

EMERGENCY DEPARTMENT (ED) OVERCROWDING: EVIDENCE-BASED ANSWERS TO FREQUENTLY ASKED QUESTIONS

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SUMMARY

Overcrowding in emergency departments is a problem in many countries around the world, including the United States and Chile. Emergency department (ED) overcrowding causes problems for patients and staff, including increased waiting times, increased ambulance diversion, increased length of stay, increased medical errors, increased patient mortality, and increased harm to hospitals due to financial losses. This article aims to describe the etiology of ED overcrowding and potential solutions through an examination of the evidence. Ultimately, ED overcrowding originates from hospital overcrowding and thus the solutions to this complex problem lie in the ED itself as well as outside of the ED.

Key words: Overcrowding, hospital operations, emergency department, emergency medicine

INTRODUCTION

The media has recently given great attention to the “crisis” in emergency department (ED) overcrowding in the United States, as if this were a recent development. As far back as

1987, after sustained and unsolvable problems with overcrowding, the first statewide conference on overcrowding was held in New York City, involving the New York (NY) chapter of the American College of Emergency Physicians (ACEP), New York Emergency Medical Services (EMS), the NY State Department of Health, and state legislators. At that time the issue was clearly delineated, but no clear solutions were forthcoming. Since that time, hospital and ED overcrowding has enjoyed cyclical media attention, but with little done to “fix” the problem.

How did it reach this point?

Hospitals in the 1960’s were, in large part, a place for elective admissions, with only a small percentage of patients being unscheduled, or “emergent.” There was also substantial capacity to allow for system-wide inefficiencies. During this time, hospitals were run primarily as a 9am–5pm, Monday through Friday business, with a skeleton crew staffing the hospital during evenings, nights and weekends. Average length of stay (LOS) exceeded 12 days, so the medical model of rounding once a day was appropriate.

Over the past 30 years, a dramatic change has occurred. The majority of admissions are now unscheduled. As many

previously inpatient procedures shifted to the ambulatory setting, left behind is a much sicker patient population, filling the hospital to capacity. Rather than scheduled admissions, the majority of patients enter through the ED, with most of these entering the hospital in the afternoon and evening. In most EDs, the volume of admissions varies little from day to day or from weekday to weekend. And yet, in far too many ways, hospitals have continued to function 9am-5pm, Monday through Friday, with a skeleton crew on evenings, nights, and weekends. This may, in part, explain the higher death rate for strokes and heart attacks in patients admitted on weekends versus weekdays. With current average LOSs of 5-6 days and median LOSs of 3 days, the model of once-daily rounding also makes far less sense.

With this mismatch of resources versus need, there should be little surprise that capacity issues would arise.

How does the institutional structure create capacity issues by design? A classic example is in surgical scheduling, which is not done smoothly throughout the week, but is rather front-loaded near the beginning of the week. Why? An orthopedist, for instance, knows that his or her patient undergoing hip replacement is critically dependent upon physical therapy in the days immediately following surgery, to prevent life-threatening postoperative complications. If the hospital's physical therapy staff is small or nonexistent on weekends, then the orthopedist has little choice but to schedule as much surgery as possible at the beginning of the week. Thus, a "traffic jam" is created in which the hospital is loaded up earlier in the week, so much so that some institutions look like a 3-day-a-week business. This has a domino effect on the entire institution. In fact, when an institution in Massachusetts, which had struggled with capacity issues for years, changed to a smooth surgical schedule, their capacity issues disappeared.

Capacity issues are further worsened by the failure to discharge patients on the weekends, which would provide more capacity as the week begins. In New York state, weekend discharges are almost half of weekday discharges. Surgical patients discharged on a Monday vs Saturday had a length of stay of 10.22 days vs 6.56 days; for medical patients, this difference was 5.12 days vs 3.90 days. This data clearly indicates a very substantial opportunity for creating capacity to ameliorate boarding. Montefiore Hospital in NYC reduced the average number of boarders from 20 to near zero by a focused and successful effort to increase weekend discharges. This intervention was so successful that it reduced their overall length of stay by a day, and allowed for closure of a 30 bed unit (personal communication, AV).

Contrary to conventional wisdom that ED volume is highly unpredictable, the number of admissions per day can be predicted with remarkable accuracy. What is most striking about this fact is the associated fact that no hospital actually anticipates and prepares for the next day's volume of admissions from the ED.

This paper will endeavor to answer some of the vital questions concerning ED overcrowding and propose some possible solutions to this critical issue.

WHAT IS ED OVERCROWDING?

Various studies have developed definitions of ED overcrowding, but in its simplest form, overcrowding exists when there is no space left to meet the timely needs of the next patient requiring emergency care. If the care of urgent problems is delayed due to congestion, then overcrowding exists. The presumption for many years was that waits were driven by poor ED design and failure to optimize flow. In some circumstances, this is unquestionably true. A substantial volume of literature, however, concludes that ED overcrowding is largely driven by the boarding of admitted patients in the ED. Thus ED overcrowding is really a result of hospital-wide overcrowding. One scoring system which has become a national standard for measuring the degree of overcrowding is the National ED Overcrowding Scale ("NEDOCS") (<http://www.nedocs.org>) (1). Elements of the NEDOCS score include number of beds in the hospital as well as the ED, total patients in the ED, number of admits in the ED, number of patients on ventilators in the ED as well as the waiting time of the longest admitted patient and the longest waiting room patient.

WHAT CAUSES ED OVERCROWDING?

Over the years, the list of reasons for overcrowding have included: the poor and uninsured who lack primary care; unnecessary visits, the safety net, surgical scheduling and seasonal illness.

Studies on the uninsured do not support the contention that they use the ED more than insured patients, or that they are a substantive cause of overcrowding (2). Furthermore, there is little evidence that low-acuity patients impact waiting times or overcrowding in any event (3). More recent studies have shown that "frequent flyers" represent the sickest patients, have the greatest admission rates, highest mortality rates, and consume a disproportionate amount of resources (4).

In a study done in the state of Oregon looking at patients who had public-based insurance (Medicaid), 23% of patients

visited the ED in one year, with 3% of patients constituting 50% of the ED visits (5).

More recently, there has been far greater emphasis on the boarding of admitted patients as the primary cause of ED overcrowding. Admitted patients are left in the ED when there is no “proper” space within the institution. A number of studies have shown a direct and strong correlation between the number of admissions being boarded in the ED and overcrowding, making it clear beyond question that this is the number one culprit related to ED overcrowding. In short, it is not really the ED that is overcrowded, it is the hospital that is overcrowded.

It is important to distinguish what overcrowding means in the ED versus the inpatient units in most hospitals. Inpatient units are considered “full” when their normal patient beds are occupied.

At this juncture, they are considered to be “incapable” of taking more patients. Emergency departments are considered “full” when all of their rooms are full, all of their hallway stretchers are full, and all of their chairs are full. Thus, there is a striking contrast between the ED and the inpatient units in their respective views of what constitutes “at capacity.” Similarly, staffing ratios which may be preserved on the inpatient units are unachievable in the ED during times of overcrowding.

WHAT ARE THE CONSEQUENCES OF ED OVERCROWDING?

A wealth of literature exists that demonstrates the consequences of overcrowding in the ED.

These consequences include the following:

A. Sick people have to wait too long to receive care

In fact, the Centers for Disease Control (CDC) reported that, for patients judged by the triage nurse to be critical, over 10% of this group waited more than an hour to see a physician (6). Many illnesses are time-dependent. Horwitz, et al., reported on measures relating to ED wait times; only 67% of acutely ill patients were seen within the recommended times in the US (7).

Pines, et al., studied the complication rate of patients with acute coronary syndrome (ACS) as a function of crowded versus non-crowded conditions, and found a significant increase in serious complications (approximately 6% vs. 3% incidence of death, cardiac arrest, heart failure, late myocardial infarction, arrhythmias, stroke, or hypotension) in those patients presenting during 8 times of overcrowding.

Earlier intervention produces better outcomes.

Late diagnoses may sometimes be too late, with permanent consequences of disability or death. Waiting times can be reduced by reducing access block.

B. Boarding increases TOTAL length of stay in the hospital, further worsening access.

Multiple studies have documented the total hospital length of stay (LOS) to be a full day longer in patients boarded in the ED versus patients with similar illnesses promptly placed on the inpatient unit (9, 10). Conversely, it has been noted that, when the patient is placed on the inpatient unit via a full capacity protocol, this effect on LOS is reversed.

C. Boarding increases walkouts, sometimes of patients needing admission

The longer the wait, the greater the number of people who leave prior to receiving care. Unfortunately, the percentage of patients with serious illness differs little in the group who leave as compared with the group that waits for care. A number of these walkouts will require subsequent admission (11-13).

D. Overcrowding reduces the quality of care and increases medical errors

A number of articles document the impact of overcrowding on the quality of care and medical error (14). Many errors are errors of omission, as the emergency staff must focus on the new emergencies coming in the door (15). Medication errors have been shown to increase in frequency as overcrowding occurs (16).

Multiple studies document inferior care rendered during times of overcrowding. Sills, et al., documented the impact of overcrowding on the care of asthma or long bone fractures in children (17). Mills, et al., showed a similar association between overcrowding and delays to provision of analgesia for adults with abdominal pain, a problem also identified in the study by Hwang, et al (18,19) Pines, et al., also demonstrated the same relationship between overcrowding and provision of care for painful conditions (20). A review of the literature in 2009 revealed similar findings (21).

Boarded admissions are at risk of adverse events or errors. Pines, et al., demonstrated an association between overcrowding and adverse cardiac events (22). In another paper, the same group showed the impact of overcrowding on the timely management of patients with community-acquired pneumonia (23).

A similar finding was described by authors at UCSF (24).

The ED has been forced to adapt to overcrowding by moving the ED out to triage, with placement of health care providers at triage, evaluation of patients in the waiting room or hallways. For example, Scheuermeyer, et al., describes a program for evaluation of possible acute coronary syndrome patients in the ED waiting room rather than in a monitored bed, and interestingly concludes that it is a “feasible alternative” (25). Art Kellermann, a notable US emergency physician and leader, wrote an accompanying editorial whose title summarizes its content titled “Waiting room medicine: has it really come to this?”(26).

E. Overcrowding increases mortality

The emergency medicine community has long been aware of the dangers of overcrowding and delays in care, but has an understandable reluctance to publish bad outcomes. Several recent articles looking at large databases that compare mortality rates in patients presenting during times of overcrowding versus times of no overcrowding conclude that the rate of death is higher during times of overcrowding. Chalfin, et al., looked at the outcomes of ICU patients subjected to a delay of greater than 6 hours to transfer to an ICU and found an increased hospital length of stay (LOS) (7 vs. 6 days) and higher mortality rates (10.7% vs. 8.4%) for these patients (27).

Singer, et al., also found an increasing mortality rate and increased LOS as a function of how long the patient was boarded in the ED (28). The mortality rate was 2.5% for those boarded for less than 2 hours and increased to 4.5% for those boarding for greater than 12 hours. Similarly, LOS increased from 5.6 days to 8.7 days. In a study performed in Western Australia, mortality was also shown to be higher during times of ED overcrowding and the authors estimated that effect to result in approximately 13 excess deaths per year in their patient population (29).

F. Overcrowding causes ambulance diversion

According to the CDC, approximately 50% of EDs experience overcrowding, and a third of US hospitals have experienced ambulance diversion (30). Ninety percent of ED directors report overcrowding as a recurrent problem, and other studies have reported diversion in up to 50% of emergency departments (31). Such overcrowding and diversion have raised an alarm regarding the ability of the health care system to respond to catastrophe.

Interestingly, there is scant evidence that ambulance diversion actually works, although there is evidence for delayed care in the face of ambulance diversion (32,33). In this regard, Nicholl, et al., demonstrated an increased mortality rate with prolonged transport times (34). What should be

clear is that ambulance diversion is driven by the boarding of admitted patients, and not otherwise related to issues of staffing or space within the ED itself (35).

WHAT ARE THE FINANCIAL CONSEQUENCES OF BOARDING ADMITTED PATIENTS?

First, some numbers. In the United States, it is estimated that it costs approximately \$1,000,000 to build a hospital bed, and \$600,000 to \$800,000 to staff that same bed. Many have argued that this is the reason hospitals have little interest in addressing the boarding problem. They are more than happy to have patients lining up to get into the hospital.

To increase or decrease the number of admissions from the ED by one a day will net (positive or negative) around \$800,000 to the institution at the end of the year. Each walkout from the ED represents roughly \$600 to \$800 in lost revenue, ignoring the loss of a potential admission among the walkouts. In separate studies, Falvo and Bayley evaluated the potential financial consequences from boarding patients in the ED (36,37).

Finally, it should be noted that decreasing overall LOS by any means is of major financial benefit to the institution. Shorter LOS for a given number of beds means that there will be more capacity. A 600 bed hospital operating at capacity with an average LOS of 6 days would need 500 beds for the same volume if the LOS decreased by a day.

HOW CAN BOARDING OF ADMITTED PATIENTS IN THE ED BE REDUCED?

A. Solutions within the ED Internal to the ED

Internal to the ED, performing patient registration at the bedside rather than in the front of the ED has been shown to decrease waiting time for patients, but, at least in some places, this effect is not sustained (38). The reasons for this are unclear, but may be related to the failure to implement this in a consistent way, regardless of volume and boarding.

One option to improve the care of patients waiting to be seen is to address boarding by adding beds to the ED. The study by Khare, et al., is one of several that conclude that this is a less than ideal solution, and that the ED patient is best served by moving admitted patients out of the ED (39). This study is congruent with a number of other studies which have demonstrated that increasing the number of ED beds simply increased the number of boarders. Others have similar conclusions (40).

Instead of adding beds, one can also add a hospitalist to focus on bed management, as per the study from Johns Hopkins (41). Having a hospitalist in this role decreased the *throughput* time for admissions by 100 minutes, and also resulted in a decrease in ambulance diversion.

Another potential solution is to place a provider in triage. The cost versus benefit analysis, however, is unclear and would need to be explored prior to implementation (42).

Analyzing *throughput* and ensuring that staff are scheduled appropriately is another potential solution. Optimizing staffing to ensure that the department is appropriately resourced at the times when patient flow is highest is a common-sense solution to flow and resource issues. This applies to physician providers as well as nursing staff (43).

B. Solutions external to the ED

Effective solutions are measured by their ability to increase capacity. The most established of these is smoothing of elective cases, early discharge of inpatients, and enhanced weekend discharges. There must also be a plan which maximizes patient safety during times of over-capacity.

Smoothing of elective cases

In general, improvement of capacity will reduce boarding. A variety of mechanisms, including smoothing of elective admissions and early discharge, will improve boarding. Much work has been done on the impact of elective scheduling of surgical admissions, demonstrating a profoundly negative impact on overall flow and boarding (see data from the Institute of Healthcare Optimization: <http://www.ihoptimize.org>). Smoothing of elective cases has led to a substantial decrease in boarding and diversion, and improved availability of both floor and ICU beds. The impact of smoothing has raised the question of whether inadequate capacity is actually a real problem, or an artificial one driven by the vagaries of the elective schedule, in conjunction with the limited services available and lack of discharges on weekends. Rathlev, et al., demonstrated the impact of elective scheduling on boarding and flow in the ED (44). Early discharge of inpatients According to one study, early discharge would decrease boarding by 96% (45) In most institutions, the result would likely not reach that magnitude however it would make a big different in bed access during peak times of admissions from the ED. At New York Univeristy, increasing the number of patients discharged before 12pm resulted in an overall decreased LOS. Their efforts were driven by the finding that admitted patients who made it to the inpatient unit before noon had an average LOS 0.6 days shorter than those arriving after noon. Insofar as early discharge results in early movement of admitted boarders to the inpatient unit, the ED will

have greater capacity to treat patients as flow increases later in the day.

Increasing weekend discharges

As noted above, the decreased number of admissions on weekends is offset by the decreased number of discharges. Increasing weekend discharges can substantially increase available capacity as the week begins. Insofar as this may require resources often not available on weekends, such as echo, MRI, and stress testing, increasing services on weekends means less demand during the week. As such, this can be accomplished not by additional staff, but simply by redistributing some to the weekends.

Full capacity protocol

Financial needs dictate that hospitals must run at near full capacity. As such, one should expect that capacity can be exceeded on a fairly regular basis. Thus, some kind of full capacity protocol (FCP) is needed. One such solution is to move ED hallway patients to inpatient hallways.

Viccellio, et al., published one institution's experience with 2000 patients placed on inpatient units in hallways, and concluded that the practice is safe (46).

A subsequent study from Stony Brook University (pending publication) documented that close to 90% of patients who actually experienced placement in both ED and inpatient corridors preferred the inpatient hallway rather than remaining in the ED. A study from the University of Pennsylvania correlated an inverse relationship between overall patient satisfaction and overcrowding. In a survey study, Garson, et al., also demonstrated a strong patient preference for being on the inpatient service rather than boarding in the ED (48)

Processes that do not improve capacity

There are a multitude of smaller process improvement opportunities within the ED, and within the institution. Examples include improving nursing report, rapid bed cleaning and turnaround, etc. Although these have value, institutions often choose to focus on the "low hanging fruit" which ultimately do nothing to improve the problems patients face from boarding, but distract from the fundamental problem.

It is also important to note that the smoothing of elective admissions, early discharge, and weekend discharge, by improving flow and capacity, make it safer for the patient, easier on the staff, and better for the financial bottom line. These solutions do not require that anyone work harder, but it does require that they work differently.

CONCLUSION

ED overcrowding is caused by institutional overcrowding, with resultant boarding of admitted patients in the ED. There is no evidence that overcrowding results from excess poor patients or non-urgent visits. ED overcrowding causes multiple problems for ED patients and staff, including increased waiting times, increased ambulance diversion, increased length of stay, increased medical errors, increased patient mortality, and increased harm to hospitals due to financial losses.

ED overcrowding can be addressed by a variety of mechanisms. Internal department improvements include bedside registration and effective use of hospitalists. Providers in triage and provider schedule optimization are additional solutions. Adding beds to the ED does not predictably improve problems with boarding and overcrowding. Externally, the smoothing of elective (schedulable) admissions probably is the single most important intervention to improve capacity, decrease boarding, preserve nurse/

patient ratios, and improve ICU access. Were there to be a system-wide implementation of smoothing, it is likely that there would be no capacity issue. Early morning discharges from inpatient units also substantially decreases ED boarding.

Increasing weekend discharges and improving services available on weekends will result in improved capacity and decreased boarding. When the number of admissions exceeds the number of beds at an institution, having a full-capacity protocol, where the inpatient units go over census rather than boarding patients in the ED, is safer, is preferred by patients and shortens length of stay. Ambulance diversion has not been shown to be effective, and has multiple adverse effects on both patient care and the financial health of the institution. Until healthcare and hospital administrators recognize that ED overcrowding really is hospital overcrowding, this issue will likely to continue to garner attention without meaningful progress being made to address the underlying issues.

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REFERENCES

- Bernstein SL, Verghese V, Leung W, et al. Development and validation of a new index to measure emergency department crowding. *Acad Emerg Med* 2003;10(9):938-42.
- Newton MF, Keirns CC, Cunningham R, et al. Uninsured adults presenting to US emergency departments: assumptions vs. data. *JAMA* 2008; 300(16):1914-24.
- Schull MJ, Kiss A, Szalai JP. The effect of low-complexity patients on emergency department waiting times. *Ann Emerg Med* 2007; 49(3):257-64.
- LaCalle E, Rabin E. Frequent users of emergency departments: the myths, the data, and the policy implications. *Ann Emerg Med* 2010; 56(1):42-8.
- Handel DA, Fu R, Vu E, et al. How much does emergency department use affect the cost of Medicaid programs? *Ann Emerg Med* 2008; 51:614-21.
- QuickStats: Percentage of emergency department visits with waiting time for a physician of >1 hour, by race/ethnicity and triage level - United States, 2003-2004. *mmWR* 2006; 55(16):463.
- Horwitz LI, Green J, Bradley EH. US emergency department performance on wait time and length of visit. *Ann Emerg Med* 2010; 55(2):133-41.
- Pines JM, Hollander JE. Association between cardiovascular complications and ED crowding. *American College of Emergency Physicians 2007 Scientific Assembly; October 8- 11, 2007; Seattle, WA.*
- Krochmal P, Riley TA. Increased health care costs associated with ED overcrowding. *Am J Emerg Med* 1994; 12(3):265-6.
- Liew D, Liew D, Kennedy MP. Emergency department length of stay independently predicts excess inpatient length of stay. *Med J Aust* 2003; 179(10): 524-6.
- Richardson DB. The access-block effect: relationship between delay to reaching an inpatient bed and inpatient length of stay. *Med J Aust* 2002; 177(9):492-5.
- Weiss SJ, Ernst AA, Derlet R, et al. Relationship between the National ED Overcrowding scale and the number of patients who leave without being seen in an academic ED. *Am J Emerg Med* 2005; 23:288-94.
- Richardson DB, Bryant, M. Confirmation of association between overcrowding and adverse events in patients who do not wait to be seen. *Acad Emerg Med* 2004; 11(5):462.
- Weissman JS, Rothschild JM, Bendavid E, et al. Hospital workload and adverse events. *Med Care* 2007; 45(5):448-55.
- Cowan RM, Trzeciak S. Clinical review: emergency department overcrowding and the potential impact on the critically ill. *Crit Care* 2005; 9(3):291-5.

16. Kulstad EB, Sikka R, Sweis RT, et al. Overcrowding is associated with an increased frequency of medication errors. *Am J Emerg Med* 2010; 28(3):304-9.
17. Sills MR, Fairclough DL, Ranade D, et al. Emergency department crowding is associated with decreased quality of care for children. *Ped Emerg Care* 2011; 27(9):837-45.
18. Mills AM, Shofer FS, Chen EH, et al. The association between emergency department crowding and analgesia administration in acute abdominal pain patients. *Acad Emerg Med* 2009; 16(7):603-8.
19. Hwang U, Richardson L, Livote E, et al. Emergency department crowding and decreased quality of pain care. *Acad Emerg Med* 2008; 15(12):1248-55.
20. Pines JM, Hollander JE. Emergency department crowding is associated with poor care for patients with severe pain. *Ann Emerg Med* 2008; 51(1):1-5.
21. Bernstein SL, Aronsky D, Duseja R, et al. The effect of emergency department crowding on clinically oriented outcomes. *Acad Emerg Med* 2009; 16(1):1-10.
22. Pines JM, Pollack CV Jr, Diercks DB, et al. The association between emergency department crowding and adverse cardiovascular outcomes in patients with chest pain. *Acad Emerg Med* 2009; 16(7):617-25.
23. Pines JM, Localio AR, Hollander JE, et al. The impact of emergency department crowding measures on time to antibiotics for patients with community-acquired pneumonia. *Ann Emerg Med* 2007; 50(5):510-6.
24. Fee C, Weber EJ, Maak CA, et al. Effect of emergency department crowding on time to pneumonia. *Ann Emerg Med* 2007; 50(5):501-9.
25. Scheuermeyer FX, Christenson J, Innes G, et al. Safety of assessment of patients with potential ischemic chest pain in an emergency department waiting room: a prospective comparative cohort study. *Ann Emerg Med* 2010; 56(5):455-62.
26. Kellermann AL. Waiting room medicine: has it really come to this? *Ann Emerg Med* 2010; 56(5):468-71.
27. Chalfin DB, Trzeciak S, Likourezos A, et al. Impact of delayed transfer of critically ill patients from the emergency department to the intensive care unit. *Crit Care Med* 2007; 35(6):1477-83.
28. Singer AJ, Thode HC Jr, Viccellio P, et al. The association between length of emergency department boarding and mortality. *Acad Emerg Med* 2011; 18(12):1324-9.
29. Richardson DB. Increase in patient mortality at 10 days associated with emergency department overcrowding. *Med J Aust* 2006; 184(5):213-6.
30. Burt CW, McCaig LF. Staffing, capacity, and ambulance diversion in emergency departments: United States, 2003-04. *Adv Data* 2006; 376: 1-23.
31. Olshaker JS, Rathlev NK. Emergency Department overcrowding and ambulance diversion: the impact and potential solutions of extended boarding of admitted patients in the emergency department. *J Emerg Med* 2006; 30(3):351-6.
32. Pham JC, Patel R, Millin MG, et al. The effects of ambulance diversion: a comprehensive review. *Acad Emerg Med* 2006; 13(11):1220-7.
33. Schull MJ, Morrison LJ, Vermeulen M, et al. Emergency department overcrowding and ambulance transport delays for patients with chest pain. *CMAJ* 2003; 68(3):277-83.
34. Nicholl J, West J, Goodacre S, et al. The relationship between distance to hospital and patient mortality in emergencies: an observational study. *Emerg Med J* 2007; 24(9):665-8.
35. Schull MJ, Lazier K, Vermeulen M, et al. Emergency department contributors to ambulance diversion: a quantitative analysis. *Ann Emerg Med* 2003; 41(4):467-76.
36. Falvo T, Grove L, Stachura R, et al. The opportunity loss of boarding admitted patients in the emergency department. *Acad Emerg Med* 2007; 14(4):332-7.
37. Bayley MD, Schwartz JS, Shofer FS, et al. The financial burden of emergency department congestion and hospital crowding for chest pain patients awaiting admission. *Ann Emerg Med* 2005; 45(2):110-7.
38. Takakuwa KM, Shofer FS, Abbuhl SB. Strategies for dealing with emergency department overcrowding: a one-year study on how bedside registration affects patient throughput times. *J Emerg Med* 2007; 32(4):337-42.
39. Khare RK, Powell ES, Reinhardt G, et al. Adding more beds to the emergency department or reducing patient boarding times: which has a more significant influence of emergency department congestion? *Ann Emerg Med* 2009; 53(5):575-85.
40. Han JH, Zhou C, France DJ, et al. The effect of emergency department expansion on emergency department overcrowding. *Acad Emerg Med* 2007; 14(4):338-43.
41. Howell E, Bessman E, Kravet S, et al. Active bed management by hospitalists and emergency department throughput. *Ann Intern Med* 2008; 149(11):804-11.
42. Abdulwahid MA, Booth A, Kuczawski M, et al. The impact of senior doctor assessment at triage on emergency department performance measures: systematic review and meta-analysis of comparative studies. *Emerg Med J* 2016; 33(7):504-13.
43. Mandavia S, Samaniego L. Improving ED efficiency to capture additional revenue. *Healthc Financ Manage* 2016; 70(6):66-9.
44. Rathlev NK, Chessare J, Olshaker J, et al. Time series analysis of variables associated with daily mean emergency department length of stay. *Ann Emerg Med* 2007; 49(3):265-71.
45. Powell ES, Khare RK, Venkatesh AK, et al. The relationship between inpatient discharge timing and emergency department boarding. *J Emerg Med* 2012; 42(2):186-96.
46. Viccellio A, Santora C, Singer AJ, et al. The association between transfer of emergency department boarders to inpatient hallways and mortality: a 4-year experience. *Ann Emerg Med* 2009; 54(4):487-91.
47. Pines JM, Iyer S, Disbot M, et al. The effect of emergency department crowding on patient satisfaction for admitted patients. *Acad Emerg Med* 2008; 15(9):825-31.
48. Garson C, Hollander JE, Rhodes KV. Emergency department patient preferences for boarding locations when hospitals are at full capacity. *Ann Emerg Med* 2008; 51(1):9-12.