Measurement of Cost of Boarding in the Emergency Department Using Time-Driven Activity-Based Costing

Maureen M. Canellas, MD, MBA*; Marcella Jewell, BA; Jennifer L. Edwards, MD, MBA; Danielle Olivier, MD; Adalia H. Jun-O'Connell, MD, MBA; Martin A. Reznek, MD, MBA

*Corresponding Author. E-mail: maureen.canellas@umassmemorial.org.

Study objective: Boarding admitted patients in emergency departments (EDs) is a national crisis that is worsening despite potential financial disadvantages. The objective of this study was to assess costs associated with boarding.

Methods: We conducted a prospective, observational investigation of patients admitted through an ED for management of acute stroke at a large, urban, academic, comprehensive stroke center hospital. We employed time-driven activity-based costing methodology to estimate cost for patient care activities during admission and aggregated results to estimate the total cost of boarding versus inpatient care. Primary outcomes were total daily costs per patient for medical-surgical (med/surg) boarding, med/surg inpatient care, ICU boarding, and ICU inpatient care.

Results: The total daily cost per patient with acute stroke was US$1856, for med/surg boarding versus US$993 for med/surg inpatient care and US$2267, for ICU boarding versus US$2165, for ICU inpatient care. These differences were even greater when accounting for costs associated with traveler nurses. ED nurses spent 293 min/d (mean) caring for each med/surg boarder; inpatient nurses spent 313 min/d for each med/surg inpatient. ED nurses spent 419 min/d caring for each ICU boarder; inpatient nurses spent 787 min/d for each ICU inpatient. Neurology attendings and residents spent 25 and 52 min/d caring for each med/surg boarder versus 62 minutes and 90 minutes for each med/surg inpatient, respectively.

Conclusion: Using advanced cost-accounting methods, our investigation provides novel evidence that boarding of admitted patients is financially costly, adding greater urgency for elimination of this practice. [Ann Emerg Med. 2024;84:376-385.]

Please see page 377 for the Editor's Capsule Summary of this article.

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INTRODUCTION

Background

Inpatient boarding, the practice of holding admitted patients in emergency departments (EDs), has become a national health crisis. In a letter to President Biden dated November 7, 2022, the American College of Emergency Physicians and 34 other stakeholder groups identified boarding as a "public health emergency" and called for support in developing interventions.[1] Boarding, measured as the time from decision to admit to patient departure from the ED, is known to adversely affect quality of care and safety and lead to increased mortality, increased readmission rates, prolonged hospital length of stay, and decreased patient satisfaction.[2-12] In addition, boarding is the primary driver of ED crowding in general and consequently negatively affects outcomes of all ED patients, not just those that experience boarding.[13-15] Despite the proven hazards associated with boarding, tactics known to reduce it have been adopted inconsistently, and boarding continues to worsen, raising questions of why.[13,14]

Experts hypothesize that financial drivers contribute to the practice of boarding.[15-19] Elective admissions are reimbursed at higher rates than unplanned ED admissions, thereby incentivizing prioritization of elective cases for inpatient beds from a revenue standpoint. From the cost perspective, however, relatively little is known about boarding. A systematic review revealed only 2 investigations of costs associated with boarding, and both studies had methodological limitations.[17] Both utilized some principles of time-driven activity-based costing. However, both lacked patient-level analyses and relied on generalizations about care times and resource needs of patients, primarily

Editor's Capsule Summary

What is already known on this topic

Boarding hospitalized patients in the emergency department (ED) impedes care and results in worse clinical outcomes for those patients.

What question this study addressed

What are the daily costs of caring for admitted patients with acute stroke activation in the ED versus in the hospital?

What this study adds to our knowledge

Boarding of hospitalized patients in the ED nearly doubled daily costs and this does not include the opportunity cost of the occupied ED beds.

How this is relevant to clinical practice

This economic analysis using time-driven activity-based costing adds one more reason why boarding is bad.

focusing on opportunity costs. Although the studies pointed toward increased costs associated with boarding, the general paucity of strong evidence has left open 2 possibilities: (1) boarding is at least cost-neutral, providing financial incentive for the practice, or (2) costs associated with boarding outweigh the financial gains, but this remains underappreciated presently in health care systems.

Importance

Our investigation addresses the limited knowledge of the costs of boarding by employing a granular accounting methodology, time-driven activity-based costing, that has previously never been applied to ED boarding at the patient level. This method has been accepted as a superior cost-accounting approach in many industries.[20] Although resource-intensive, it has been employed successfully in a growing number of health care settings.[20-24] Calculating the costs associated with boarding may provide financial impetus to eliminate this pervasive practice in addition to the well-known quality and safety issues associated with it.

Goals of This Investigation

In this investigation, we sought to determine the costs associated with boarding versus inpatient care by employing time-driven activity-based costing.

MATERIALS AND METHODS

Study Design and Setting

We conducted this prospective investigation at an urban, academic, level 1 trauma, comprehensive stroke center hospital with approximately 90,000 ED encounters and 40,200 inpatient admissions annually. For acute code stroke patients at this facility, boarding medical-surgical (med/surg) patients is the responsibility of the admitting service's attending, their trainees, and the ED nurses, whereas boarding ICU patients is the responsibility of the ED attending, their trainees, and the ED nurses, and the admitting service's attending and trainees continue to manage the patients as consultants.

Selection of Participants

For feasibility, we sought a subpopulation of ED patients who would be easily identifiable near time of arrival and would have high likelihood of admission. Ultimately, we identified patients for whom the ED code stroke protocol was activated as the best candidate subpopulation. (Emergency physicians activated code stroke protocol if acute stroke was in the differential diagnosis and last known well was within 24 hours.) During a 4-week period in January/February 2022, research assistants were present in the ED nearly continuously and observed all code stroke patient encounters, except when overlapping activations occurred. When overlaps occurred, research assistants followed the patient with the highest likelihood of admission, as determined in real time by the neurology team or principal investigator. Encounters that resulted in discharge, ED observation, patient leaving prior to treatment completion, admission to a nonneurology stroke team, and/or urgent thrombectomy were subsequently excluded. This study was reviewed by the local institutional review board and deemed exempt.

Measurements

Time-driven activity-based costing. We employed time-driven activity-based costing informed by patient encounter–level observation to characterize resource utilization and cost associated with boarding, measured as the time from decision to admit to patient departure from the ED versus inpatient care. Described by Kaplan and Porter,[25] time-driven activity-based costing methodology estimates time spent by personnel performing activities over a specified patient care cycle. These data are combined with salary data and operating cost allocation to provide complete and more accurate financial enumeration of the care cycle.

Time-driven activity-based costing begins with process mapping to identify activity steps in a patient's care cycle and resources used to complete it.[26] Direct observation, activity reporting tools, and/or interviews are then

employed to estimate staff time utilization and other resources for each activity step. The method then calculates a capacity cost rate for each resource utilized, including personnel and operating costs (including annual operating, maintenance, and housekeeping costs), with the following equation (with resource cost being all costs associated with having that resource available to treat patients and resource capacity being the time that each resource has available for treating and caring for patients):

$$Capacity\ Cost\ Rate\left(\frac{\$}{minute}\right) = \frac{Resource\ Cost}{Resource\ Capacity}$$

Capacity cost rates are summed within each activity to get total cost of the activity. Lastly, activities are summed to calculate the total cost of the care cycle.

Process mapping. We developed process maps for ED code stroke encounters from decision to admit to hospital discharge that were validated via structured feedback from ED, neurology, and other hospital caregivers and administrators.

Physician and nurse utilization estimation. To estimate physician and nurse utilization in the ED, research assistants directly observed patient encounters following code stroke activation alert by stationing themselves just outside the patient's room, which was also proximate to the patient's nurse's work station. Research assistants recorded care-related activities, including bedside care, team rounding, documentation, and care coordination (care activities not contained within the other categories), for emergency medicine and neurology attendings and residents and ED nurses. Research assistants tracked all care activities occurring within or proximate to the patient's room. Emergency medicine and neurology attendings and residents were also given surveys to document care times of additional care-related activities that did not occur proximate to the patient's room and may not have been observed by research assistants. A visual representation of this process is shown in Figure 1.

To estimate physician and nurse utilization in the inpatient setting, neurology physicians and nurses reported their activities and time spent via a structured activity reporting tool. The reporting tool itself and training for reporting accuracy were developed and implemented in collaboration with emergency medicine and neurology attendings, residents, and nurses. Once patients transitioned from the ED to an inpatient unit, activity reporting tools were hand-delivered twice daily at shift changes to nurses and residents involved in the care. The reporting tools were emailed to attendings once daily given that they were responsible for care over an entire day and hand-delivery often was not feasible. A visual representation of this process is shown in Figure 2. Remaining missing data were imputed based on mean values of results for similar patient encounters for that location (ICU versus med/surg unit), shift (day versus night), and professional role (attending, resident, or nurse).

Of note, we elected to employ direct observation in the ED (supplemented with self-reporting for emergency physicians for activities that may not have been observed by research assistants), anticipating that (1) distributing the reporting tool correctly to all caregivers involved in the ED care of any included patient would be challenging and (2) accurate recall would have been more challenging for ED caregivers than for their inpatient counterparts given that shift changes and hand-offs of care occurred more frequently in the ED and given that ED staff cared for a greater number of patients with higher turnover. In addition, due to the proximity of nurses' stations to patient rooms in the ED, direct observation was feasible in that area, as opposed to the inpatient units where patient rooms and caregiver stations were remote, making direct observation by research assistants highly limited. Both direct observation and self-reporting methods were considered effective and standard methods for time-driven activity-based costing.[27,28] Notably, self-reporting by emergency physicians has been shown to be accurate on an aggregate basis, despite inaccuracy at the encounter level.[29] Furthermore, self-reporting had been reported to be more accurate when performed contemporaneously and with structured tools, both of which we leveraged in our investigation.[27,28]

Outcomes

The primary outcome was estimated daily cost of boarding versus inpatient care.

Analysis

The study site's finance department provided financial information, including personnel and unit operational costs for the fiscal year.

Personnel. Personnel cost included salary and fringe costs (37% of salary). The capacity cost rate for physicians and nurses was calculated by dividing their cost per year by the mean clinical minutes scheduled per year.

During the study, a proportion of nurse care was provided by traveler nurses. This was common across the United States at the time of the study, but with

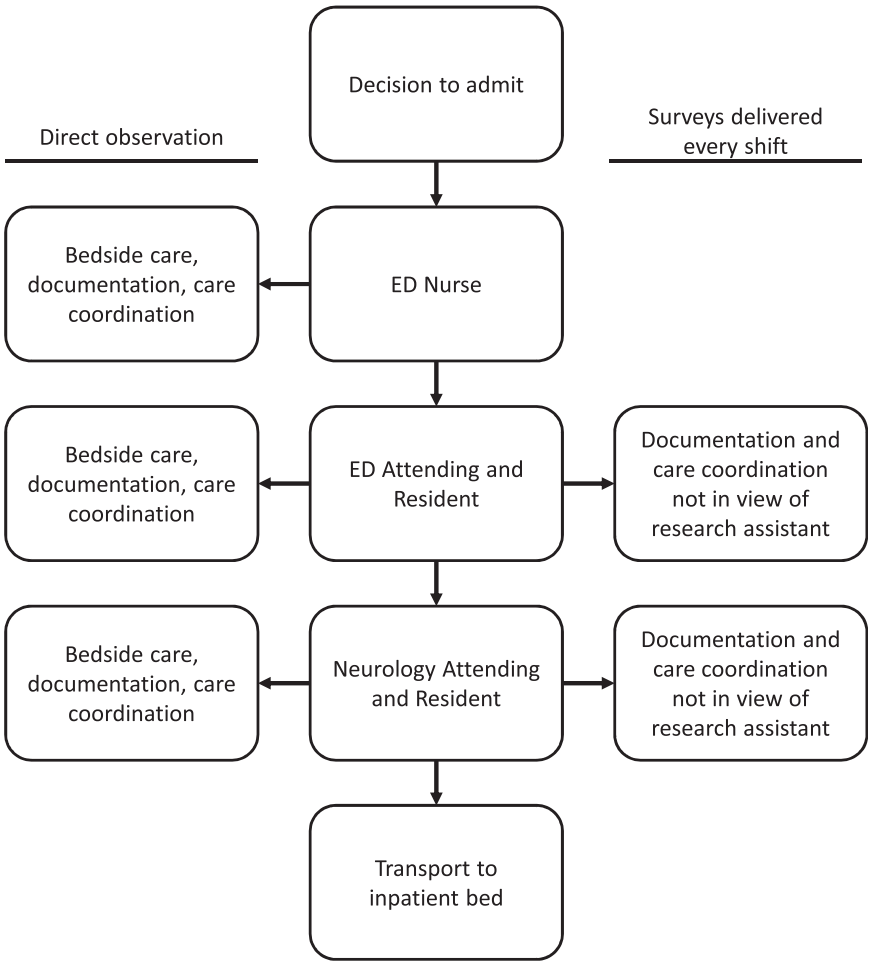

Figure 1. Emergency department boarding process map.

local variation in proprortions.[30] To support generalizability, we opted to report nurse costs in 2 ways: (1) assuming employed nurse salaries only and (2) accounting for traveler nurse proportions and salaries.

Space/operating costs. Operating costs included annual supplies, equipment, maintenance, utilities, personnel with cross-unit duties (social work, technicians, secretaries, housekeeping, etc), and other general operating and administrative costs. The capacity cost rate for an ED, neurology ICU, and neurology med/surg bed was calculated by dividing the annual operational cost of the unit by the total number of available bed-minutes for that unit annually.

We calculated the estimated costs per patient with acute stroke on a per day basis to facilitate interpretation.

To account for inherent cost differences associated with complexity of ICU versus med/surg care, we considered the 2 levels of care separately. Accordingly, we subcategorized phases of care into med/surg boarding, ICU boarding, med/surg inpatient, and ICU inpatient. For patients downgraded from ICU to med/surg during their inpatient course, activities and costs were allocated to the subcategory based on the patient's location at the time of that activity (ICU versus med/surg unit). For patients downgraded while boarding, activities that occurred while designated for an ICU admission were allocated to ICU boarding, and activities that occurred following downgrade were allocated to med/surg boarding.

RESULTS

Characteristics of Study Subjects

One hundred nineteen code stroke activations occurred during the study period; research assistants observed 69 encounters in the ED following exclusions due to overlapping activations. Twenty-five encounters ultimately met inclusion criteria (Figure 3).

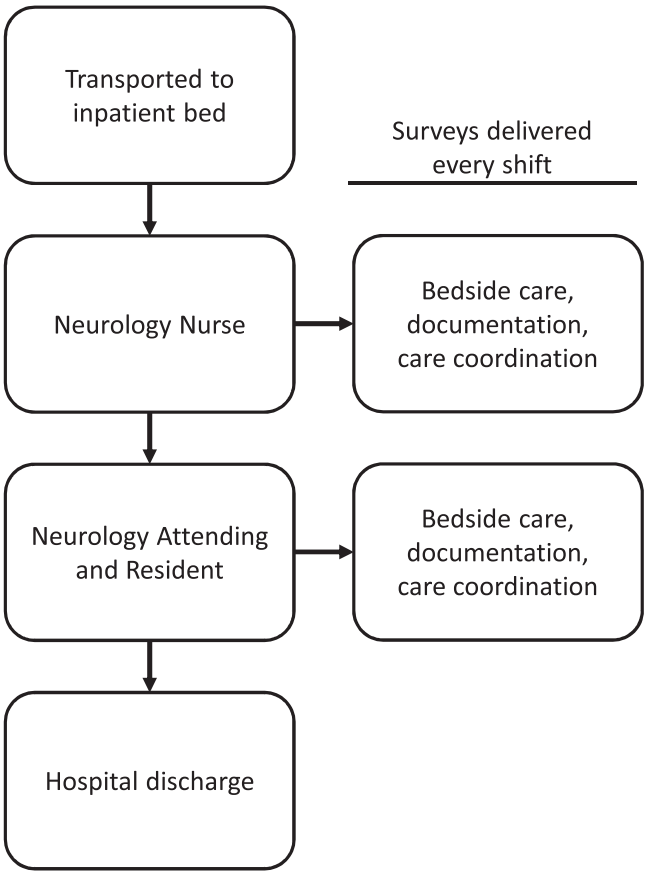

Figure 2. Inpatient care process map.

In total, the 25 encounters accounted for 563.8 hours of boarding (med/surg, 398.2 hours; ICU, 165.6 hours) and 1,400.1 hours of inpatient care (med/surg, 1,195 hours; ICU, 205.1 hours). Med/surg admissions experienced a mean of 38.4 hours of boarding (range, 5.0 to 116.2 hours) and 24.9 hours of inpatient length of stay (range, 0 to 119.5 hours). ICU admissions experienced a mean of 20.7 hours of ICU boarding (range, 4.6 to 35.0 hours) and 49.5 hours of med/surg boarding (range, 0 to 119.0 hours), with an ICU inpatient length of stay of 25.6 hours (range, 0 to 120.1 hours) and a med/surg inpatient length of stay of 96.6 hours (range, 0 to 209.8 hours). Eleven of the 17 med/surg admissions never received an inpatient bed, and 5 of the 8 ICU admissions never received an ICU bed. These patients experienced 0 hours of inpatient length of stay, thus skewing quartiles toward 0. The majority of boarding time was observed directly by research assistants, and inpatient activity reporting tool response rates for attendings, residents, and nurses were 24%, 62%, and 56%, respectively, with low coefficients of variation (ie, less than 1) (Table).

Main Results

Total daily cost for acute stroke patients. The daily total cost was US$1,856 for med/surg boarding versus US$993 for med/surg inpatient care and US$2,267 for ICU boarding versus US$2,165 for ICU inpatient care when not accounting for traveler nurse cost (Figure 4).

When accounting for the complement of traveler nurses (35% for the ED and 13% for inpatient units), the daily total cost was US$2,258 for med/surg boarding versus US$1,095 for med/surg inpatient care and US$2,843 for ICU boarding versus US$2,423 for ICU inpatient care (Figure 5).

Staff care trends. Nurses: ED nurses spent a mean of 292.7 min/d caring for each med/surg boarder (median, 173.8 min/d; IQR, 133.8 to 369.7 min/d). Inpatient nurses spent a mean of 313.7 min/d caring for each med/surg inpatient (median, 285.1 min/d; IQR, 263.8 to 337.0 min/d). ED nurses spent a mean of 419.3 min/d caring for each ICU boarder (median, 387.4 min/d; IQR, 295.8 to 419.3 min/d), whereas inpatient nurses spent a mean of 786.6 min/d caring for each ICU inpatient (median, 786.6 min/d; IQR, 786.6 to 786.7 min/d).

Physicians. Emergency medicine attendings spent a mean of 9.2 min/d caring for each med/surg boarder (median, 0.2 min/d; IQR, 0.0 to 9.6 min/d), and emergency medicine residents spent a mean of 12.2 min/d (median, 2.7 min/d; IQR, 0.0 to 7.0 min/d). Emergency medicine attendings spent a mean of 23.8 min/d caring for each ICU boarder (median, 23.8 min/d; IQR, 14.7 to 26.7 min/d), and emergency medicine residents spent a mean of 37.2 min/d (median, 26.3 min/d; IQR, 12.7 to 37.2 min/d).

Neurology attendings spent a mean of 24.9 min/d caring for each med/surg boarder (median, 22.1 min/d; IQR, 3.2 to 37.7 min/d), and neurology residents spent a mean of 52.0 min/d (median, 47.6 min/d; IQR, 18.3 to 79.1 min/d). Neurology attendings spent a mean of 62.3 min/d caring for each med/surg inpatient (median, 62.2 min/d; IQR, 61.2 to 63.4 min/d), and neurology residents spent a mean of 89.8 min/d (median, 83.5 min/d; IQR, 77.1 to 93.5 min/d).

Neurology attendings spent a mean of 46.8 min/d caring for each ICU boarder (median, 51.5 min/d; IQR, 46.8 to 58.0 min/d), and neurology residents spent a mean of 92.3 min/d (median, 92.3 min/d; IQR, 58.4 to 125.0 min/d). Neurology attendings spent a mean of 49.4 min/d caring for each ICU inpatient (median, 49.4 min/d; IQR, 49.4 to 51.0 min/d), and neurology residents spent a mean of 108.8 min/d (median, 108.8 min/d; IQR, 101.5 to 108.8 min/d).

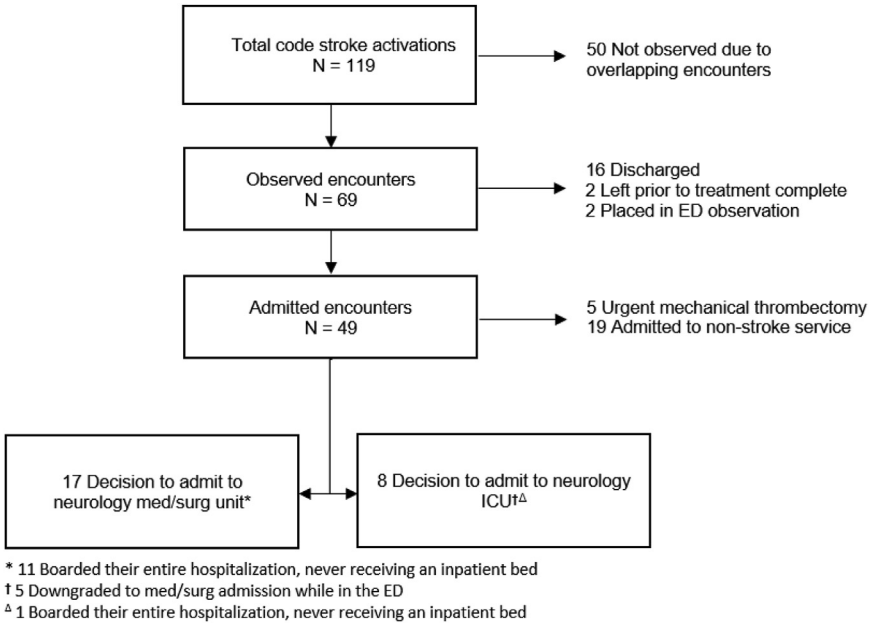

Figure 3. Study group selection.

Figure 6 shows physician and nurse activity distributions during boarding and inpatient phases of care. Of note, by hospital policy, responsibility for boarding med/surg patients and code stroke patients who received thrombolytics requiring ICU admission transitioned to the inpatient service at time of decision to admit; however, the emergency physicians were available for urgent/timely needs. Responsibility for boarding of other ICU patients remained with the ED team.

LIMITATIONS

This was a single-site, convenience sample study, potentially limiting generalizability. Local staffing and financial and managerial practices may have influenced observed differences between ED and inpatient costs. However, we identified no areas other than traveler nurse complement in which the study site experience was likely to have been meaningfully dissimilar from others. Focusing on acute stroke care may have limited generalizability to other disease processes that may require variable resource intensity overall and during various stages of their episode of care. However, per the finance department, operating costs for the neurology units were comparable with those for other med/surg and ICU inpatient units in the hospital and our study sample included patients with a wide range of exposure to boarding (ie, minimal exposure to boarding through those who boarded their entire length of stay). The difference in emergency medicine versus neurology attending salaries/benefits would have varied for other specialties; however, the attending portion of overall cost was minimal, so this likely was of limited impact. Resident and nurse salaries were seniority-based and otherwise standardized across specialties and care areas, so the convenience methodology posed no limitation with regard to nurse and resident salary cost drivers. Generalizability may also be limited to those hospitals with similar delineations of responsibility for boarders as the study site.

ED observations were interrupted intermittently due to research assistant, patient, and operational factors. However, research assistants observed that greater than 60% of each included patient's boarding time was sufficient for generating time estimates for time-driven activity-based costing. Response rates for the activity reporting tool were variable; however, the available data were also sufficient for time-driven activity-based costing and the preimputation coefficients of variation were low (ie, less than 1). Although

Table. Coefficients of variation for the neurology team's preimputation survey responses.*

Staff Type	Med/Surg Boarding	Med/Surg Inpatient	ICU Boarding	ICU Inpatient
Neurology resident	0.62	0.79	0.68	0.98
Neurology attending	0.46	0.40	0.26	0.48
Neurology nurse (AM)	N/A	0.74	N/A	0.43
Neurology nurse (PM)	N/A	0.58	N/A	0.59

*The coefficient of variation is the ratio of the SD to the mean (ie, σ/μ). The lower the coefficient of variation, the lower the fluctuation of responses. N/A is listed for neurology nurses as they do not care for patients in the ED during their med/surg boarding or ICU boarding.

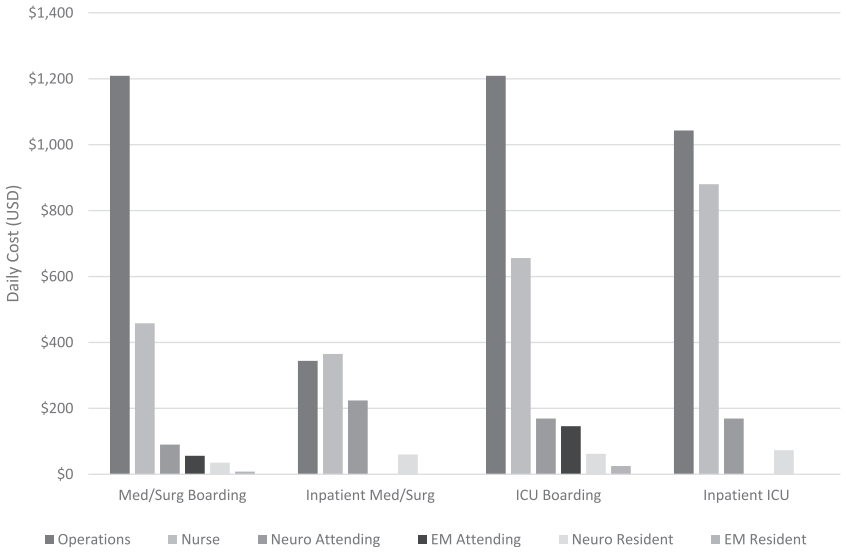

Figure 4. Comparison of daily cost components assuming employed nurses only and no traveler nurses. The total daily cost of boarding for each unit is as follows: med/surg boarding, US$1,856; inpatient med/surg, US$993; ICU boarding, US$2,267; ICU inpatient, US$2,165. *EM*, emergency medicine.

direct observation and contemporaneous, structured self-reporting generally were considered sufficient for time-driven activity-based costing, it remained possible that our inpatient activity reporting tools and ED direct observation varied in accuracy of estimation. For reasons outlined in the Materials and Methods section, we elected to perform the varied methodology by location to optimize accuracy of data collection for that unit based on geographic and work flow factors, and we believe that this approach was superior to a uniform approach across the two settings.

Estimations of physician and nurse time were designed and performed for purposes of calculating estimated cost of care, according to the time-driven activity-based costing methodology. The study was not designed specifically to assess staff time in caring for patients. Accordingly, trends were reported without firm conclusions.

Lastly, our investigation did not include known additional costs related to boarding, including prolonged total hospital length of stay increases and the opportunity cost caused by ED beds being occupied by admitted

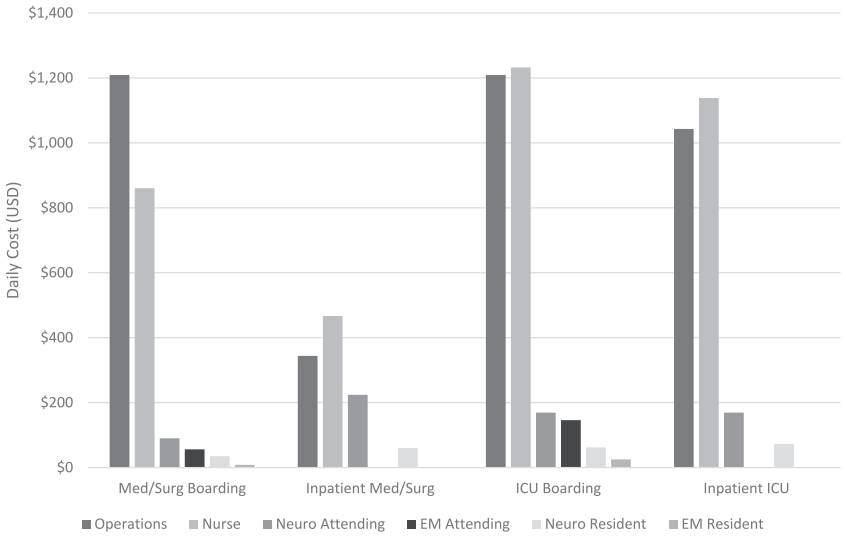

Figure 5. Comparison of daily cost components with actual complement of traveler nurses. The total daily cost of boarding for each unit is as follows: med/surg boarding, US$2,258; inpatient med/surg, US$1,095; ICU boarding, US$2,843; ICU inpatient, US$2,423.

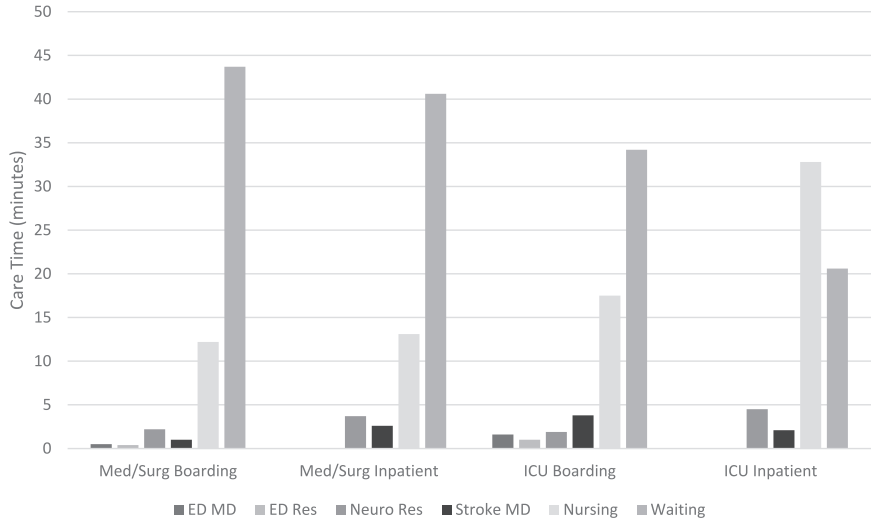

Figure 6. Distribution of physician and nurse care activities across phases of care. *MD*, attending physician, either MD or DO; *Res*, resident physician.

patients and therefore not available for evaluation and treatment of new patients seeking care in the ED, as well as theoretical costs including staff inefficiencies in caring for other ED patients when burdened by boarding patients and increased cost associated with potential malpractice lawsuits due to the association between boarding and increased morbidity and mortality.[2,3,31,32] Therefore, the total overall cost associated with boarding of patients after post–acute stroke is likely even greater than what we report.

DISCUSSION

Our investigation, the first to measure cost of inpatient boarding for patients with acute stroke using the advanced cost-accounting methodology of time-driven activity-based costing informed by patient encounter–level data, demonstrated that the cost of caring for boarding patients was greater than that of caring for patients in the inpatient setting. Most notably, the practice of boarding med/surg patients in the ED resulted in nearly a doubling of the cost of care. In addition, we observed this difference in cost to be even greater in the case that there was a larger proportion of traveler nurses in the ED than in the inpatient setting, a common scenario across the nation. Although the costliness of boarding ICU patients in the ED was less pronounced, it was at least 5% more costly, even without traveler nurse consideration, which likely remains meaningful in the current milieu of narrow financial margins in health care.

In general, cost-accounting methods traditionally employed in health care are thought to fall short in showing true costs associated with care of individual patients, individual conditions, and even cycles of care.[26] We suspect that that phenomenon has extended to boarding and contributes to health care leaders potentially not appreciating expenses associated with boarding. With regard to the notion that boarding has been incentivized by greater revenue generated by an elective admission over an unscheduled admission (US$700 difference for Medicare), our results, assuming generalizability to other hospitals and conditions, revealed that this additional revenue for a single elective admission would be erased by just 19 hours of boarding of ED-admitted patients.[19]

Although this study was not specifically designed or powered to draw conclusions related to time differences across specific staff types, potentially important trends in granular staff care times were identified. The time spent by physicians and nurses caring for patients varied depending on acuity and location. Med/surg patients appeared to receive similar time from nurse staff regardless of care location. ICU-level patients, however, received less nurse time while boarding in the ED versus once they arrived in the ICU. Anecdotally, nurse staff at the study site reported these findings to have had face validity and that they were likely explained by higher nurse-to-patient ratios in the ICU (1:2 cap). The observation that patients may have received more nurse care in the ICU with overall lower cost underscored that the boarding phase of care was not only more expensive but also potentially provided less value to the patient, at least in terms of time of nurse care.

Regarding physician time, med/surg patients appeared to receive less care time from the neurology team when boarding versus after reaching the inpatient unit. Similar to nurse staff, physician staff anecdotally reported that these findings had face validity, reporting that the findings were likely explained by both systems and geographical factors. Neurology teams reported staffing being budgeted to

inpatient capacity, so boarding patients stretched the inpatient teams beyond functional capacity. In addition, the majority of their work occurred in inpatient units, so traveling to the ED was challenging to workflows. Finally, they identified potential psychological drivers for minimizing time in the ED because the environment was believed to not be conducive to inpatient-style rounding owing to frequent movement of ED staff and patients, patients occupying hallways beds, and general noise-presenting barriers to communication and patient privacy during rounds. Regardless, our observation of less physician time spent for med/surg patients while boarding underscored that despite the boarding phase of care for med/surg patients being nearly twice as expensive, there was potentially less value for the patient, at least in terms of time of neurologists' care. Additional investigations are warranted to assess further the observed differences in time spent by physicians and nurses when caring for admitted patients in an ED versus an inpatient unit in order to identify potential causes for the variation and potential mitigating solutions.

In conclusion, our investigation provides evidence that boarding admitted patients in EDs, in addition to known negative quality and safety implications, is financially costly, providing added incentive and urgency for the elimination of boarding. Furthermore, our results likely even underestimate the total cost of boarding to health systems given that our investigation focused on the cost differential by care setting and did not include other potential costs associated with boarding, such as opportunity costs, increased inpatient hospital length of stay, risk of increased medical malpractice cost, and potential staff inefficiencies in caring for other ED patients when burdened by boarding patients.

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Author affiliations: From the Department of Emergency Medicine (Canellas, Edwards, Olivier, Reznek), University of Massachusetts T.H. Chan School of Medicine, Worcester, MA; the Department of Emergency Medicine (Canellas, Edwards, Olivier, Reznek), UMass Memorial Health, Worcester, MA; University of Massachusetts T.H. Chan School of Medicine (Jewell), Worcester, MA; the Department of Neurology (Jun-O'Connell), University of Massachusetts T.H. Chan School of Medicine, Worcester, MA; and the Department of Neurology (Jun-O'Connell), UMass Memorial Health, Worcester, MA.

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Data sharing statement: Datasets are unable to be shared given they contain the study site's confidential financial information (eg, staff salaries, overhead costs, administrative costs).

All authors attest to meeting the four ICMJE.org authorship criteria: (1) Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; AND (2) Drafting the work or revising it critically for important intellectual content; AND (3) Final approval of the version to be published; AND (4) Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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