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Authors

Bekmezian, Arpi
Chung, Paul J
Cabana, Michael D
et al.

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Factors Associated With Prolonged Emergency Department Length of Stay for Admitted Children

Arpi Bekmezian, MD, Paul J. Chung, MD, MS,†‡ Michael D. Cabana, MD, MPH,*§ Judith H. Maselli, MSPH,* Joan F. Hilton, ScD, MPH,|| and Adam L. Hersh, MD, PhD**

Objective: To estimate the prevalence of and to identify factors associated with prolonged emergency department length-of-stay (ED-LOS) for admitted children.

Methods: Data were from the 2001–2006 National Hospital Ambulatory Medical Care Survey. The primary outcome was prolonged ED-LOS (defined as total ED time >8 hours) among admitted children. Predictor variables included patient-level (eg, demographics including race/ethnicity, triage score, diagnosis, and admission to inpatient bed vs intensive care unit), physician-level (intern/resident vs attending physician), and system-level (eg, region, metropolitan area, ED and hospital type, time and season, and diagnostic and therapeutic procedures) factors. Multivariable logistic regression was performed to identify independent predictors of prolonged ED-LOS.

Results: Median ED-LOS for admitted children was 3.7 hours. Thirteen percent of pediatric patients admitted from the ED experienced prolonged ED-LOS. Factors associated with prolonged ED-LOS for admitted children were Hispanic ethnicity (odds ratio [OR], 1.76; 95% confidence interval [95% CI], 1.10–2.81), ED arrival between midnight and 8 A.M. (OR, 2.80; 95% CI, 1.87–4.20), winter season (January–March: OR, 1.81; 95% CI, 1.20–2.74), computed tomography scan or magnetic resonance imaging (OR, 1.65; 95% CI, 1.05–2.58), and intravenous fluids or medications (OR, 1.81; 95% CI, 1.10–2.97). Children requiring ICU admissions (OR, 0.29; 95% CI, 0.11–0.77) or receiving pulse oximetry in the ED (OR, 0.52; 95% CI, 0.34–0.81) had a lower risk of experiencing prolonged ED-LOS.

Conclusions: We found that prolonged ED-LOS occurs frequently for admitted pediatric patients and is associated with Hispanic ethnicity, presentation during winter season, and early morning arrival. Potential strategies to reduce ED-LOS include improved availability of interpreter services and enhanced staffing and additional inpatient bed availability during winter season and overnight hours.

Key Words: boarding, crowding, emergency department length of stay, NHAMCS, pediatric admissions, overcrowding

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Emergency department (ED) overcrowding has been a growing issue internationally for the last 20 years[1–9] and is fast becoming an important problem for children.[10,11] The Institute of Medicine recently issued a report describing a "national epidemic of overcrowded Eds" and called for researchers to attend to deficiencies in pediatric emergency care and for hospitals to eliminate the practice of boarding admitted patients.[12] *Boarding* refers to the situation where admitted patients wait a prolonged period in the ED before gaining access to appropriate inpatient beds. When time of admission decision is unavailable, prolonged ED length of stay (ED-LOS) of admitted patients (time from arrival to transfer to an inpatient bed) can be used as a proxy for boarding time.[8,13] Prolonged ED-LOS is an important indicator of ED overcrowding[6,8,12,14,15] and a quality indicator for ED throughput.[16,17]

Pediatric ED visits have been increasing, with approximately 30 million children receiving emergency care in the United States annually.[18] Children comprise more than a quarter of all ED visits.[12] The main role of the ED is to facilitate rapid access to emergency care for patients with acute conditions.[3,6] Hence, it is neither intended nor prepared to provide prolonged care.[19] Studies in adult patients have linked prolonged ED-LOS with increased mortality,[4,20] inpatient length of stay,[8,20,21] ED waiting times and patients leaving without being seen,[6,17,22,23] ambulance diversion (declining to accept patients from other EDs or Emergency Medical Services),[6,15,24] contracting nosocomial infections,[1] and decreased patient satisfaction.[25,26] Prolonged ED-LOS may be especially deleterious for admitted children, particularly in tertiary care hospitals, where they may have chronic, severe, and/or complex subspecialty medical conditions and special health care needs.[27–29]

To our knowledge, however, prolonged ED-LOS for admitted children has never been systematically studied. The extent to which prolonged ED-LOS for admitted pediatric patients exists, the specific factors that contribute to it, and whether children in vulnerable groups are at increased risk are unknown. Our objective was to estimate the prevalence of and to identify factors that are independently associated with prolonged ED-LOS for admitted children from the ED.

METHODS

Study Design and Data Collection

This was a retrospective study of the National Hospital Ambulatory Medical Care Survey (NHAMCS) 2001–2006. The NHAMCS is the largest public-use administrative database that collects data on the use and provision of emergency care services. This public-use data set is exempted from review by the University of California, San Francisco Institutional Review Board.

The NHAMCS is a population-based stratified sample survey of ED visits in US hospitals. The NHAMCS has been conducted annually since 1992 by the National Center for Health Statistics (NCHS). The NHAMCS surveys visit noninstitutional, general, and short-stay hospitals in the United States. The NHAMCS uses a 4-stage probability sampling to include geographic primary sampling units, hospitals within the primary sampling units, EDs within the hospitals, and patients within the EDs. National estimates are based on patient weighting assigned

From the *Department of Pediatrics, University of California, San Francisco; †Department of Pediatrics, University of California, Los Angeles; ‡RAND Health, RAND Corporation, Santa Monica; §Institute for Health Policy Studies, Department of Pediatrics, University of California, San Francisco; and ||Department of Epidemiology & Biostatistics, University of California, San Francisco, CA.

Reprints: Arpi Bekmezian, MD, Division of General Pediatrics, University of California, San Francisco, 505 Parnassus Ave, M687, Box 0110, San Francisco, CA 94143-0110 (e-mail: bekmeziana@peds.ucsf.edu).

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by NCHS statisticians. The weight for each visit takes into account all sampling stages and is used to produce unbiased national annual estimates. A detailed description of the NHAMCS procedures is available on the NCHS Web site.[30]

The primary study outcome variable was the occurrence of prolonged ED-LOS in admitted children. Prolonged ED-LOS was defined as a dichotomous variable based on total ED time more than 8 hours, consistent with previous studies defining prolonged ED-LOS for admitted patients.[7,8] We also examined the total ED-LOS as a continuous variable (minutes), which was calculated as the difference between the recorded time of arrival in the ED and the recorded time of departure to inpatient bed. Since 2001, NHAMCS has included data on ED-LOS. During the years 2001–2006, there were 2643 sampled pediatric ED visits that resulted in an admission, of which 77% (2024 hospital admissions) had ED-LOS information. Unlike time of arrival in the ED, the time of admission decision is not recorded in NHAMCS; therefore, we were unable to calculate boarding time (the time between decision to admit and departure to an inpatient bed).

Predictor variables were selected a priori according to our clinical experience and previous studies evaluating predictors of prolonged ED-LOS.[13,17,31,32] We classified predictor variables as patient level, physician level, and system level. Patient-level predictors included demographics, admission diagnosis, and 2 measures of illness acuity—admission to a regular bed versus the intensive care unit (ICU), and triage score. Patient demographic variables included sex, age, race, ethnicity, and insurance. Age was collapsed into a 3-level categorical variable (0–1 years old, 1–5 years old, and 6–18 years old) to capture differences in outcome by specific age groups. Race and ethnicity were combined to create 5 categories: white (non-Hispanic), black (non-Hispanic), Hispanic, Asian, and other. Insurance was examined in 3 groups: private, Medicaid, and other (eg, self-pay, no charge/charity). Triage score was assessed by all EDs as the immediacy with which a patient should be seen by a physician and was classified into less than 15 minutes and 15 minutes or more to capture patients with emergent conditions. The single physician-level characteristic was ED provider type (intern/resident vs attending physician).

System-level variables included US census region, Standard Metropolitan Statistical Area (SMSA) status, hospital safety-net status, ED type (pediatric vs general), time and season of service, and diagnostic and therapeutic procedures performed during the visit. The US census regions were divided into Northeast, Midwest, South, and West. The *SMSA status* was defined as an urban area of 50,000 inhabitants or more. In addition, we characterized hospitals as high and low safety-net status based on the percentage of visits at each hospital in which the expected method of payment was charity/no charge, self-pay, or Medicaid.[33] To facilitate comparison between pediatric EDs and general EDs, we defined pediatric EDs as those in which the visit population was at least 75% pediatric (18 years old or younger).[31] Time of ED arrival was collapsed into 2 categories (12 A.M.–8 A.M., 8 A.M.–12 A.M.), roughly reflecting variations in staffing and volume. Seasons of service were divided into January to March (winter season, when hospital census is highest because of respiratory illnesses and influenza)[34,35] and April to December. Diagnostic and therapeutic procedures included blood tests, pulse oximetry, cardiac monitoring, electrocardiogram (EKG), computed tomography (CT), magnetic resonance imaging (MRI), intravenous fluid (IVF), and medication administration.

Statistical Analysis

Bivariate analyses were performed using weighted χ^2 analyses. Variables significantly associated with prolonged ED-LOS at $P \leq 0.2$ (a common standard)[36] were entered into a multivariate logistic model. In addition, we included predictors (race, CT/MRI, ICU, pediatric ED, SMSA, safety-net hospital, and study year) that have been suggested in other studies as possible contributors to longer ED-LOS.[31,32,37] Odds ratios (ORs) are presented with 95% confidence intervals (95% CIs). To test the robustness of our findings, we repeated the analyses excluding patients who received CT/MRI (because receipt of CT/MRI could be an unavoidable reason for prolonged ED-LOS) and also performed multivariate linear regression using log-transformed ED-LOS as an alternative outcome variable. To test for selection bias, we compared patient characteristics of visits with missing ED-LOS data with those with complete ED-LOS data using χ^2 analyses.

The SEs were calculated using Taylor series approximations generated via SUDAAN (10.0th version, Research Triangle Park, NC), which took into account the complex sample design. All estimates presented were based on at least 30 actual visits. A 2-tailed $P < 0.05$ was considered significant. All analyses were performed using SAS statistical software (9.2th version, SAS Institute, Cary, NC) and SUDAAN.

RESULTS

Study Population

During the 6-year study period (2001–2006), 4% of ED visits for children 18 years or younger (95% CI, 3.71–4.77) resulted in hospital admission. Hospital admission was more likely for children presenting to pediatric EDs than for children presenting to general EDs (7% vs 4%, $P < 0.01$). Among admitted patients, 46% were female and 51% were younger than 5 years (Table 1). Most visits were to general EDs in metropolitan areas. In terms of race/ethnicity, 58% were white (non-Hispanic), 22% black (non-Hispanic), and 17% were of Hispanic origin. Approximately equal proportions of patients had either private insurance (40%) or Medicaid (38%). The most common admission diagnoses (based on *International Classification of Disease, Ninth Revision*, *Clinical Modification*) were pneumonia, fever, dehydration, and asthma; 8% of admitted patients were in the ICU.

Frequency of Prolonged ED-LOS

Thirteen percent (95% CI, 10%–15%) of admitted pediatric patients experienced prolonged ED-LOS, and the mean and median ED-LOS for all patients were 5.5 and 3.7 hours, respectively. There were no differences in total ED-LOS or in the prevalence of prolonged ED-LOS across study years ($P = 0.26$). Although a higher percentage of children presenting to pediatric EDs compared with general EDs were admitted, there was no difference in the percentage experiencing prolonged ED-LOS between these 2 settings (16% vs 12%, $P = 0.15$).

Multivariate Analyses of ED-LOS

In multivariable analysis, several patient and system characteristics were independently associated with prolonged ED-LOS. Controlling for potential confounders (Table 2), factors independently associated with prolonged ED-LOS for admitted children were Hispanic ethnicity (OR, 1.76; 95% CI, 1.10–2.81), ED arrival between midnight and 8 A.M. (OR, 2.80; 95% CI, 1.87–4.20), receipt of CT or MRI (OR, 1.65; 95% CI, 1.05–2.58), IVF or medications (OR, 1.81; 95% CI, 1.10–2.97), and the January to March period (OR, 1.81; 95% CI, 1.20–2.74). The ICU admission and use of pulse oximetry were inversely associated with prolonged ED-LOS (OR, 0.29; 95% CI, 0.11–0.77 and OR, 0.52; 95% CI, 0.34–0.81, respectively).

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TABLE 1. Characteristics of Admitted Pediatric Patients 2001–2006 Based on Actual Sample Size of 2643 ED Visits

	Percent % (95% CI)
Age	
<1	22 (19, 25)
1–5	29 (26, 32)
6–18	49 (46, 52)
Female sex	46 (43, 49)
Race/ethnicity	
White	58 (54, 62)
Black	22 (19, 25)
Hispanic	17 (14, 20)
Asian	2 (1, 3)
Other	2 (1, 3)
Insurance	
Private	40 (37, 43)
Medicaid	38 (34, 42)
Other	15 (12, 18)
Missing	6 (4, 8)
Triage score	
<15 min	30 (26, 34)
≥15 min	56 (52, 60)
Missing	14 (11, 17)
Diagnosis of pneumonia	10 (8, 12)
Diagnosis of fever	10 (8, 12)
Diagnosis of dehydration	8 (6, 10)
Diagnosis of asthma	6 (5, 7)
Admission to ICU	8 (6, 10)
Provider	
Resident/intern	22 (17, 27)
Other	77 (72, 82)
Missing	1 (0, 2)
Region	
Northeast	14 (11, 17)
Midwest	32 (24, 40)
South	36 (29, 43)
West	18 (14, 22)
Hospital in SMSA	88 (83, 93)
0%–49% safety-net hospital	65 (59, 71)
≥50% safety-net hospital	35 (29, 41)
ED	
Pediatric	20 (12, 28)
General	80 (72, 88)
Time of arrival	
0800–2359	85 (83, 87)
0–0800	15 (13, 17)
Months of service	
April–December	71 (66, 76)
January–March	29 (24, 34)
Pulse oximetry	34 (30, 38)
Blood test, EKG, or cardiac monitor	69 (66, 72)
IVF or medications	81 (78, 84)
Prolonged ED-LOS (>8 h)	13 (11, 15)

These risk factors remained significantly associated with ED-LOS when we repeated the analyses excluding patients who received CT/MRI. Patient age, sex, insurance, triage score, ED provider type, hospital region, area, or type and other interventions (blood test, EKG, cardiac monitoring) were not associated with prolonged ED-LOS. We did not find significant interactions between ethnicity and other predictors of prolonged ED-LOS.

Furthermore, in analyses using total ED-LOS as a continuous variable, results did not change with the exception of triage score less than 15 minutes becoming inversely associated with prolonged total ED-LOS ($P = 0.012$).

DISCUSSION

Prolonged ED-LOS for children was common in this national sample. We found that 13% of pediatric patients admitted 2001–2006 from EDs nationwide experienced prolonged ED-LOS (>8 hours from time of arrival) before transfer to an inpatient bed. After controlling for multiple clinical and system-level factors, Hispanic ethnicity, ED arrival time between midnight and 8 A.M., admission during winter months (January–March), receipt of imaging studies, and receipt of IVF or medications in the ED increased the odds of prolonged ED-LOS, whereas admission to the ICU decreased the odds of prolonged ED-LOS. To our knowledge, ours is the first study to examine predictors of prolonged ED-LOS specifically for children admitted through the ED.

Our findings are similar to other adult-only or adult and pediatric studies that have reported prolonged ED-LOS occurring in 4.6% to 16% of admitted patients.[4,6,8] Prolonged ED-LOS and boarding of admitted pediatric patients threaten patient safety and strategies to prevent them are a key research priority.[12] According to the Joint Commission, more than 50% of reported "sentinel events" of morbidity and mortality resulting from treatment delay occurred in EDs.[38]

Previous studies have noted ethnic disparities in the receipt of timely emergency medical care for both Hispanic[32,39–42] and African American[13] patients. Our study exclusively focused on pediatric admissions and found that children of Hispanic ethnicity were nearly twice as likely as white (non-Hispanic) children to experience prolonged ED-LOS. Hispanic patients have been reported to have higher rates of ruptured appendicitis, a proxy for delayed ED care.[41] Brousseau et al[39] noted that Hispanic patients had decreased odds of timely medical care or a brief wait before receiving medical care. Others have reported Hispanic ethnicity to be associated with longer ED-LOS[32] and longer ED waiting time.[42] It is possible that prolonged ED-LOS in this group of children is related to language barriers, with additional time required to obtain medical history, explain and discuss diagnoses or procedures, and to wait for the arrival of interpreters. Previous studies have shown that interpreters are underused for Hispanic patients who are hospitalized[43] or seen in the ED.[44] Hampers et al[40] also showed that a perceived language barrier was associated with longer pediatric ED visits and increased use of diagnostic studies—possibly to compensate for an incomplete medical history. The primary language spoken is not recorded in NHAMCS; therefore, we were unable to analyze the effect of a provider-patient language barrier on prolonged ED-LOS. Other possible explanations we could not address using the NHAMCS database include level of literacy, education, and availability of primary care.

A strong predictor for prolonged ED-LOS in our study was time of ED arrival between midnight and 8 A.M. This suggests that variations in staffing may contribute to reduced throughput in the ED. In addition, hospital occupancy may peak in the early morning hours,[17] leading to prolonged ED-LOS. We also noted prolonged ED-LOS during the months of January to March, corresponding to the peak activity of pediatric viral illness

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TABLE 2. Characteristics Associated With Prolonged ED-LOS for Admitted Pediatric Patients 2001–2006

	Prolonged ED-LOS Adjusted Odds Ratio (OR) (95% CI)
Age	
<1 yr	0.64 (0.36, 1.13)
1–5 yr	1.00 (0.67, 1.49)
6–18 yr	1
Sex	
Male	1
Female	1.29 (0.90, 1.84)
Race/ethnicity	
White	1
Black	1.33 (0.86, 2.07)
Hispanic	**1.76 (1.10, 2.81)**
Asian	0.36 (0.09, 1.35)
Other	1.37 (0.40, 4.66)
Triage	
<15 min	*
>15 min	
No diagnosis of pneumonia	1
Diagnosis of pneumonia	0.45 (0.16, 1.31)
No diagnosis of fever	1
Diagnosis of fever	0.99 (0.48, 2.02)
No diagnosis of asthma	
Diagnosis of asthma	*
No diagnosis of dehydration	
Diagnosis of dehydration	*
Admission to regular bed	1
Admission to ICU	**0.29 (0.11, 0.77)**
Other provider	
Resident/intern	*
Hospital in non-SMSA	1
Hospital in SMSA	0.99 (0.49, 2.00)
0–49% safety-net hospital	1
≥50% safety-net hospital	1.14 (0.72, 1.81)
General ED	1
Peds ED	1.46 (0.87, 2.46)
Time of arrival	
0800–2359	1
0–0800	**2.80 (1.87, 4.20)**
Months of service	
April–December	1
January–March	**1.81 (1.20, 2.74)**
Year	
2001	1
2002	1.13 (0.47, 2.69)
2003	1.00 (0.47, 2.11)
2004	0.56 (0.24, 1.29)
2005	1.13 (0.54, 2.37)
2006	0.70 (0.32, 1.52)
No pulse oximetry	1
Pulse oximetry	**0.52 (0.34, 0.81)**
No blood test, EKG, or cardiac monitor	
Blood test, or EKG or cardiac monitor	*
No imaging	1
CT scan or MRI	**1.65 (1.05, 2.58)**
No IVF or meds	1
IVF or meds	**1.81 (1.10, 2.97)**

Predictors in bold type are statistically significant.

OR = 1, reference group.

*Variables on bivariate analyses with a value of $P > 0.20$.

(respiratory syncytial virus and influenza) admissions nationwide.[34,35] Hillier et al[17] also showed that hospital occupancy and ED-LOS peaked between January and March. The seasonal variation in prolonged ED-LOS in our study parallels hospital census trends, further supporting inpatient bed shortage as the primary cause of prolonged ED-LOS in the ED.[2,6,10,11,14,19,45,46] In regard to throughput and efficiency, it was notable that we found no increase in the likelihood of prolonged ED-LOS for patients evaluated and treated by interns or residents compared with attending physicians only.

As expected, we showed that diagnostic imaging such as CT or MRI was strongly associated with prolonged ED-LOS among admitted children. For some patients (such as children with abdominal pain of unknown etiology), imaging may play an important role in the admission decision, making the prolonged ED-LOS unavoidable. In addition, the need for diagnostic testing may reflect more complex or severe illness, a factor that might not be completely accounted for by other clinical characteristics included in our model. To test the possibility that prolonged ED-LOS caused by CT/MRI is fundamentally different than other prolonged ED-LOS, we repeated the analyses excluding patients who received CT/MRI. The results were similar.

We found that children requiring ICU admissions or receiving pulse oximetry in the ED had a lower risk of experiencing prolonged ED-LOS. Triage category less than 15 minutes was also associated with shorter total ED-LOS (in continuous ED-LOS analysis). This suggests that EDs and hospitals are generally succeeding in transitioning the most critically ill patients out of the ED more quickly than other admitted patients. This has been supported by other studies.[32] No other factors decreased the odds of prolonged ED-LOS.

Currently, there is no consensus on a quantitative definition for prolonged ED-LOS. We chose the 8-hour cutoff ("access block") used by other investigators and shown to be associated with adverse patient outcomes.[7,8] Emergency department physician and nursing shifts often range from 8 to 12 hours, and the 8-hour cutoff may capture patients at heightened risk for medical errors during shift change and "hand-off" in care. Other studies have defined prolonged ED-LOS using a cutoff of 6 hours[20,22] or 12 hours.[32] Although the definition may seem arbitrary, the dichotomous condition is a convenient benchmark for quality improvement studies. Nevertheless, to address the possibility of bias arising from using a dichotomous threshold, we also examined the results using ED-LOS as a continuous variable. We found no major differences in the independent predictors, with Hispanic race, ICU admission, CT/MRI, pulse oximetry, and IVF/medications remaining significant.

Results from a previous study using NHAMCS during 2001–2002 found an increased ED-LOS for admitted children presenting to pediatric EDs compared with general EDs.[31] In our

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study, which included 4 additional years of data, prolonged ED-LOS in the ED and total ED-LOS did not differ between pediatric and general EDs. Although we observed a higher proportion of pediatric admissions occurring in pediatric EDs compared with general EDs, ED-LOS was similar in these 2 settings. This suggests that system factors which may be common to both pediatric and general EDs, rather than differences in patient populations, likely underlie the problem of prolonged ED-LOS.

There were several limitations to our analysis. Because ED-LOS information was missing for 23% of patients admitted from the ED, we were unable to include these visits in our analysis. However, when we compared these visits to those with complete ED-LOS data, the patients were similar in age, gender, ethnicity, triage score, insurance, and hospital region, area and type. In addition, other factors affecting ED-LOS were not captured in this model, such as hospital occupancy and ED overcrowding or volume, and actual complexity and severity of patients' illness. The validity of triage category as a proxy for clinical severity is uncertain and additionally may be interpreted differently at different hospitals. Another limitation of NHAMCS is that we cannot definitively access boarding time, that is, the period between admission decision and transfer from ED to inpatient bed. Nonetheless, prolonged ED-LOS for admitted patients has been previously shown to be associated with adverse patient outcomes.[1,4,8,20,21]

Notwithstanding these limitations, there are important implications from this study. A recent report by the Institute of Medicine suggested that the development of pediatric emergency care in the United States is "uneven," as many EDs slowly adopt national standards to accommodate pediatric patients.[12] Controlling for multiple clinical and system-level variables, we found that prolonged ED-LOS occurs frequently for admitted pediatric patients and is associated with patient-level and system-level factors, most notably Hispanic ethnicity, presentation during influenza season, and early morning arrival. These findings point to potential targets for interventions to reduce ED-LOS, thereby improving quality and patient satisfaction with ED care. Potential strategies include enhanced staffing and additional inpatient bed availability during winter season and overnight hours. In addition, cultural competency policies and linguistically appropriate services in the ED (eg, bilingual staff and interpreter services) may help address significant differences in ED-LOS associated with patient ethnicity and further improve pediatric ED care.

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