, temperature). To assess for differences between cases with complete data and cases missing one or more variables, we performed bivariate analyses assessing for significant differences between these two groups. We found no difference in any of the variables used for modeling, except that cases with missing data were less likely to be treated by physicians who were board certified in emergency medicine (15% vs. 5%; p = 0.015). κ and intraclass correlation scores suggested good intrarater and interrater agreement (~0.8) when assessing variables with defined categorical fields on the data collection form.

DISCUSSION

Asthma is a disease of significant morbidity, and more severely ill patients may be subjected to increased diagnostic testing. However, there is no evidence that increased diagnostic testing leads to improved patient outcomes. In general, diagnostic testing adds little to the management of patients with asthma and may cause unnecessary medical expenditure, pain, radiation exposure, and harm.[1–7] Furthermore, unnecessary testing is associated with false-positive results, which require additional testing, a type of medical error referred to as iatrogenesis imperfecta.[28]

In this study, almost half of all pediatric patients with asthma were subjected to ancillary testing, a surprisingly high number given that we excluded patients with complex diagnoses, comorbidities, and those younger than 1 year of age. Indeed, given the strict inclusion criteria

Table 3
Hierarchical Logistic Regression Demonstrating the Association of Model Variables with the Performance of Chest Radiography

Conceptual Framework Structure	Model Variables	β*	Significance†	Adjusted Odds Ratio	95% CI	
					Lower	Upper
Predisposing	Patient age	0.003	0.897	1.003	0.958	1.050
	Patient gender	0.099	0.645	1.104	0.724	1.685
Need	Triage category					
	Nonurgent		0.627	Reference		
	Urgent	−0.244	0.335	0.784	0.478	1.286
	Emergent	−0.178	0.624	0.837	0.411	1.706
	Temperature >38°C	0.223	0.001	1.250	1.119	1.396
	Oxygen saturation	−0.042	0.205	0.959	0.899	1.023
	Disposition	0.248	0.437	1.282	0.685	2.398
Enabling	Provider type					
	General emergency medicine		0.651	Reference		
	General pediatrics	−0.403	0.201	0.668	0.360	1.240
	Pediatric emergency medicine subspecialty	−0.285	0.379	0.752	0.398	1.421
	Other	−0.276	0.688	0.758	0.197	2.924
	Payer type					
	Self pay		0.380	Reference		
	Government	−0.341	0.431	0.711	0.304	1.660
	Commercial	−0.054	0.901	0.948	0.404	2.220
Health system	Hospital volume	−0.140	0.566	0.869	0.539	1.402
	Children's hospital	0.253	0.288	1.288	0.808	2.054
	Academic hospital	−0.281	0.364	0.755	0.411	1.385

Hosmer-Lemeshow goodness-of-fit chi-square = 4.5, p = 0.81.
*Estimated variable coefficient.
†Significance based on Wald chi-square test.

Table 4
Hierarchical Logistic Regression Demonstrating the Association of Model Variables with the Performance of Blood Testing

Conceptual Framework Structure	Model Variables	β*	Significance†	Adjusted Odds Ratio	95% CI Lower	95% CI Upper
Predisposing	Patient age	0.063	0.051	1.065	1.000	1.135
	Patient gender	−0.770	0.011	0.463	0.255	0.841
Need	Triage category					
	Nonurgent		0.403	Reference		
	Urgent	−0.446	0.237	0.640	0.306	1.341
	Emergent	−0.094	0.850	0.910	0.342	2.424
	Temperature	0.069	0.394	1.072	0.914	1.257
	Oxygen saturation	−0.144	0.001	0.866	0.795	0.944
	Hospital admission	1.295	0.001	3.649	1.670	7.973
Enabling	Provider type					
	General emergency medicine		0.118	Reference		
	General pediatrics	−0.469	0.279	0.626	0.268	1.461
	Pediatric emergency medicine subspecialty	−1.065	0.023	0.345	0.138	0.862
	Other	−1.236	0.308	0.291	0.027	3.129
	Payer type					
	Self pay		0.714	Reference		
	Government	0.569	0.421	1.766	0.442	7.053
	Commercial	0.563	0.429	1.756	0.436	7.079
Health system	Hospital volume	0.319	0.375	1.376	0.680	2.785
	Children's hospital	−0.761	0.033	0.467	0.232	0.941
	Academic hospital	0.590	0.225	1.805	0.695	4.683

Blood gas analysis was excluded.
Hosmer-Lemeshow goodness-of-fit chi-square = 14.04, p = 0.08.
* Estimated variable coefficient.
† Significance based on Wald chi-square test.

for patients with asthma in this study, it is difficult to imagine how blood tests could improve patient management at all. Chest radiographs were ordered twice as often as blood tests. In this study, we found that predisposing, enabling, and health system characteristics did not influence the rate of ordering chest radiographs. In fact, the need characteristic temperature was the only variable significantly associated with the ordering of chest radiographs. This may be explained by the desire of the treating physician to rule out pneumonia, given the presence of fever. However, most pneumonias associated with asthma are viral in nature and do not require any change in management of acute asthma. Crain et al. surveyed U.S. emergency physicians and found that two thirds obtained chest radiographs in pediatric asthmatic patients with fever and that physicians practicing in community hospital EDs were more likely to obtain radiographs than physicians practicing in children's hospital EDs.[6]

Other studies have found that health system and physician training characteristics are associated with variation in the care of pediatric asthma, fever, and croup.[29,30] Patients presenting to children's hospital EDs are less likely to undergo chest radiographs than patients presenting to community EDs, and general emergency physicians are more likely to order chest radiographs than pediatricians or family practitioners.[6,8,31] However, two out of three of these studies were surveys and did not evaluate actual clinical practice, and these studies did not differentiate between physicians with subspecialty training in pediatrics and those without. The lack of health system and physician characteristic effect in our analysis of chest radiograph use may be because the majority of PECARN hospitals are academic teaching hospitals and therefore may be more similar to academic children's hospital EDs than community EDs or because there are very few differences by health system or physician training in the ordering of chest radiographs.

Even though only 14% of patients with asthma in this study received blood testing, we believe this is an unacceptably high rate, given that the patients in this sample had uncomplicated asthma. Many of the variables included in our study are not modifiable; however, it is important to know the context in which, and the types of patients for which, ancillary testing is ordered so that interventions to decrease ancillary testing can be appropriately targeted. Our results suggest that educational efforts to reduce blood testing in patients with asthma should be targeted at nonchildren's hospitals and physicians without PEM subspecialty training.

The finding that children with asthma treated by emergency or pediatric physicians without subspecialty PEM training were more likely to undergo blood testing may reflect the comfort level of the practitioner in treating pediatric patients with asthma, but may also reflect a difference in treatment approaches imparted by initial emergency medicine residency training. Physicians trained in primary emergency medicine are faced with a more severely ill case mix and are thus are appropriately trained to rule out disease before presuming wellness. In contrast, physicians with subspecialty training in PEM encounter, in general, a less severely ill case mix and a healthier patient population with less complex disease. We should not be surprised that practice patterns differ. Individual provider comfort with pediatric patients may also play a role. This study was not designed to test physician reasoning behind test ordering behaviors.

LIMITATIONS

In retrospect, this study may have been improved in several ways. First, we did not use validated asthma severity measures to compare patients at baseline for illness severity. However, most asthma severity scores incorporate oxygen saturation, a measure that was used in this study.[32–34] Second, a large proportion of patients had some missing data. Bivariate analyses with and without missing data suggest that this did not affect our results. Third, the analysis was limited to a three-month period and therefore does not reflect the seasonality of pediatric illness. Fourth, data were abstracted from medical records and therefore had inherent limitations in lack of documentation of medical information and the reasons for physician decision making. Therefore, we report associations only. The reported differences are relative, not absolute, indicators of quality of care (i.e., efficiency). Finally, this study was not designed to test the medical reasoning behind ancillary testing.

CONCLUSIONS

Almost one third of pediatric patients with asthma undergo chest radiography in the ED, with fever the only variable significantly associated with increased ordering of chest radiographs. Most patients did not undergo blood testing, but those who did were more likely to be treated by physicians without subspecialty PEM training, and these patients were more likely to be younger, female, admitted to the hospital, hypoxic, and treated at a nonchildren's hospital. Interventions to decrease the use of chest radiographs should target the management of febrile patients with asthma. Interventions to decrease blood testing in asthmatic patients should target physicians without PEM subspecialty training and those practicing in nonchildren's hospitals and should focus on patients who are perceived to be more severely ill.

References

1. Brooks LJ, Cloutier MM, Afshani E. Significance of roentgenographic abnormalities in children hospitalized for asthma. Chest. 1982; 82:315–8.
2. Mahabee-Gittens M, Bachman D, Shapiro E, Dowd D. Chest radiographs in the pediatric emergency department for children <18 months of age with wheezing. Clin Pediatr. 1999; 38:395–9.
3. Rushton A. The role of the chest radiograph in the management of childhood asthma. Clin Pediatr. 1982; 21:325–8.
4. Gershel JC, Goldman HS, Stein REK, Shelov SP, Ziprkowski M. The usefulness of chest radiographs in first asthma attacks. N Engl J Med. 1983; 309:336–9.
5. Tsai SL, Crain EF, Silver EJ, Goldman HS. What can we learn from chest radiographs in hypoxemic asthmatics? Pediatr Radiol. 2002; 32:498–504.
6. Crain EF, Weiss KB, Fagan MJ. Pediatric asthma care in US emergency departments: current practice in the context of the National Institutes of Health Guidelines. Arch Pediatr Adolesc Med. 1995; 149: 893–901.
7. Gentile NT, Ufberg J, Barnum M, McHugh M, Karras D. Guidelines reduce x-ray and blood gas utilization in acute asthma. Am J Emerg Med. 2003; 21:451–3.
8. Hampers LC, Faries SG. Practice variation in the emergency management of croup. Pediatrics. 2002; 109:505–8.
9. Wennberg JE. Understanding geographic variations in health care delivery. N Engl J Med. 1999; 340:52–3.
10. Perrin JM, Homer CJ, Berwick DM, Woolf AD, Freeman JL, Wennberg JE. Variations in the rates of hospitalization of children in three urban communities. N Engl J Med. 1990; 320:1183–7.
11. Sweich PJ, Smith KM, Dowd MD, Walkley EI. Pediatric emergency medicine practice patterns: a comparison of pediatric and general emergency physicians. Pediatr Emerg Care. 1998; 14:89–94.
12. Glaser NS, Kuppermann N, Yee CK, Schwartz DL, Styne DM. Variation in the management of pediatric diabetic ketoacidosis by specialty training. Arch Pediatr Adolesc Med. 1997; 151:1125–32.
13. Brown JC, Klein EJ, Lewis CW, Johnston BD, Cummings P. Emergency department analgesia for fracture pain. Ann Emerg Med. 2003; 42:197–205.
14. Scribano PV, Baker MD, Ludwig S. Factors influencing termination of resuscitative efforts in children: a comparison of pediatric emergency medicine and adult emergency medicine physicians. Pediatr Emerg Care. 1997; 13:320–4.
15. Belfer RA, Gittelman MA, Muniz AE. Management of febrile infants and children by pediatric emergency medicine and emergency medicine: comparison with practice guidelines. Pediatr Emerg Care. 2001; 17:83–7.
16. Hampers LC, Trainor JL, Listernick R, et al. Setting-based practice variation in the management of simple febrile seizure. Acad Emerg Med. 2000; 7:21–7.
17. Cimpello LB, Klein H, Avner JR. Practice patterns of pediatric versus general emergency physicians for pain management of fractures in pediatric patients. Pediatr Emerg Care. 2004; 20:228–32.
18. The Pediatric Emergency Care Applied Research Network. The Pediatric Emergency Care Applied Research Network (PECARN): rationale, development and first steps. Acad Emerg Med. 2003; 10:661–8.
19. Aday LA, Awe WC. Health services utilization models. Handbook of Health Behavior Research 1: Personal and Social Determinants. New York: Plenum, 1997.
20. Phillips KA, Morrison KR, Anderson A, Aday LA. Understanding the context of healthcare utilization: assessing environmental and provider-related variables in the behavioral model of utilization. Health Serv Res. 1998; 33:571–96.
21. Andersen R. A Behavioral Model of Families' Use of Health Services. Center for Health Administration, Research Series 25. Chicago, IL: University of Chicago, 1968.
22. Andersen R, Newman JF. Societal and individual determinants of medical care utilization in the United States. Milbank Q. 1973; 51:95–124.

23. Nichol MB, Stimmel GL, Lange SC. Factors predicting the use of multiple psychotropic medications. J Clin Psychiatry. 1995; 56:60–6.
24. Alpern ER, Stanley RM, Gorelick MH, et al., for the PECARN. Epidemiology of a Pediatric Emergency Medicine Research Network. The Pediatric Emergency Care Applied Research Core Data Project. Pediatr Emerg Care. 2006; 22:689–99.
25. Draper N, Smith H. Applied Regression Analysis. 2nd ed. New York: Wiley, 1981.
26. Hosmer DW, Lemeshow S. Applied Logistic Regression. New York: Wiley, 1989.
27. Norusis MJ. SPSS 9.01 for Windows. Chicago IL: SPSS Inc., 1996.
28. Morrow G. Iatrogenesis imperfecta—a new pediatric problem. Pediatrics. 1975; 55:453–5.
29. Emerman CL, Cydulka RK, Skobeloff E. Survey of asthma practice among emergency physicians. Chest. 1996; 109:708–12.
30. Isaacman DJ, Kaminer K, Veligeti H, Jones M, Davis P, Mason J. Comparative practice patterns of emergency medicine physicians and pediatric emergency medicine physicians managing fever in young children. Pediatrics. 2001; 108:354–8.
31. Wittler RR, Cain KK, Bass MD, James W. A survey about management of febrile children without source by primary care physicians. Pediatr Infect Dis J. 1998; 17:271–7.
32. Baxt WG. Prospective application of an asthma severity rule. Acad Emerg Med. 2002; 9:868–9.
33. Becker AB, Nelson NA, Simons FE. The pulmonary index. Assessment of a clinical score for asthma. Am J Dis Child. 1984; 138:574–6.
34. Smith SR, Baty JD, Hodge D III. Validation of the pulmonary score: an asthma severity score for children. Acad Emerg Med. 2002; 9:99–104.

APPENDIX A

Pediatric Emergency Care Applied Research Network Members

Participating centers and site investigators are listed as follows in alphabetical order: Atlantic Health System/ Morristown Memorial Hospital (M. Gerardi), Bellevue Hospital Center (M. Tunik), Calvert Memorial Hospital (K. Melville), Children's Hospital of Buffalo (K. Lillis), Children's Hospital of Michigan (P. Mahajan), Children's Hospital of New York - Presbyterian (S. Miller [deceased]), Children's Hospital of Philadelphia (E. Alpern), Children's National Medical Center (J. Chamberlain, S. Teach), Cincinnati Children's Hospital Medical Center (R. Ruddy), DeVos Children's Hospital (J. Hoyle), Franklin Square Hospital (C. Alexander), Harlem Hospital Center (J. Tsung), Holy Cross Hospital (C. Johns), Howard County Medical Center (D. Monroe), Hurley Medical Center (R. Stanley), Johns Hopkins Medical Center (A. Walker), Marquette General Hospital (D. Snowdon), Medical College of Wisconsin/Children's Hospital of Wisconsin (M. Gorelick), St. Barnabas Health Care System (J. Brennan), University of California Davis Medical Center (N. Kuppermann), University of Michigan (D. Treloar), University of Rochester (J. Goepp), University of Utah/Primary Children's Medical Center (H. Cornelli), Upstate Medical Center (J. Callahan), Washington University/St. Louis Children's Hospital (D. Jaffe).

Pediatric Emergency Care Applied Research Network Steering Committee: N. Kuppermann (Chair), E. Alpern, J. Chamberlain, J. M. Dean, M. Gerardi, J. Goepp, M. Gorelick, J. Hoyle, D. Jaffe, C. Johns, N. Levick, P. Mahajan, R. Maio, K. Melville, S. Miller (deceased), D. Monroe, R. Ruddy, R. Stanley, D. Treloar, M. Tunik, A. Walker.

Maternal and Child Health Bureau/Emergency Medical Services for Children liaisons: D. Kavanaugh, H. Park.

Central Data Management and Coordinating Center: M. Dean, R. Holubkov, S. Knight, A. Donaldson.

Data Analysis and Management Subcommittee: J. Chamberlain (Chair), M. Brown, H. Corneli, J. Goepp, R. Holubkov, P. Mahajan, K. Melville, E. Stremski, M. Tunik.

Grants and Publications Subcommittee: M. Gorelick (Chair), E. Alpern, J. M. Dean, G. Foltin, J. Joseph, S. Miller (deceased), F. Moler, R. Stanley, S. Teach.

Protocol Concept Review and Development Subcommittee: D. Jaffe (Chair), K. Brown, A. Cooper, J. M. Dean, C. Johns, R. Maio, N. C. Mann, D. Monroe, K. Shaw, D. Teitelbaum, D. Treloar.

Quality Assurance Subcommittee: R. Stanley (Chair), D. Alexander, J. Brown, M. Gerardi, M. Gregor, R. Holubkov, K. Lillis, B. Nordberg, R. Ruddy, M. Shults, A. Walker.

Safety and Regulatory Affairs Subcommittee: N. Levick (Chair), J. Brennan, J. Brown, J. M. Dean, J. Hoyle, R. Maio, R. Ruddy, W. Schalick, T. Singh, J. Wright.

The Pediatric Emergency Care Applied Research Network is supported by cooperative agreements U03MC00 001, U03MC00003, U03MC00006, U03MC00007, and U03MC00008 from the Emergency Medical Services for Children program of the Maternal and Child Health Bureau, Health Resources and Services Administration, U.S. Department of Health and Human Services.