An Empirical Assessment of Boarding and Quality of Care: Delays in Care Among Chest Pain, Pneumonia, and Cellulitis Patients

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Abstract

Background: As hospital crowding has increased, more patients have ended up boarding in the emergency department (ED) awaiting their inpatient beds. To the best of our knowledge, no study has compared the quality of care of boarded and nonboarded patients.

Objectives: This study sought to examine whether being a boarded patient and boarding longer were associated with more delays, medication errors, and adverse events among ED patients admitted with chest pain, pneumonia, or cellulitis.

Methods: This study was a retrospective cohort design in which data collection was accomplished via medical record review from two urban teaching hospitals. Patients admitted with chest pain, pneumonia, or cellulitis between August 2004 and January 2005 were eligible for inclusion. Our outcomes measures were: 1) delays in administration of home medications, cardiac enzyme tests, partial thromboplastin time (PTT), and antibiotics; 2) medication errors; and 3) adverse events or near misses. Primary independent variables were boarded status, boarding time, and boarded time interval. Multiple logistic regression models controlling for patient, ED, and hospital characteristics were used.

Results: A total of 1,431 patient charts were included: 811 with chest pain, 387 with pneumonia, and 233 with cellulitis. Boarding time was associated with an increased odds of home medication delays (adjusted odds ratio [AOR] = 1.07, 95% confidence interval [CI] = 1.05 to 1.10), as were boarded time intervals of 12, 18, and 24 hours. Boarding time also was associated with lower odds of having a late cardiac enzyme test (AOR = 0.93, 95% CI = 0.88 to 0.97).

Conclusions: Boarding was associated with home medication delays, but fewer cardiac enzyme test delays. Boarding was not associated with delayed PTT checks, antibiotic administration, medication errors, or adverse events/near misses. These findings likely reflect the inherent resources of the ED and the inpatient units.

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The Institute of Medicine (IOM) report “To Err Is Human” brought public attention to the frequency of adverse events in medicine in the United States. Emergency departments (EDs) are an important locus for medical errors due in part to conditions including multiple concurrent tasks,
Hospital crowding has emerged as an important factor related to medical error\textsuperscript{9} and has led to more “boarded” patients (i.e., patients who are admitted but wait in the ED while their inpatient beds become available).\textsuperscript{6,7} ED care focuses on stabilization and initial diagnosis rather than inpatient management. Because boarded patients receive treatment in areas not designed for function as inpatient units, their care may be suboptimal compared to inpatient levels. Nevertheless, the Joint Commission has mandated that hospitals provide appropriate and adequate care to patients held in temporary bed locations such as the ED.\textsuperscript{8} The IOM concluded that boarding not only compromises the patient’s experience, but adds to an already stressful environment for ED workers, increasing the potential for errors, treatment delays, and diminished quality of care, and called for the elimination of boarding.\textsuperscript{9}

Important conclusions and policy recommendations regarding boarding have been made with limited supporting data. Studies have shown that longer ED length of stay (LOS) and boarding times are associated with longer hospital LOS, higher rates of recurrent myocardial infarction, increased rates of patients leaving the ED without being seen, diversion, and increased mortality.\textsuperscript{1,10–18} To the best of our knowledge, no study has compared the quality of care provided to boarded and nonboarded patients.

We compared care provided to boarded patients with that given to nonboarded patients. We hypothesized that being a boarded patient and boarding longer increases delays in laboratory checks, administration of antibiotics and home medications, medication errors, and adverse events.

**METHODS**

**Study Design**

This was a retrospective cohort study in which data collection was accomplished via medical record review from two urban teaching hospitals. We reviewed records of patients admitted from the ED between August 1, 2004, and January 31, 2005, with chest pain, pneumonia, or cellulitis. Based on pilot work,\textsuperscript{19} the current study included two sites and an expanded sample size, compared care provided to boarded patients with inpatient unit care, and adapted an instrument from the National Emergency Department Safety Study (NEDSS, a large multicenter study on adverse events\textsuperscript{20}). Our study was approved by the relevant institutional review boards prior to commencement of the study. We received funding from the Eleanor and Miles Shore Grant and the Risk Management Foundation.

**Study Setting and Population**

Data came from chart review and administrative databases from two Boston nonprofit, academic, urban teaching hospitals. The hospitals average 54,000 and 80,000 annual ED visits. At one hospital, the emergency physicians (EPs) and ED nurses manage boarded patients; at the other hospital, the inpatient physicians and either ED or inpatient “float” nurses take responsibility for boarded patients. We used a review methodology employed in similar quality-of-care studies:\textsuperscript{5,20} trained research assistants (RAs) abstracted explicit information from the entire ED chart and first 26 hours of admission. RAs flagged charts containing potential adverse events and copied the entire admission for implicit review (see Data Supplement S1 for the original instrument, available as supporting information in the online version of this paper).

We included patients admitted to the hospital from the ED for more than 26 hours with an admission diagnosis of chest pain, pneumonia, or cellulitis. We selected these conditions as they are common reasons for admission, guidelines exist for their care, and they require follow-up laboratory tests and/or medications that may be delayed for boarded patients.\textsuperscript{21–26} We used International Classification of Disease, 9th Revision (ICD-9), codes assigned for hospital admission diagnosis to identify patients. We chose a 26-hour window to avoid patients admitted to an observation unit, since only one hospital had an observation unit at the time of the study. At the other hospital, low-risk chest pain patients were often ruled out in the ED and were discharged home. We excluded patients admitted directly to the catheterization suite, transferred from other hospitals, who were less than 18 years of age, needing precaution rooms, and not admitted to standard medicine inpatient units (i.e., operating room, nonmedical teams, or intensive care unit) to minimize extremes of boarding time and maximize patient comparability.

**Study Protocol**

We adapted our instrument based on our pilot study,\textsuperscript{6} the Harvard Emergency Department Quality study,\textsuperscript{7} standard guidelines for the three conditions,\textsuperscript{21–26} and the NEDSS project (e.g., by adding questions on time of home medication administration, cardiac enzyme checks, partial thromboplastin time [PTT] checks, and heparin administration).\textsuperscript{20,27} We refined our instrument (e.g., adding unstable vital signs to the adverse event screen) based on consultation with five board-certified EPs and two doctoral-level health services researchers. Prior to data collection, we piloted chart abstraction forms on 15 pseudo-randomly selected sample charts.

The study’s principal investigator (PI, SWL) supervised the administration of chart abstraction and review. RAs (seven medical students, one auxiliary health care student, and one registered nurse) received uniform training that included reviewing sample charts to assure reliability of abstraction using an adapted version of the NEDSS manual.\textsuperscript{20} RAs used an adapted NEDSS code book that defined important variables. To monitor abstraction performance, there were periodic meetings and evaluations to clarify coding. The PI resolved any data conflicts. Physician reviewers had similar, although less intensive, training. We developed a uniform abstraction form using Microsoft Access, 2003 (Microsoft Inc., Redmond, WA).

To establish reliability, the PI reabstracted a randomly selected 4% of charts. Kappa values were 0.84, 0.76, and 0.51 for the presence of a home medication (hydrochlorothiazide), a medication error, and flagging charts as having possible adverse events, indicating
Measures

Independent Variables. Because no one has determined a specific cutoff point at which quality of care may become compromised for boarding patients, we created three primary independent variables to examine boarding: 1) a dichotomous variable, “boarded” status, indicating whether decision to admit–to–ED departure time was greater than 2 hours using bed request time as a proxy for decision to admit; 2) a continuous variable, “boarding time,” representing the time starting from decision to admit and ending when the patient departed the ED; and 3) a variation on the first and second variables, “boarded time interval,” defined as the time patients spent in the ED starting 2 hours after decision to admit and ending after a 6-, 12-, 18-, or 24-hour interval of analysis (see Figure 1). We chose 2 hours after bed request to demarcate boarded patients to be consistent with the ED Benchmarking Summit (the findings of a consensus group created to address standardization of ED performance measures) definition and to create a comparable group of nonboarded patients.29 We defined continuous boarding time according to the ED Benchmarking Summit29 and the Government Accountability Office.3 All nonboarded patients would have been excluded had the start point for the boarding time variable been 2 hours after decision to admit; hence, boarding time had a different start point than the other two variables. We felt that inclusion of all patients better assessed whether boarding time as a continuous variable was related to outcomes. We examined 6-hour intervals given that laboratory tests and medications often have at least 6-hour intervals between tests or administration. “Nonboarded time” represented the time nonboarded patients spent on the inpatient unit starting 2 hours after decision to admit until either 24 hours later or the end of a defined interval of analysis (Figure 1).

We controlled for certain patient, ED, and hospital characteristics that were potential confounders. At the patient level, we controlled for age, sex, self-reported race/ethnicity, Emergency Severity Index (ESI), means of ED arrival (e.g., ambulance), and comorbidities, using a Romano-Adjusted Charlson Comorbidity Score (a single variable that aggregates relevant comorbidities modified for use with ICD-9 codes).30–34 We also adjusted for the following ED and hospital characteristics: level of ED crowding at time of bed request, shift when patient arrived at the ED, admission day hospital occupancy, and hospital size.5,10,35 We selected the commonly used Emergency Department Work Index (EDWIN), which includes number of ED patients, admitted patients, ED attending physicians present, treatment bays, and patient triage category, to measure ED crowding. Crowding was divided into three categories based on EDWIN score: 1) active but manageable (<1.5), 2) busy (1.5–2), and 3) crowded (>2).36,37 Because other studies have examined how crowding affects outcomes, we chose to examine whether boarding, independent of crowding, relates to delays. Hospital occupancy was measured in terms of midnight occupancy. We considered using number of ED patients present to measure crowding, but found that the correlation was less between boarding time and EDWIN.

Outcome Measures. Our outcome variables were delays, errors, and adverse events. We examined delays in administration of home medications of all patients, repeat cardiac enzyme checks, PTT tests among chest pain patients, and administration of subsequent antibiotic doses among pneumonia and cellulitis patients.

We examined all patients’ usual home medication regimens listed in the admission note and the times first prescribed and administered for the following four medication categories: diabetes, cardiovascular, pulmonary, and gastrointestinal. These medication categories were thought most likely to have clinical relevance if

Figure 1. Example of flow of boarded and nonboarded patients through the ED. A patient arrives to the ED (Point A). The decision is made to admit the patient and a bed request is made (Point B). After two hours, the patient has either been admitted and is on the floor and is defined as a “nonboarded” patient (Point F), or has not, in which case the patient is still in the ED and is defined as a “boarded” patient (Point C). In this example, the boarded patient stays until the end of the 18 hour “boarded time interval,” which represents 20 hours of “boarding time” (Point D). The “early admission period” represents the 24 hours after the two hour boarded vs. nonboarded demarcation.
missed. Any medication or its equivalent not administered during a “reasonable time frame” was considered a delayed home medication, unless a reason was specified by the inpatient team. We defined a patient as having delayed home medications if at least 50% of their home medications were delayed.

For chest pain patients, we examined delays in obtaining repeat cardiac enzymes as well as PTT tests for patients who received heparin. For cellulitis and pneumonia patients, we examined delays in administration of repeat doses of antibiotics. To calculate laboratory testing intervals, at least two laboratory tests were required for analysis eligibility. Similarly, as antibiotics have different dosing schedules, we calculated intervals only for subsequent doses of the same antibiotic.

To define delays and “reasonable time frame,” a panel of three board-certified EPs with administrative and research interests and expertise in quality of care convened prior to data analysis (SWL, RTG, AGH). For laboratory exams, they defined “delayed” as being greater than 2 hours after the standard expected interval between laboratory tests. Eight hours was the standard interval between cardiac tests on the inpatient units at both institutions; therefore, we defined a “delayed cardiac enzyme” as greater than 10 hours after the previous test. Similarly, both institutions used a 6-hour test as the standard after initial heparin administration. Therefore, a “delayed PTT” was 8 hours after starting heparin. We defined “delayed administration of antibiotics” as 30 minutes after the standard dosing interval following Shah and colleagues. For home medications, the panel agreed that a “reasonable time frame” was 1.5 times the standard interval for administering the medication.

Following the IOM report and the NEDSS project, we defined an “error” as the failure to complete a planned action or the use of a wrong plan to achieve an aim. “Medication errors” included wrong patient, wrong drug, drug–drug interaction, dose error, route error, frequency error, and incorrect strength. Originally, the NEDSS instrument was used to define medication errors, but we found physician order entry (POE) to affect NEDSS medication events such as lack of date or time. Since one site lacked ED POE, our final definition of medication error only included events unaffected by POE.

A “near miss” was defined an error that could cause injury, but did not do so because of chance or specific circumstances or because it was intercepted before the injury occurred. An “adverse event” was an injury (a pathologic alteration in condition) that resulted from medical intervention and not from natural progression of the underlying condition; a “preventable adverse event” was an adverse event associated with an error.

Research assistants identified charts with potential adverse events or near misses based on an adapted NEDSS screening instrument. Two board-certified EPs then independently verified the presence and preventability of such events (reviewers included SWL, RTG, JT, and AGH). The physicians were required to agree that an event was an adverse event or a near miss and whether they were preventable or intercepted. Any initial disagreement was resolved through discussion.

Data Analysis
Differences in characteristics of boarded and nonboarded patients were initially tested with the use of Wilcoxon and chi-square tests. We then calculated differences in frequencies of events.

To examine our three independent variables, we had to define an “exposure period” or time frame over which we measured outcomes for each variable. For the dichotomous variable boarded status, the exposure period was the “early admission period,” which represented the first 24 hours after admission starting 2 hours after bed request. To coincide with the start time of the continuous variable boarding time, the exposure period was the first 26 hours after decision to admit. For the boarded time interval variable, our exposure period was the same as the independent variable, which started 2 hours after decision to admit and ended after a 6, 12, 18, or 24-hour interval. Delays or adverse events with a target time within the defined exposure period were eligible for the applicable analysis. We assumed that medication errors occurred during the applicable exposure periods. Because time of medication error was not noted in our instrument, we could not determine exactly when medication errors occurred, only that they occurred sometime during the patient’s ED stay and/or the first 26 hours after admission.

To determine whether boarding was associated with our outcome measures, we used our three definitions of boarding. First, we compared boarded and nonboarded patients in frequency of delays, errors, and adverse events during the early admission period regardless of whether the events occurred in the ED or on the inpatient unit. Second, we examined whether boarding time was associated with outcomes over the first 26 hours of admission. Third, we compared delays and adverse events in patients with boarded time intervals of 6, 12, 18, and 24 hours to nonboarded patients over the same lengths of time. Because boarded patients were censored from analysis if they left the ED before the end of the interval, this analysis localized their outcomes to the ED during that interval. It also allowed for the possibility that events followed a nonlinear pattern.

We ran separate logistic regression models for boarded status, boarding time, and boarded time interval for each outcome measure, adjusting for individual, ED, and hospital characteristics previously described. In addition to perceived clinical relevance, variables included in the models were also chosen to control for any imbalance between boarders and nonboarders. All variables in the models were prespecified without employing any of the variable selection techniques. In models with few outcomes, we used a subset of available covariates, retaining those we believed were most related to the dependent variable, to avoid overfitting. Model assumptions were checked and model assessment was performed by calculating goodness-of-fit statistics. No adjustment was made for the inflation of type I errors resulting from multiple comparisons.
Sensitivity Analyses
We conducted sensitivity analyses by varying the definitions of our outcomes. In addition to our main specifications, we ran multivariable models with patients having delayed home medications if any, 25%, and 75% of their home medications were delayed. For cardiac enzymes, we defined delays as 8 and 9 hours after last check. For PTT, we defined delays to be 6 and 7 hours after heparin was initiated. For antibiotics, we defined delays as 1 and 2 hours after standard dosing interval. We also conducted a within-site analysis.

Our pilot study found that 28% of ED patients had an undesirable event while boarding. With 1,431 charts, our study had greater than 80% power to detect a 27% difference in undesirable events between boarded and nonboarded patients at the 0.05 level. Originally we powered our study to detect a difference in this composite undesirable event score. However, because patients had variable exposures (e.g., chest pain patients who received heparin had more opportunities for delays than chest pain patients who did not receive heparin) we decided to divide outcomes into separate categories. As a result, we were likely underpowered for certain outcomes such as medication errors and adverse events. Statistical analysis was performed using SAS (Version 9.2, SAS Institute, Cary, NC).

RESULTS
A total of 1,467 ED patients were eligible for inclusion during the study period. Eleven patients were excluded because they were classified (e.g., admission diagnosis stated pneumonia, but patient admitted for abdominal pain). Multiple attempts failed to locate 25 charts. Our final analysis was based on 1,431 charts (811 chest pain, 387 pneumonia, and 233 cellulitis).

Characteristics of Study Subjects
Our study included 371 nonboarded patients and 1,060 boarded patients. Boarded and nonboarded patients were similar in terms of age, sex, race/ethnicity, ESI, and adjusted Charlson score (Table 1). Boarded patients arrived more often by ambulance and during the day shift and experienced more ED crowding at the time of bed request. Median time spent in the ED after bed request was 5.2 hours for boarded patients (interquartile range [IQR] = 3.1 to 9.8) and 1.3 hours for nonboarded patients (IQR = 1.0 to 1.7).

Main Results
Boarded status and boarded time intervals were associated with increases in home medication delays but decreases in some laboratory related delays. Boarded patients had a somewhat higher frequency of missed home medications than nonboarded patients (44%, 95% confidence interval [CI] = 40% to 48% vs. 34%, 95% CI = 28% to 41%) but fewer delayed cardiac enzyme tests (20%, 95% CI = 16% to 23% vs. 34%, 95% CI = 27% to 41%) over the early admission period. There was little difference between boarded and nonboarded patients in terms of antibiotic and PTT test delays (Table 2). Differences in frequency of home medication and cardiac enzyme delays were also observed when we compared nonboarded and boarded time intervals (Table 3). At each 12-, 18-, and 24-hour interval, boarded patients missed home medications more frequently than nonboarded patients. Boarded patients at 6, 12, and 18 hours had significantly fewer delayed cardiac enzymes tests than nonboarded patients (Table 3).

After adjusting for covariates, each hour of continuous boarding time increased the odds of delayed home medications by 7% (adjusted odds ratio [AOR] 1.07, 95% CI = 1.05 to 1.10), and 12-, 18-, and 24-hour boarded time intervals were also associated with home medication delays (Table 4). Conversely, boarding time decreased the odds of having a delayed cardiac enzyme check (AOR = 0.93, 95% CI = 0.88 to 0.97), which was also observed at the 12- and 18-hour boarded time intervals. Boarding was not associated with delayed PTT checks or antibiotic administration. We found no differences between boarded and nonboarded patients in terms of medication errors and adverse events. We report these findings in Data Supplement S2 (available in online version).

Table 1
Characteristics of Nonboarded Versus Boarded Patients*

<table>
<thead>
<tr>
<th>Variable</th>
<th>All Patients (n = 1431)</th>
<th>Nonboarded Patients (n = 371)</th>
<th>Boarded Patients (n = 1,060)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yr, mean ± SD</td>
<td>65 ± 17</td>
<td>65 ± 16</td>
<td>65 ± 17</td>
</tr>
<tr>
<td>Male, %</td>
<td>790 (56)</td>
<td>197 (53)</td>
<td>593 (56)</td>
</tr>
<tr>
<td>Race/ethnicity, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>1,047 (73)</td>
<td>257 (69)</td>
<td>790 (75)</td>
</tr>
<tr>
<td>African American</td>
<td>177 (12)</td>
<td>62 (17)</td>
<td>115 (11)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>131 (9.2)</td>
<td>34 (9.2)</td>
<td>97 (9.2)</td>
</tr>
<tr>
<td>Asian</td>
<td>25 (1.7)</td>
<td>5 (1.3)</td>
<td>20 (1.9)</td>
</tr>
<tr>
<td>Other</td>
<td>24 (1.7)</td>
<td>7 (1.9)</td>
<td>17 (1.6)</td>
</tr>
<tr>
<td>Not documented</td>
<td>27 (1.9)</td>
<td>6 (1.6)</td>
<td>21 (2.0)</td>
</tr>
<tr>
<td>ESI, mean ± SD</td>
<td>2.3 ± 0.7</td>
<td>2.3 ± 0.6</td>
<td>2.3 ± 0.7</td>
</tr>
<tr>
<td>EDWIN crowding index, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 &lt; 1.5</td>
<td>1,050 (73)</td>
<td>300 (81)</td>
<td>750 (71)</td>
</tr>
<tr>
<td>1.5–2.0</td>
<td>240 (17)</td>
<td>52 (14)</td>
<td>188 (18)</td>
</tr>
<tr>
<td>&gt;2.0</td>
<td>141 (9.9)</td>
<td>19 (5.1)</td>
<td>122 (12)</td>
</tr>
<tr>
<td>Shift of ED arrival, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 7AM–3PM</td>
<td>679 (47)</td>
<td>126 (34)</td>
<td>553 (52)</td>
</tr>
<tr>
<td>Evening 3PM–11PM</td>
<td>580 (41)</td>
<td>200 (54)</td>
<td>380 (36)</td>
</tr>
<tr>
<td>Night 11PM–7AM</td>
<td>172 (12)</td>
<td>45 (12)</td>
<td>127 (12)</td>
</tr>
<tr>
<td>Hospital</td>
<td>89 (± 8)</td>
<td>90 (± 8)</td>
<td>88 (± 8)</td>
</tr>
<tr>
<td>ED LOS (hours), mean ± SD</td>
<td>9.5 ± 6.4</td>
<td>5.2 ± 6.7</td>
<td>11.0 ± 6.7</td>
</tr>
<tr>
<td>Boarding</td>
<td>3.6 ± 3.1</td>
<td>1.3 ± 2.4</td>
<td>5.2 ± 6.7</td>
</tr>
<tr>
<td>time (hours), median IQR</td>
<td>(2.0–7.6)</td>
<td>(1.0–1.7)</td>
<td>(3.1–9.8)</td>
</tr>
</tbody>
</table>

EDWIN = Emergency Department Work Index; ESI = Emergency Severity Index; LOS = length of stay.
*Boarded patients are those who stayed in the ED >2 hours after time of bed request.
as supporting information in the online version of this paper).

**Sensitivity Analysis**

Our findings that boarding time was associated with higher frequency of home medications delays remained robust when the dependent variables were defined as missing any, 25%, or 75% of home medications (AOR = 1.07, 95% CI = 1.04 to 1.10; AOR = 1.07, 95% CI = 1.04 to 1.10; and AOR = 1.09, 95% CI = 1.06 to 1.12, respectively) and even when we conducted a within-site analysis (50% delayed home medications AOR = 1.08, 95% CI = 1.04 to 1.11, for Site 1; and AOR = 1.07, 95% CI = 1.00 to 1.14, for Site 2).

Similarly, when we defined cardiac enzymes test delays to be 8 or 9 hours after a previous laboratory draw, boarding time was associated with fewer delays (AOR = 0.96, 95% CI = 0.94 to 0.99; and AOR = 0.97, 95% CI = 0.94 to 0.99, respectively). Furthermore, analyses of cardiac enzyme delays at 10 hours for Site 1 and Site 2 were both similar (AOR = 0.92, 95% CI = 0.87 to 0.98; and AOR = 0.91, 95% CI = 0.83 to 0.99, respectively). Our heparin, antibiotic, and medication errors sensitivity analyses also supported the original findings.

**DISCUSSION**

Despite policy recommendations from several agencies, the issue of boarding in the ED remains widespread. In this study, boarded patients arrived more often during the daytime shift (hospital discharges may have occurred more often in the evening, leading to shorter boarding times for those patients who arrived during

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### Table 2

Differences in Delays Between Nonboarded Versus Boarded Patients Over the Early Admission Period

<table>
<thead>
<tr>
<th>Variable</th>
<th>All Patients</th>
<th>Nonboarded Patients</th>
<th>Boarded Patients</th>
<th>Difference % (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients with eligible home meds</td>
<td>n = 781</td>
<td>n = 214</td>
<td>n = 567</td>
<td>10 (2.4 to 18)</td>
</tr>
<tr>
<td>Delayed home medications, n (%)</td>
<td>323 (41)</td>
<td>73 (34)</td>
<td>250 (44)</td>
<td></td>
</tr>
<tr>
<td>Chest pain patients</td>
<td>n = 769</td>
<td>n = 208</td>
<td>n = 561</td>
<td>-14 (-21 to -6.8)</td>
</tr>
<tr>
<td>Delayed cardiac enzyme check, n (%)</td>
<td>180 (23)</td>
<td>70 (34)</td>
<td>110 (20)</td>
<td></td>
</tr>
<tr>
<td>Chest pain patients on heparin</td>
<td>n = 238</td>
<td>n = 77</td>
<td>n = 161</td>
<td>-5.8 (-19 to 7.7)</td>
</tr>
<tr>
<td>Delayed prothrombin time, n (%)</td>
<td>102 (43)</td>
<td>36 (47)</td>
<td>66 (41)</td>
<td></td>
</tr>
<tr>
<td>Pneumonia/cellulitis patients</td>
<td>n = 425</td>
<td>n = 123</td>
<td>n = 302</td>
<td>4.4 (-6.0 to 15)</td>
</tr>
<tr>
<td>Delayed antibiotics, n (%)</td>
<td>186 (44)</td>
<td>50 (41)</td>
<td>136 (45)</td>
<td></td>
</tr>
</tbody>
</table>

Unless otherwise specified, n = patients at risk for outcome.

### Table 3

Frequency of Delays During Six-hour Nonboarded and Boarded Time Intervals

<table>
<thead>
<tr>
<th>Hours</th>
<th>Delay: All Patients at Risk (%)</th>
<th>Delay: Nonboarded Patients (%)</th>
<th>Delay: Boarded Patients (%)</th>
<th>Delay: Boarded Patients (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Present</td>
<td>Present</td>
<td>Present</td>
<td>Present</td>
</tr>
<tr>
<td></td>
<td>95% CI</td>
<td>95% CI</td>
<td>95% CI</td>
<td>95% CI</td>
</tr>
<tr>
<td></td>
<td>Difference %  (95% CI)</td>
<td>Difference %  (95% CI)</td>
<td>Difference %  (95% CI)</td>
<td>Difference %  (95% CI)</td>
</tr>
</tbody>
</table>

*For each specific six-hour interval, the denominator represents the number of patients with medications or laboratory tests that would be due before the end of the time interval. The numerator represents the number of outcomes. The numerator represents the number of outcomes. Outcomes listed for boarding patients differ from Table 2 because patients were censored if they were not in the ED at the end of the interval.
the evening shift) and had more home medication delays but fewer delayed cardiac enzyme tests than nonboarded patients during the early admission period. There were no differences in PTT tests, antibiotic delays, medication errors, or adverse events. Interval and multivariable regression analysis yielded similar results.

Little empirical evidence exists comparing quality of care between ED-boarded patients and nonboarded patients. Although studies suggest that boarding patients have lower satisfaction scores than nonboarding patients, there remains a dearth of information about the effect of boarding. Viccellio et al. found mortality rates to be higher for patients who were admitted to standard inpatients beds than for patients who boarded on inpatient unit hallways, although this may have been due to patient complexity and acuity rather than a hallway benefit. Otherwise, the closest comparable studies examined the transition between ED and inpatient units or ED LOS. Shah et al. found that 38% (212/551) of patients who had their first dose of antibiotics in the ED had at least a 30-minute delay in antibiotic administration on the floor. Our study found a similar rate of delay (44% of all patients). Diercks et al. found that patients with ED LOS greater than 8 hours had decreased adherence to American Heart Association guidelines for myocardial infarctions and increased rates of myocardial reinfarction compared to patients with ED LOS of 4 to 8 hours (AOR = 1.23, 95% CI = 1.01 to 1.48). Chalfin et al. found that hospital survival was significantly lower in patients transferred to the intensive care unit with ED LOS of greater than 6 hours, compared with less than 6 hours (17.4% vs. 12.9%). However, these latter two studies were based on voluntary, observational data. Richardson found that patients with ED LOS of greater than 8 hours had mean hospital LOS of 4.9 days versus 4.1 days for patients with ED LOS of less than 8 hours. While these studies indicate that long ED LOS may be undesirable, none compared care while boarding in the ED with care on inpatient units.

Table 4
Multivariable Logistic Regression of Boarded Status, Boarding Time, and Boarded Time Intervals on Delays for the Entire Early Admission Period, First Twenty-six Hours of Admission, and Six-hour Intervals

<table>
<thead>
<tr>
<th>Exposure period and independent variables:</th>
<th>Early Admission Period</th>
<th>First 26 hours of Admission</th>
<th>6 Hours*</th>
<th>12 Hours</th>
<th>18 Hours</th>
<th>24 Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Outcomes:</strong>†</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delayed 50%</td>
<td>n = 781</td>
<td>n = 781</td>
<td>n = 67</td>
<td>n = 150</td>
<td>n = 250</td>
<td>n = 225</td>
</tr>
<tr>
<td>home medications</td>
<td>(0.85–1.78)</td>
<td>(1.05–1.10)</td>
<td>(0.37–3.83)</td>
<td>(1.16–5.24)</td>
<td>(2.04–8.24)</td>
<td>(1.34–20.27)</td>
</tr>
<tr>
<td>Delayed cardiac enzymes</td>
<td>n = 769</td>
<td>n = 769</td>
<td>NA</td>
<td>n = 277</td>
<td>n = 242</td>
<td>NA</td>
</tr>
<tr>
<td>prothrombin time</td>
<td>0.70</td>
<td>0.93</td>
<td>0.21</td>
<td>0.09–0.48)</td>
<td>0.03–0.53)</td>
<td></td>
</tr>
<tr>
<td>Delayed antibiotics</td>
<td>n = 238</td>
<td>n = 238</td>
<td>n = 56</td>
<td>n = 82</td>
<td>n = 80</td>
<td>NA</td>
</tr>
<tr>
<td>Delayed time</td>
<td>0.97</td>
<td>0.97</td>
<td>0.35</td>
<td>0.09–0.48)</td>
<td>0.03–0.53)</td>
<td></td>
</tr>
<tr>
<td>Delayed antibiotics</td>
<td>n = 425</td>
<td>n = 425</td>
<td>n = 41</td>
<td>n = 95</td>
<td>n = 104</td>
<td>n = 127</td>
</tr>
<tr>
<td>time</td>
<td>(0.46–1.06)</td>
<td>(0.88–0.97)</td>
<td>0.21</td>
<td>0.09–0.48)</td>
<td>0.03–0.53)</td>
<td></td>
</tr>
<tr>
<td>Delayed antibiotics</td>
<td>1.08</td>
<td>1.01</td>
<td>0.81</td>
<td>1.34</td>
<td>1.04</td>
<td>0.51</td>
</tr>
<tr>
<td>antibiotics</td>
<td>(0.67–1.73)</td>
<td>(0.97–1.04)</td>
<td>(0.23–2.85)</td>
<td>(0.54–3.35)</td>
<td>(0.35–3.05)</td>
<td>(0.05–5.04)</td>
</tr>
</tbody>
</table>

Values are presented as n = number of patients at risk for outcome and AOR (95% CI). The models control for age, sex, race/ethnicity, ESI, means of arrival, Charlson comorbidity, shift of arrival, EDWIN score, hospital capacity, and site, unless otherwise noted.

AOR = adjusted odds ratio; EDWIN = Emergency Department Work Index; ESI = Emergency Severity Index; NA = the numerators presented in Table 3: odds ratios are not available when there were no events; PTT = partial thromboplastin time.

*Limited to the follow-up time in the specified boarded time interval. Boarded patients were censored from analysis if they left before the end of the interval. Due to limited sample size, these analyses only controlled for age. PTT had no adjustment due to rarity of outcomes.

†Table 2 lists number of outcomes for boarded versus nonboarded status variable and Table 3 for boarded and nonboarded time interval analysis. The number of outcomes for the boarding time variable was the same as for the boarded status variable.

‡Adjusted odds ratios, but adjusted for age only outcome due to the limited sample size. The only exception is the row labeled as “Delayed prothrombin time”—no adjustment was done for this due to rarity of outcomes.
manner as provided by inpatient units. This may be secondary to the difference between the ED and inpatient unit environments, such as availability of chronic home medications or nursing perceived scope of practice. Furthermore, longer boarding times mean that many patients remain beyond the shift of the original caregiving team. The more handoffs patients undergo between teams, the greater the likelihood of communication failure and medical errors. 

Conversely, in the case of cardiac enzyme checks, boarding was associated with fewer delays. This suggests that some care provided to boarding patients is better than that found on inpatient units. Multiple reasons may influence why patients have delayed cardiac enzyme tests while on the inpatient units. Inpatient teams are expected to perform more comprehensive histories and physical exams before writing laboratory orders. Also, inpatient laboratory tests depend on phlebotomists' schedule, while ED samples are drawn by the ED nurses or aides, likely decreasing delays. Furthermore, cardiac enzyme tests sent from the ED may be processed through use of point-of-care testing and may have a quicker turnaround time than those processed at the central laboratory. Finally, ED personnel may be more attuned to cardiac care and therefore be more vigilant about checking cardiac tests than ordering home medications.

LIMITATIONS

First, as mentioned previously, we powered our study based on a calculation of a composite score from our pilot study. Because we divided outcomes into separate categories, our null findings for PTT, antibiotics, errors, and adverse events may be due to sample size (type II error). We did not adjust for multiple comparisons. Because our home medication and cardiac enzyme outcomes were similar in different analyses, our results are not likely due to chance. Second, chart abstraction methods have inherent limitations in terms of accurately measuring quality of care. Valid reasons not documented may account for patients not receiving certain home medications or antibiotics, potentially overstating the frequency of delays. However, this potential bias would likely be distributed similarly across all patients and would unlikely affect our findings. Third, while substantial reliability existed for home medication and medication errors, only moderate agreement while substantial reliability existed for home medication bias would likely be distributed similarly across all patients, stating the frequency of delays. However, this potential document may account for patients not receiving certain medications or antibiotics, potentially overestimating home medication errors. 

CONCLUSIONS

Our study indicates that the quality of care for patients boarding in the ED and patients on inpatient units differs. Care for boarded patients worsens in areas for which the ED is not designed (e.g., delivery of routine home medications). This finding may extend to other routine, nonacute functions of inpatient care. By contrast, ED care is better in areas that are more consistent with typical ED practice, such as cardiac enzyme checks.

This study suggests that the quality of care depends on the systems of care and resources available at that location. While the elimination of ED boarding altogether would obviate these issues, such a solution is not imminent. Meanwhile, systems that aim to improve ED care for boarding patients should focus on decreasing those aspects of care that fall outside the routine systems of ED care, such as provision of home medications. This may include creating computer-based flags requiring admission orders or transferring responsibility of boarded patients to inpatient teams. Future studies should examine the generalizability of our findings to other EDs and whether such policies can improve the quality of care provided to boarded patients.

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References


Supporting Information

The following supporting information is available in the online version of this paper:
Data Supplement S1. Chart review instruments.
Data Supplement S2. Differences in medication errors and adverse events between nonboarded versus boarded patients over the early admission period.

The documents are in PDF format.

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