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ORIGINAL RESEARCH CONTRIBUTION

The Association Between Length of Emergency Department Boarding and Mortality

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Abstract

Objectives: Emergency department (ED) boarding has been associated with several negative patient-oriented outcomes, from worse satisfaction to higher inpatient mortality rates. The current study evaluates the association between length of ED boarding and outcomes. The authors expected that prolonged ED boarding of admitted patients would be associated with higher mortality rates and longer hospital lengths of stay (LOS).

Methods: This was a retrospective cohort study set at a suburban academic ED with an annual ED census of 90,000 visits. Consecutive patients admitted to the hospital from the ED and discharged between October 2005 and September 2008 were included. An electronic medical record (EMR) system was used to extract patient demographics, ED disposition (discharge, admit to floor), ED and hospital LOS, and in-hospital mortality. Boarding was defined as ED LOS 2 hours or more after decision for admission. Descriptive statistics were used to evaluate the association between length of ED boarding and hospital LOS, subsequent transfer to an intensive care unit (ICU), and mortality controlling for comorbidities.

Results: There were 41,256 admissions from the ED. Mortality generally increased with increasing boarding time, from 2.5% in patients boarded less than 2 hours to 4.5% in patients boarding 12 hours or more ($p < 0.001$). Mean hospital LOS also showed an increase with boarding time ($p < 0.001$), from 5.6 days (SD ± 11.4 days) for those who stayed in the ED for less than 2 hours to 8.7 days (SD ± 16.3 days) for those who boarded for more than 24 hours. The increases were still apparent after adjustment for comorbid conditions and other factors.

Conclusions: Hospital mortality and hospital LOS are associated with length of ED boarding.

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Emergency department (ED) crowding and inadequate inpatient capacity are among the most important issues facing U.S. hospitals today and have been described by the Institute of Medicine as a public health crisis.[1] ED crowding is caused by periodic mismatches in demand for care and supply of resources in the ED, including staffing and bed space.[2] ED crowding manifests as long waits for patients to be seen by providers, high left-without-being-seen rates, long ED lengths of stay (LOS), and long waiting times before inpatient bed placement (also known as ED boarding).[3] The Centers for Medicare and Medicaid Services will include several measures of ED crowding in pay-for-reporting in 2013.[4] The reason for the focus on measuring ED crowding is that it is not only undesirable because patients have to wait longer, but ED crowding has also been associated with several negative patient-oriented outcomes, including delays in important medications and higher complication rates after ED evaluation, including an increase in mortality.[5–13]

A major contributor to the supply–demand mismatch and resultant crowding is episodes of ED boarding.[3,14–16] ED boarding occurs when insufficient

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hospital capacity is available for admitted patients to be transferred to inpatient beds. The result is that admitted patients remain in the ED, sometimes for long periods. The concern is that due to competing demands by other patients and general system overload, boarders do not receive the same level of care that they would in inpatient beds.[13] Several recent articles have identified safety issues with boarding, including adverse events, higher rates of ventilator-associated pneumonia,[17] higher mortality rates for intensive care unit (ICU) patients per se,[5,6] and for admissions overall. There are also higher rates of medication errors and preventable adverse events.[18,19] To our knowledge, few studies have evaluated the association between length of ED boarding and patient outcomes in a general ED population.

This study was designed to explore the association between ED boarding and clinically important patient outcomes in an academic, suburban setting. We hypothesized that longer ED boarding times would be associated with hospital mortality and LOS.

METHODS

Study Design

We performed a retrospective cohort study to explore the association between length of ED boarding and outcomes of boarded ED patients at a single hospital. The study was approved by the institutional review board and exempt from written, informed consent.

Study Setting and Population

The study site was a suburban, university-based, academic ED with an affiliated emergency medicine residency training program and an annual ED census of 90,000 visits. All patients admitted to the hospital through the ED and discharged during the study period of October 2005 through September 2008 were included in the study. Admissions data for all ED cases were extracted from the University Health System Consortium.[20] Cases were excluded from all analyses if boarding time or any of the outcomes (LOS, in-hospital mortality, ICU admission) were missing.

Study Protocol

Our site has developed a unique system for dealing with ED crowding and prolonged boarding of admitted patients. A medical admitting resident is assigned to the ED who briefly evaluates each admission and assigns the patient to a medical team. While in the ED, the care of boarders is rendered by the admitting medical team, which may or may not see the patient before he or she is transferred to the ward. To reduce ED boarding, we have developed a full-capacity protocol in which boarders are admitted to inpatient hallways when beds are no longer available in the ED to see new patients, and there are no open beds on the inpatient wards.[21] While this system helps to decongest the ED, the number of patients that can be accommodated in any inpatient hallway is limited to one to two at any given time. Furthermore, only stable patients are eligible for this pathway.

An electronic medical record (EMR) system was used to extract patient demographics and clinical data for each patient. The ED disposition (discharge, admit to floor, admit to hallway), ED and hospital LOS, and in-hospital mortality were extracted. For this study, ED boarding was defined as ED LOS ≥ 2 hours after the admission order was written and processed.

Data regarding time of admission and time for transfer to floor are based on ED clerk input. The ED clerk enters the time of admission into the EMR. The admissions clerk enters when a bed is assigned (either regular bed or hallway bed). The time of arrival to the unit is input by the floor clerk (to the assigned bed, either room or hallway) into the EMR. When a patient moves from hallway to room, this is also input by the clerk on the floor into the EMR.

The data for patients who were boarded in the ED were compared across defined time intervals (2–5, 6–11, 12–24, >24 hours) for length of ED boarding. The primary outcome was in-hospital mortality. Secondary outcomes were the rate of transfer or upgrade of patients to an ICU setting and total hospital LOS. Length of ED boarding was defined as the interval between calling in the admission and physically leaving the ED. LOS was calculated as the interval between admission to the inpatient floor and hospital discharge.

Measures of Disease/Injury Severity. Measures of comorbidity were used to adjust for differences in case mix. Comorbidity indicator variables for 29 diseases and conditions were created using the method developed Elixhauser et al.[22] and used by the Agency for Healthcare Research and Quality (AHRQ) Healthcare Cost and Utilization Project (HCUP),[23] which uses International Classification of Diseases, ninth revision (ICD-9), codes from administrative data to identify the conditions. The All Patient Refined Diagnosis-Related Groups (APR-DRG) severity of illness and mortality risk scales (Likert scales from 1 = minor to 4 = extreme) were used as general descriptors of the severity of patient conditions.[21]

Data Analysis

Descriptive statistics were used to evaluate the association between length of ED boarding and hospital LOS, subsequent transfer to an ICU, and mortality. Continuous data are presented as means and 95% confidence intervals (CIs) and compared with analysis of variance. Binary data are expressed as the percentage frequency of occurrence and compared with chi-square tests. Univariate analyses were performed using the visit as the unit of analysis.

Multivariate logistic regression was used to identify factors that were associated with in-hospital mortality and admission to ICU, while linear regression was used to identify factors that were associated with inpatient LOS. Generalized estimating equation methods were used to account for cluster effects of patients with repeat visits. Multivariate models included adjustments for all factors that we considered as potential predictors based on prior knowledge and clinical relevance and that were available in the databases, i.e., comorbidities,

age, sex, race, weekend, and shift (8 AM–4 PM, 4 PM–12 AM, and 12 AM–8 AM). Interaction terms were not considered for this exploratory model. In addition to adjusting for categorical variables via indicator variables, adjustments for continuous variables (i.e., age) were also made using indicator variables because we did not presuppose linear relationships between predictors and outcomes. Standard errors were examined for evidence of overfitting and colinearity among predictors. No adjustments were made for risk of mortality or severity of illness, since these are reflections of comorbidities and outcome. Statistical analysis was performed with Predictive Analytic SoftWare (PASW, International Business Machines Corp., Armonk, NY) for Windows (Microsoft Inc., Redmond WA), Version 18.

RESULTS

During the study period there were 42,149 patients admitted from the ED; 893 (2.1%) of these were excluded for missing data, resulting in 41,256 cases used in the analysis. The mean (±SD) age of these patients was 53.1 (±24.6) years, 52% were male, 80% were white, 9% were Hispanic, and 7% were black or African American. The mean (±SD) LOS was 6.0 (±11.7) days, and 12.1% were admitted to the ICU. A total of 1,153 patients (2.8%) died during their hospital stay, 50.2% remained in the ED for at least 2 hours, and 13.5% stayed in the ED for at least 6 hours. After excluding 64 patients with unknown risk of illness and risk of mortality, there was a determination of extreme severity of illness and risk of mortality in 9.8 and 7.2% of patients, respectively. Comorbidities are shown in Table 1. With regard to how long patients who were moved from the ED to an inpatient hallway were ''boarded'' on inpatient units, 28% of hallway patients immediately went to a normal room, another 25% waited less than an hour, and the remainder (46%) waited for a mean of 10.3 hours. Overall, the mean inpatient hallway time was just less than 5 hours.

Mortality increased with increasing boarding time (Table 2, Figure 1), from 2.5% in patients boarded less than 2 hours to 4.5% in patients boarding 12 hours or more ($p < 0.001$). The pattern was slightly different after adjustment for other factors, wherein mortality was slightly lower in the 24 + -hour boarding group than in the 12- to 24-hour group. Examination of the results indicated that this was due to older patients being boarded (data not shown).

ICU admission was also significantly different across boarding times (Table 2, Figure 2), essentially showing increased ICU admissions with increased boarding times. This pattern was unchanged after multivariate adjustment.

Hospital LOS showed a strictly increasing pattern with boarding time ($p < 0.001$). LOS increased from 5.6 days for those boarding for 2 hours or less to 8.7 days for those boarding 24 hours or more (Table 2, Figure 3). LOS showed a significant increase in relation to boarding time even after adjusting for other factors. There were no indications of colinearity or overfitting in any of the outcome multivariate models, which would have an effect on model interpretation.

DISCUSSION

Our results suggest that prolonged ED boarding is associated with worse clinically important patient outcomes such as hospital LOS and mortality. Our findings are similar to those of recent studies demonstrating that boarding is associated uniformly with negative effects.[5,18,19] There are several potential explanations. The first is that there is a direct causal relationship between boarding and patient outcomes. This may be due to the fact that boarders contribute to ED crowding, placing an increased burden on ED personnel (particularly nursing staff) who are often busy seeing new and potentially more unstable patients, while dedicating less time to caring for those patients who are already admitted and boarded. Also, although physician care is provided by the inpatient services, the ED boarders may be the last patients to be seen by the services caring for these patients and may be less frequently reevaluated. Workups and other therapeutic interventions may be delayed as well.

Another possible contributor to the association between boarding and worse outcomes is that by admitting low-risk patients to hospital hallways (the full-capacity protocol), high-risk patients preferentially tend to stay in the ED longer. Thus, the increase in hospital mortality and LOS may be due to an increase in injury or illness severity and not a direct result of prolonged boarding. Regardless, ED boarders are at increased risk of poor patient outcomes, and alternative plans must be made to care for them to avoid compromised care. Finding strategies that make boarding safer (such as having inpatient teams manage ED patients while they are in the ED) may reduce adverse events related to boarding, but even this will continue to place arriving patients at risk if the ED does not have adequate remaining staff and space to function appropriately.

While our study has focused on the association between boarding and hospital mortality and LOS for those admitted to the hospital, there is mounting evidence that prolonged boarding has many effects on other ED patients waiting for care. This is important because increased numbers of boarders have been associated with several negative patient-oriented outcomes. Specifically, there have been reported associations between the number of boarding patients in the ED and 1) delays in antibiotics,[12] 2) delays in pain medication,[11,24,25] 3) lower patient satisfaction,[25] 4) delays in abdominal computed tomography results,[26] 5) prolonged disposition times in patients with acute asthma,[27] 6) higher complication rates in acute coronary syndrome (ACS) and non–ACS-related chest pain,[28] and 7) higher rates of ventilator-associated pneumonia in trauma patients who are admitted through the ED.[29] Taken together, these results underscore the compelling need to develop solutions that reduce or eliminate boarding altogether, as suggested by the Institute of Medicine.[1]

This study documents that the population boarding in the ED represents a group with higher LOS, morbidity, and mortality. Even without a causal link between boarding and outcome, these data should compel

Table 1
Baseline Characteristics of Patients

Characteristic	All Patients	Boarding Categories (Hours)				
		<2	2–6	6–12	12–24	24+
Number of patients	41,256*	20,527	15,145	3,121	2,086	377
Mean (±SD) age, yr	53.1 (24.6)	49.6 (26.2)	55.4 (23.0)	58.5 (20.1)	61.4 (19.4)	62.9 (18.7)
65 years of age and older, %	36.8	33.0	39.3	41.8	46.7	50.9
Male, %	52.1	52.2	51.2	53.9	54.6	58.1
Race, %						
White	80.0	79.1	80.4	80.7	84.5	82.8
Black or African American	6.7	6.7	6.8	7.0	5.6	7.2
Hispanic	9.1	9.7	8.8	8.0	6.4	6.4
Boarding time 6+ hours, %	13.5	0	0	100	100	100
Illness severity, % (n = 42,092)						
Minor	29.1	32.4	27.7	23.0	19.3	18.0
Moderate	35.5	35.8	35.3	36.1	33.8	32.9
Major	25.6	23.0	27.4	28.3	32.5	31.0
Extreme	9.8	8.8	9.6	12.6	14.4	18.0
Risk of mortality, % (n = 42,092)						
Minor	50.5	55.1	48.3	43.3	34.9	32.9
Moderate	26.5	24.7	27.8	28.5	31.9	29.2
Major	15.8	13.8	16.6	18.6	22.9	24.4
Extreme	7.2	6.3	7.2	9.7	10.4	13.5
Weekend visit, %	24.9	27.1	23.2	21.4	20.9	32.6
Shift, %						
Evening (4 PM–midnight)	38.3	43.2	29.5	33.9	62.8	25.5
Night (midnight–8 AM)	12.4	10.8	12.2	25.1	9.7	13.0
Comorbidities, %†						
Congestive heart failure	8.1	7.1	8.6	9.2	11.4	11.1
Valvular disease	5.0	4.5	5.3	5.8	6.7	6.4
Peripheral vascular disease	5.6	4.9	5.9	6.6	8.2	8.8
Hypertension	41.5	38.3	43.7	45.9	49.3	47.5
Other neurologic disorders	6.9	6.5	7.3	7.1	7.5	9.0
Chronic pulmonary disease	15.2	14.0	15.7	18.1	18.3	18.8
Diabetes mellitus						
No complications	16.0	14.4	17.1	18.0	20.2	19.6
With complications	3.9	3.4	4.2	4.9	4.4	5.3
Hypothyroidism	9.2	8.4	9.9	10.4	10.3	12.2
Renal failure	9.3	8.1	9.9	11.8	12.2	13.8
Coagulation deficiency	3.3	3.1	3.3	3.8	4.3	3.4
Obesity	8.0	7.2	8.7	9.4	8.8	10.6
Weight loss	4.3	3.9	4.5	5.4	5.2	6.9
Fluid and electrolyte disorders	24.8	22.8	25.9	28.0	30.6	32.9
Deficiency anemias	15.2	13.9	15.8	17.4	18.3	20.2
Alcohol abuse	4.2	4.0	4.0	5.0	6.1	4.5
Drug abuse	3.7	3.4	3.8	4.0	4.4	5.0
Psychoses	3.6	3.4	3.7	3.6	4.7	5.3
Depression	10.7	10.0	11.5	11.2	12.5	8.8
Outcomes						
Median hospital LOS, days (IQR)	3 (2–6)	3 (2–6)	3 (2–7)	4 (2–7)	4 (3–8)	5 (3–9)
In-hospital mortality, %	2.8	2.5	2.7	3.9	4.5	4.5
Admitted to ICU, %	12.1	12.4	10.8	14.5	14.6	15.9

*Sixty-four cases were excluded because illness severity and risk of mortality could not be determined based on diagnoses of these cases.
†Excludes comorbidity categories affecting <3% of the sample (pulmonary circulation disorders, paralysis, liver disease, chronic peptic ulcer, HIV/AIDS, lymphoma, metastatic cancer, solid tumor without metastasis, rheumatoid arthritis, blood loss anemias).
ICU = intensive care unit; LOS = length of stay.

hospitals to assure the highest quality of care to this patient population. To date, no studies have supported the idea that this can be accomplished by allowing admitted patients to languish in the ED. The findings described here are congruent with other studies that document the myriad harmful consequences of boarding of admitted patients in the ED. Taken together with literature supporting the benefits of moving patients to the inpatient services, as measured by overall LOS, patient preference, and ED wait times, the current systematic tolerance of boarding of inpatients in the ED is unacceptable.

LIMITATIONS

This was a retrospective review of a large computerized database. As such, we can only estimate associations between predictor variables and outcomes. Ultimately,

Table 2
In-hospital Mortality by Length of ED Boarding Time

ED Boarding Time, hours	In-hospital Mortality %	Multivariate Odds Ratio (95% CI)	ICU admission %	Multivariate Odds Ratio (95% CI)	Mean LOS (±SD)	Multivariate LOS Mean Increase in Days (95% CI)
<2	2.5	Reference	12.4	Reference	5.6 (11.4)	Reference
2–6	2.7	0.91 (0.80–1.05)	10.8	0.85 (0.79–0.91)	6.1 (11.9)	0.23 (0.00–0.46)
6–12	3.9	1.24 (1.00–1.54)	14.5	1.14 (1.01–1.29)	6.8 (11.4)	0.49 (0.08–0.90)
12–24	4.5	1.43 (1.13–1.82)	14.6	1.18 (1.02–1.35)	7.3 (11.8)	0.74 (0.25–1.23)
24+	4.5	1.23 (0.73–2.09)	15.9	1.19 (0.88–1.61)	8.7 (16.3)	1.93 (0.79–3.06)

Multivariate results are adjusted for age, sex, race, weekend, shift, and Elixhauser comorbidity variables.

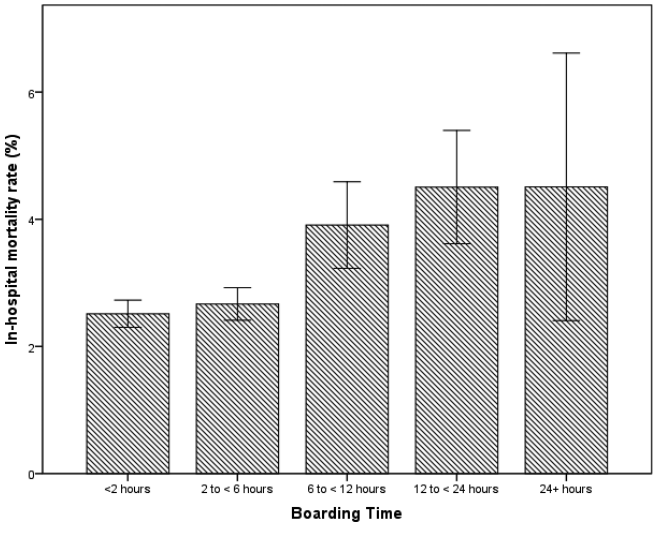

Figure 1. In-hospital mortality rate by length of boarding time.

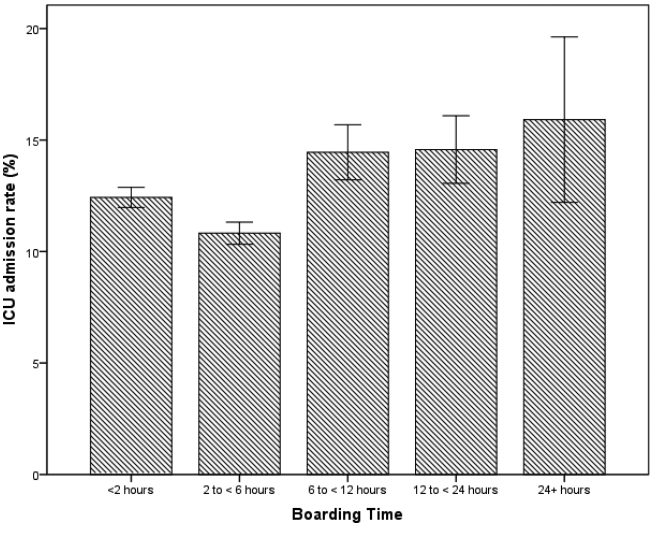

Figure 2. ICU admission rate by length of boarding time. ICU = intensive care unit.

causality could only be determined in a prospective clinical trial in which admitted patients are randomized to prolonged ED boarding or immediate transfer to an inpatient bed. While this type of a trial would be unethical, studying interventions to reduce boarding, examining outcomes such as mortality and hospital LOS, would be desirable.

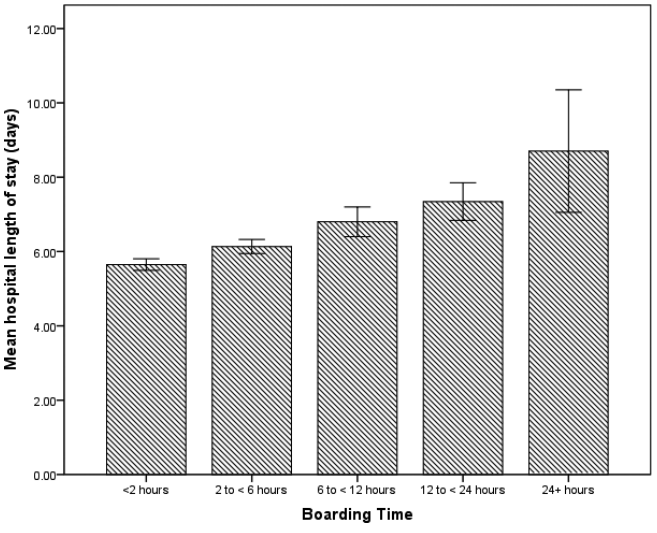

Figure 3. Mean hospital LOS by length of boarding time. LOS = length of stay.

We used all available cases to develop the models, and as a result we did not have an independent database to use for external validation. To assess the effect of hospital LOS outliers on results, we repeated the LOS analyses after excluding all patients who had a hospital LOS longer than 200 days, which was an arbitrary cutoff determined after examination of the data. Removing these outliers from the analyses had no effect on the results.

CONCLUSIONS

Emergency department boarding was associated with higher inpatient mortality rates and longer hospital length of stay in this hospital. Efforts to reduce boarding may improve outcomes for ED patients who are admitted to the hospital.

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