


Correlation Between Emergency Department Crowding and Adverse Occurrences in an Academic Hospital: A Retrospective Cohort Study

Wajdan Alassaf¹, Razan Albrahim², Jana K Abukhaled³, Mujahid Aldhaif¹, Mashaer Ahmed Mohammed¹, Alia Al Baiz⁴, Muna Aljahany¹ 

¹Department of Emergency, King Abdullah Bin Abdulaziz University Hospital, Princess Nourah bint Abdulrahman University, Riyadh, Saudi Arabia; ²Department of Internal Medicine, College of Medicine, Princess Nourah bint Abdulrahman University, Riyadh, Saudi Arabia; ³Department of Family Medicine, Prince Sultan Military Medical City, Riyadh, Saudi Arabia; ⁴Department of Epidemiology and Biostatistics, Health Science Research Center, Princess Nourah bint Abdulrahman University, Riyadh, Saudi Arabia

Correspondence: Muna Aljahany, Department of Internal Medicine, College of Medicine, Princess Nourah bint Abdulrahman University, P.O. Box 84428, Riyadh, 11671, Saudi Arabia, Tel +966118238711, Email msaljahany@pnu.edu.sa

Background: Emergency care predominantly involves the treatment of abrupt clinical status deteriorations, illness exacerbation, and potentially life-threatening injuries. However, crowding and excessive delays in the emergency department (ED) affect the quality of care and are associated with undesirable outcomes.

Objective: This study aimed to determine the association of emergency department (ED) crowding with patient outcomes at a teaching hospital in Saudi Arabia's Central Province.

Methods: Using a retrospective chart review of electronic medical records, we extracted mortality, morbidity, and safety events-related data of all adult, pediatric, and obstetric patients who presented to the King Abdullah Bin Abdulaziz University Hospital (KAAUH) emergency department (ED) between January 2019 and December 2022. Based on the emergency department (ED) census, these data were cross-referenced by date with the emergency department (ED) situation.

Results: Sixty patients had safety events; medication-related safety events were the most prevalent (38%), followed by care-coordination events (30%). Twenty cases of mortality and morbidity were reported. Crowding significantly affected adverse medication-related and care-coordination events ($p = 0.0212$), with a more significant effect on moderate safety events than on mild safety events ($p = 0.0348$). Influence of emergency department (ED) crowding ($p = 0.3740$) was on mortality or morbidity outcomes was detected. The data was extracted from a total of 139176 emergency visits for all categories.

Conclusion: In Saudi Arabia, emergency department (ED) crowding signifies a critical healthcare crisis, potentially compromising quality of care. Our findings provide evidence of increased errors in medication, care coordination, and medical care due to emergency department (ED) crowding. Implementing micro and macro-level strategies to reduce emergency department (ED) crowding could help improve patient outcomes.

Keywords: emergency department, crowding, mortality, morbidity, safety events, Saudi Arabia

Background

Emergency care is predominantly aimed at caring for patients with abrupt clinical deterioration, exacerbation of medical conditions, and potentially life-threatening injuries. Therefore, the emergency department (ED) plays a pivotal role in public health. Crowding and delays in the ED affect the quality of care and are associated with undesirable outcomes.^{1,2} ED crowding is defined as a situation wherein the demand for emergency care exceeds the available patient-care resources.³ Worldwide, ED crowding is considered a significantly increasing concern owing to the healthcare threat it poses.⁴

Different causes of ED crowding have been identified previously, with frequently reported causes including hindered access, a large volume of low-acuity cases, increased presentation by older adults, and hampered post-treatment discharges.⁵ In government hospitals in Saudi Arabia, ED crowding and longer-duration stays have been associated with the overuse of emergency department for non-emergency cases.^{6,7} There is abundant evidence that ED crowding has negative consequences for both patients and staff,⁸ including delays in patient admission; lowering the standard of care; lengthening waiting times, especially among noncritical patients; lessening patient satisfaction; increasing the number of patients who leave without being seen; and increasing the frequency of medical errors. Furthermore, ED crowding significantly affects clinicians' decision-making, leading to higher mortality rates and clinicians forgetting information that may be crucial for patient safety.^{6,9} Previous studies have investigated the impact of ED crowding on patient outcomes, and the findings of studies by Al-Qahtani et al, and Akhtar confirmed that the duration that patients spent in the ED was associated with higher rates of mortality and morbidity, longer hospitalization, and declining adherence to treatment guidelines by medical staff.^{10–12} Similarly, Bernstein SL and Pines JM have demonstrated that ED crowding is a widespread issue that is linked to higher patient mortalities and inadequate healthcare.^{13,14} A study conducted in the Stockholm region of Sweden found a strong correlation between high levels of ED crowding and high mortality rates.¹⁵ However, another study at a teaching hospital in Saudi Arabia revealed no significant association between mortality rates and ED crowding.⁹ Consequently, there is controversy regarding how ED crowding affects patient outcomes. A study conducted at the Seoul National University Bundang Hospital revealed a strong correlation between ED crowding and in-hospital cardiac arrests.¹⁶

As the reports in the literature suggest, ED crowding may adversely affect patient outcomes. Therefore, the correlation between ED crowding and patient outcomes should be assessed. To the best of our knowledge, most studies on this topic have been conducted in Western countries, whereas Saudi Arabia and other Middle Eastern countries have seen the least amount of research on this topic. Therefore, it is necessary to assess the interrelationships among these factors. Thus, to bridge the abovementioned knowledge gap, generate solid evidence on the issue, and advance our understanding of the relationship between patient outcomes and ED crowding, this study aimed to investigate the relationship between ED crowding and patient outcomes at a teaching hospital in Saudi Arabia's Central Province.

Study Area

This retrospective study was conducted at the King Abdullah Bin Abdulaziz University Hospital (KAAUH), Riyadh, Saudi Arabia. The six-floor teaching hospital with a 406-bed capacity has a 37-bed ED that includes two triage beds, four respiratory zone-dedicated beds established as per the Ministry of Health (MOH) recommendation, three rapid assessment zone beds, two active resuscitation beds, two procedure beds, seven treatment beds, one isolation bed, two obstetric beds, and one bed in a safe room (for psychiatric patients). The remaining rooms are non-operational owing to manpower issues. During the study period, the manpower comprised seven nurses per duty shift (distributed between triage, screening, and patient care), an on-board certified emergency medicine consultant and one or two staff physicians per duty shift.

Methods

Study Design and Population

The study was a retrospective chart review of all mortality and morbidity cases. The target population comprised all documented mortality and morbidity cases in the Emergency Department (ED) as well as all documented safety events that occurred between January 2019 and December 2022. The study dataset was extracted from the hospital database and collated in a Microsoft Excel (MS Excel) file. After data extraction, the cases were categorized under the same theme, if applicable. Morbidity and mortality were categorized as follows: (i) death, (ii) Intensive Care Unit (ICU) admission, (iii) ward admission, and (iv) discharge. Safety events were classified as follows: (i) behavioral, (ii) care coordination, (iii) medical care, (iv) medication, and (v) radiology. In our study, "safety events" refer to incidents or occurrences that compromise patient safety within the Emergency Department (ED) of King Abdullah bin Abdulaziz University Hospital (KAAUH). These events included errors, accidents, or other adverse incidents that pose risks to the patient's well-being. Medication errors include prescribing, dispensing, and administering medications, leading to incorrect dosages, incorrect

medications, or adverse reactions. Care coordination issues refer to problems in coordinating care among different healthcare providers or departments, which may result in delayed or fragmented patient care. Medical care complications are adverse outcomes or complications related to the medical procedures, treatments, or interventions provided to patients. Behavioral incidents are instances of disruptive behavior, violence, or aggression within the Emergency Department (ED) that may threaten the safety of patients and healthcare staff. Radiology-related incidents are errors or issues related to diagnostic imaging procedures, such as misinterpretation of images or failure to perform the necessary follow-up actions.

To ensure accurate classification and minimize errors, all cases were carefully reviewed based on clear, predefined criteria. If there were any inconsistencies, the research team discussed them and reached a consensus. When data were missing or conflicting, we cross-checked with hospital records whenever possible. If crucial details could not be retrieved, those cases were not included in certain analyses but remained part of the overall event count.

To prevent bias in data collection, those extracting the information were not aware of the study's main hypothesis. They followed a structured data collection process and received proper training to ensure consistency. Before starting the full review, we conducted a preliminary assessment to refine categorization and make sure everyone followed the same approach.

To further enhance accuracy, two independent reviewers performed the data extraction. If they had any disagreements, a third reviewer helped resolve them.

Additionally, as per the Safety Assessment Code (SAC), safety events were labeled according to severity as Extreme (sentinel), Major, Moderate, Minor, or Insignificant; no information was excluded from the study analysis.

Ethics Statement and Informed Consent

Ethical approval was obtained from the Institutional Review Board of the Princess Nourah Bint Abdulrahman University (PNU), Riyadh, Saudi Arabia (IRB log number: 22-0018). The study complies with the declaration of Helsinki.

Statistical Analyses and Data Management

All data analyses were conducted using JMP Pro version 14.2. Univariate analyses and descriptive statistics were used to describe Documented Safety Event Cases and Documented Mortality and Morbidity Cases in the King Abdullah bin Abdulaziz University Hospital (KAAUH) Emergency Department within the study period; frequencies (n) and percentages (%) were used to describe categorical variables (Table 1 and Table 2). For the bivariate analyses, the analysis of variance (ANOVA) test was used to test the differences in Emergency Department (ED) crowding across five categories of Adverse Occurrences: Behavioral, Care Coordination, Medical Care, Medication, and Radiology and three categories of Severity of Safety Events: Mild, Moderate, and Severe (Table 3). To assess the differences in mortality/morbidity outcome levels according to Emergency Department (ED) crowding, ANOVA was performed for the following categories: Admission, Intensive Care Unit (ICU) admission, Discharge, and Death (Table 4). The level of significance was set at $p < 0.05$ for all statistical tests.

Table 1 Safety Events in the KAAUH ED During the Study Period

Variable	Level	N (%)
Safety Event Cases	Behavioral	3 (5%)
	Care Coordination	18 (30%)
	Medical Care	11 (18%)
	Medication	23 (38%)
	Radiology	5 (8%)
Total		60

Table 2 Disposition of Mortality and Morbidity Cases in the KAAUH ED During the Study Period

Variable	Level	N (%)
Mortality and morbidity cases	Admission	11 (55%)
	ICU* admission	5 (25%)
	Discharge	1 (5%)
	Death	3 (15%)
Total		20

Abbreviation: *ICU, intensive care unit.

Table 3 Correlation of ED Crowding With Adverse Occurrences and Severity of Safety Events

Variable	Level	Mean \pm SD	p-value
Adverse Occurrences	Behavioral	74.33 \pm 24.09	0.0212*
	Care Coordination	118.17 \pm 41.63	
	Medical Care	107 \pm 26.19	
	Medication	128.30 \pm 23.13	
	Radiology	95.60 \pm 23.01	
Severity of Safety Events	Mild	120.38 \pm 30.86	0.0348*
	Moderate	125.17 \pm 35.57	
	Major	98.31 \pm 26.82	

Note: *Statistically significant p-value was calculated using ANOVA.

Table 4 Correlation of ED Crowding With the Mortality/Morbidity Outcomes

Level	Mean \pm SD	p-value
Admission	121.45 \pm 29.28	0.3740
ICU* admission	129.60 \pm 34.33	
Discharge	105 \pm **	
Death	93.33 \pm 8.33	

Note: *Discharge standard deviation of this data set is zero because we only have one case observed.

Abbreviation: **ICU, intensive care unit.

Results

A total of 60 patients were included in the safety event cases at the King Abdullah Bin Abdulaziz University Hospital (KAAUH) emergency department (ED) during the study period (Table 1). The distribution of safety events was as follows: 5% Behavioral Safety, 30% Care Coordination, 18% Medical Care, 38% Medication Safety, and 8% Radiological Safety.

The relationships between emergency department (ED) crowding, adverse occurrences, and the severity of safety events are shown in Table 4.

Emergency department (ED) crowding had a significant main effect on medication-related adverse occurrences (128.30 \pm 23.13) and care-coordination adverse occurrences (118.17 \pm 41.63), with a p-value of 0.0212. Additionally, emergency department (ED) crowding significantly impacted the severity of safety events, with moderate events (125.17 \pm 35.57) and mild events (120.38 \pm 30.86) being more pronounced under crowded conditions (p = 0.0348; Table 2).

In the morbidity and mortality analysis, twenty patients were included from the King Abdullah Bin Abdulaziz University Hospital (KAAUH) emergency department (ED) during the study period (Table 3). Of these, 55% (n = 11)

were admitted to the ward, 25% (n = 5) were admitted to the Intensive Care Unit (ICU), 5% (n = 1) were discharged, and 15% (n = 3) died.

Table 4 shows the relationship between emergency department (ED) crowding and mortality and morbidity outcomes. There was no significant difference in mortality and morbidity outcomes during emergency department (ED) crowding ($p = 0.3740$), suggesting that, while crowding may influence safety events, it does not directly affect patient survival or overall morbidity in this cohort.

Discussion

In this study, we determined that while emergency department (ED) crowding did not have a statistically significant impact on overall mortality and morbidity, it was associated with a range of adverse patient safety events, primarily related to medication, care coordination, and medical care (Table 1). These findings align with previous studies, Kulstad et al; Pines et al; Depinet et al, that highlight the negative effects of ED crowding on patient safety and quality of care.^{17–19}

The majority of occurrences were moderate. Moderate severity was defined as events that induced permanent lessening of bodily functioning (sensory, motor, physiologic, or intellectual) that was unrelated to the natural course of the illness/injury and differed from the expected outcomes of consumer healthcare management or any of the following: increased length of stay (5–25 days) or additional operations or procedures.²⁰ This was followed by minor events (defined as increases in levels of care required, including review and evaluation, additional investigations, and referral to another clinician).²⁰ Although no sentinel events occurred, the risk persisted, with an increased probability of further consequences with a system overextension. Mortality accounted for 15% of the total mortality and morbidity census data, with five cases. This finding aligns with the previous report of a dissociation between ED crowding and ED mortality rates,⁹ although ED crowding was associated with an ICU mortality rate.¹⁰

Improved ED functioning and decreased crowding fundamentally affect patient care quality and safety. This multi-disciplinary work includes almost every department in the hospital to prevent hindrances to access and identify alternative treatment areas for low-acuity cases that can be managed by family medicine or general practitioners with direct reference and support by the ED where needed.

ED crowding is a global issue.² The Australasian College for Emergency Medicine defines “crowding” as the situation where ED function is impeded by the number of patients waiting to be seen, undergoing assessment and treatment, or waiting for departure that exceeds the physical or staffing capacity of the department. Additionally, “access block” is described as the situation where patients cannot access appropriate hospital beds within a reasonable time, not exceeding 8 hours.²¹ Based on this definition and our data, it is evident that, in Saudi Arabia, EDs are experiencing severe crowding. In the present study, 20 cases of morbidity and mortality were reported due to ED crowding. This study identified different cases with various specialties, and the outcomes included admission, ICU admission, discharge, and death. The cases covered a range of medical conditions, from traumatic wounds and kidney stones to more critical conditions, such as myocardial infarction, diabetic ketoacidosis, and stroke. Moreover, three deaths within the ED occurred at the time of crowding. A similar observation was made by Derlet et al, wherein ED crowding was associated with delays in identifying and treating time-sensitive conditions, such as acute myocardial infarction, acute stroke, acute surgical emergencies, and severe sepsis. One case of delayed treatment resulted in an unforeseen fatality.²² Maximum crowding was observed during ICU admission, followed by ward admission. However, we found no conclusive evidence of a relationship between ED crowding and mortality or morbidity. Our findings are consistent with the results of an earlier study conducted in Saudi Arabia by Khubrani et al,⁹ who found no significant association between crowding and mortality or morbidity. Similar observations have been reported by Van der Linden et al and Park et al^{23,24} However, our findings are at odds with those of retrospective studies conducted in Italy, Sweden, and Australia, which found a greater mortality rate within 7, 10, and 10 days in overcrowded Eds, respectively.^{25–27}

ED crowding significantly increased the likelihood of negative outcomes and patient mortality. Pearce et al reported that the mortality risk increases by more than 50% for every 5-hour stay.²⁸ Poor service, patient walkouts, and staff burnout all contribute to these heightened risks. Previous research has examined various approaches to improve patient safety in the ED. For example, Rosen et al found that learning from previous errors enhanced safety.²⁹ Negarandeh et al

observed that competent nurses improved patient safety.³⁰ Training and education play crucial roles in patient safety. However, most studies have overlooked the effect of crowding on patient safety.³¹

This is the first study to provide a detailed description of various safety errors in a quantifiable manner. The effects of ED crowding on healthcare delivery, including healthcare procedures, care quality, and efficiency, have been extensively examined. The study found that the two most significant safety errors due to ED crowding were pharmacological errors, including incorrect weight input, mis-filled prescriptions, doses lower or higher than appropriate, incorrect frequency instructions, incorrect entries, and errors in medication names. For example, Buscopan was prescribed at 200 mg instead of 10 mg, salbutamol solution (was ordered as 2.5 mL instead of 2.5 mg), and morphine was prescribed in mL instead of in mg. The impact of crowding on medication errors has been rarely reported. Kulstad et al observed a significant positive correlation ($p = 0.001$) between crowding and safety errors while prescribing and dispensing medications.¹⁷

In this study, the two most severely impacted domains were care coordination and medical care, which included delays in the management of high blood pressure, orthopaedic care, and gastrointestinal cases. Laboratory and radiographic tests were not conducted on pediatric patients with abdominal pain, and some patients were discharged without informing the ED team. Other errors included the transfer of ICU patients to regular wards, delayed insulin administration, and performing radiography without pregnancy testing. Patient-care coordination errors have been studied previously by Depinet et al, Gaieski et al, and Pines et al. Crowding was a significant factor that hampered the care of critically ill pediatric patients, patients with sepsis, and patients suffering from severe pain.^{18,19,32} These findings emphasize the need to address and mitigate ED crowding to ensure optimal patient outcomes and effective care coordination in healthcare settings. Other safety events, although less severely impacted by ED crowding, included radiological errors, such as incorrect radiological reports and behavioral safety issues, with three instances of aggressive behavior by patients' relatives due to delays in treatment initiation.

Furthermore, despite the burdened landscape of emergency rooms, healthcare providers demonstrated competency and lack of negligence. This was evident in the impact of ED crowding on safety events, where moderate safety events were more common than mild ones, and major safety events were the least common ($p = 0.0348$).

Therefore, it is important to consider how internal factors affect the patient flow in the ED. Due to an aging population and comorbidities, specialized consultations and diagnostic tests are extremely important for reducing patient length of stay and achieving safe discharge. Extended inpatient stay may be caused by ED crowding, delayed reporting of test findings, consultations, or lack of inpatient beds.³³ Productivity in the ED is essential for ensuring smooth patient flow, particularly during emergencies. Crowding can impede a patient's transition through the ED to other appropriate departments. System obstruction results from an imbalance between the demand for and supply of medical resources (eg, staff, consultants, diagnostics, and beds), whereas maintaining resource equilibrium along the path maintains a regular flow. All of these factors impose a strain on an already understaffed ED workforce. Consequently, there is a risk of safety-related adverse events, as observed in our study.

This study contributes to the increasing number of literature on ED crowding by providing data specific to our healthcare setting. In contrast to other global studies, this one looks at congestion in a local setting, providing information about elements specific to our healthcare system. Furthermore, our results point out how important it is to address patient safety indicators, including medication errors and care coordination issues, in addition to mortality.

We recommend increasing staffing and allocating more resources, which would help in reducing errors and enhancing services, especially during peak hours. As well as involving two healthcare professionals to verify medication before it is administered and using automated verification procedures can help in improving medication accuracy and reducing errors which would be helpful in the emergency department. Strengthening teamwork between the emergency department and inpatient teams can help in smoother transfers and reduce delays. Finally, further research on the impact of ED crowding on high-risk patients, such as the elderly, is needed to understand long-term health outcomes.

Limitations

This study had several limitations. First, owing to the retrospective study design, some information was missing or inaccurately entered into the electronic records. However, we compared records and ensured completeness of data by

referring to other sources, such as hospital mortality and morbidity records. The generalizability of this study is limited because of the single-center study design and it being conducted at a hospital within a women's university.

Conclusion

ED crowding is not merely a problem of prolonged waits and hallways filled with patients but also a severe crisis for the healthcare system.

Our findings support the increasing evidence linking ED crowding to potential compromises in patient care quality. The study's results imply that ED crowding is linked to increased errors in medication use, care coordination, and medical care. Addressing this issue requires targeted interventions, such as optimized resource allocation and workflow improvement.

Further large-scale studies conducted over longer durations in a multicenter setting are needed to assess the harmful adverse effects of ED crowding and develop effective strategies to mitigate its impact.

Abbreviations

ED, Emergency Department; KAAUH, King Abdullah Bin Abdulaziz University Hospital; MOH, Ministry of Health; ICU, Intensive Care Unit; SAC, Safety Assessment Code; PNU, Princess Nourah University.

Data Sharing Statement

Data from this study are available on request from corresponding author.

Ethics Approval and Consent to Participate

Ethical approval was obtained from the Institutional Review Board of the Princess Nourah Bint Abdulrahman University (PNU), Riyadh, Saudi Arabia (IRB log number: 22-0018). All methods were performed according to guidelines. Informed consent were obtained for record access.

Funding

The authors extend their appreciation to the Deputyship for Research & Innovation, Ministry of Education in Saudi Arabia for funding this research work through the project number RI-44-0026.

Disclosure

The authors have no conflict of interest to declare.

References

1. Alabbasi K, Kruger E, Tennant M. Evaluation of emergency health-care initiatives to reduce crowding in a referral medical complex, Jeddah, Saudi Arabia. *Saudi J Health Syst Res*. 2021;1:134–139. doi:10.1159/000517487
2. Wang Z, Xiong X, Wang S, Yan J, Springer M, Dellinger RP. Causes of emergency department crowding and blockage of access to critical services in Beijing: a 2-year study. *J Emerg Med*. 2018;54:665–673. doi:10.1016/j.jemermed.2018.02.009
3. American College of Emergency Physicians. Policy statement, crowding, approved. 2019. Available from: <https://www.acep.org/patient-care/policy-statements/crowding>. Accessed January 24, 2023.
4. Di Somma S, Paladino L, Vaughan L, Lalle I, Magrini L, Magnanti M. Crowding in emergency department: an international issue. *Intern Emerg Med*. 2015;10:171–175. doi:10.1007/s11739-014-1154-8
5. Morley C, Unwin M, Peterson GM, Stankovich J, Kinsman L. Emergency department crowding: a systematic review of causes, consequences and solutions. *PLoS One*. 2018;13:e0203316. doi:10.1371/journal.pone.0203316
6. Al-Qahtani MF, Khubrani FY. Exploring potential association between emergency department crowding status and patients' length of stay at a university hospital in Saudi Arabia. *Open Access Emerg Med*. 2021;13:257–263. doi:10.2147/OAEM.S305885
7. Dawoud SO, Ahmad AM, Alsharqi OZ, Al-Raddadi RM. Utilization of the emergency department and predicting factors associated with its use at the Saudi Ministry of Health General Hospitals. *Glob J Health Sci*. 2015;8:90–106. doi:10.5539/gjhs.v8n1p90
8. Rasouli HR, Esfahani AA, Nobakht M, et al. Outcomes of crowding in emergency departments; a systematic review. *Arch Acad Emerg Med*. 2019;7:e52.
9. Khubrani F, Al-Qahtani M. Association between emergency department crowding and mortality at a teaching hospital in Saudi Arabia. *Open Public Health J*. 2020;13:756–762. doi:10.2174/1874944502013010756
10. Al-Qahtani S, Alsultan A, Haddad S, et al. The association of duration of boarding in the emergency room and the outcome of patients admitted to the intensive care unit. *BMC Emerg Med*. 2017;17:1–6. doi:10.1186/s12873-017-0143-4

11. Akhtar N, Kamran S, Singh R, et al. Prolonged stay of stroke patients in the emergency department may lead to an increased risk of complications, poor recovery, and increased mortality. *J Stroke Cerebrovasc Dis.* 2016;25:672–678. doi:10.1016/j.jstrokecerebrovasdis.2015.10.018
12. Cardoso LT, Grion CM, Matsuo T, et al. Impact of delayed admission to intensive care units on mortality of critically ill patients: a cohort study. *Crit Care.* 2011;15:1–8. doi:10.1186/cc9975
13. Bernstein SL, Aronsky D, Duseja R, et al. The effect of emergency department crowding on clinically oriented outcomes. *Acad Emerg Med.* 2009;16:1–10. doi:10.1111/j.1553-2712.2008.00295.x
14. Pines JM, Hilton JA, Weber EJ, et al. International perspectives on emergency department crowding. *Acad Emerg Med.* 2011;18:1358–1370. doi:10.1111/j.1553-2712.2011.01235.x
15. Af Ugglas B, Djärv T, Ljungman PLS, Holzmann MJ. Emergency department crowding associated with increased 30-day mortality: a cohort study in Stockholm Region, Sweden, 2012 to 2016. *J Am Coll Emerg Physicians Open.* 2020;1:1312–1319. doi:10.1002/emp2.12243
16. Kim JS, Bae HJ, Sohn CH, et al. Maximum emergency department crowding is correlated with occurrence of unexpected cardiac arrest. *Crit Care.* 2020;24:1–8. doi:10.1186/s13054-019-2683-3
17. Kulstad EB, Sikka R, Sweis RT, Kelley KM, Rzechula KH. ED crowding is associated with an increased frequency of medication errors. *Am J Emerg Med.* 2010;28:304–309. doi:10.1016/j.ajem.2008.12.014
18. Depinet HE, Iyer SB, Hornung R, Timm NL, Byczkowski TL. The effect of emergency department crowding on reassessment of children with critically abnormal vital signs. *Acad Emerg Med.* 2014;21:1116–1120. doi:10.1111/acem.12478
19. Pines JM, Hollander JE. Emergency department crowding is associated with poor care for patients with severe pain. *Ann Emerg Med.* 2008;51:1–5. doi:10.1016/j.annemergmed.2007.07.008
20. Institute for Healthcare Improvement. Patient safety self-assessment tool. Available from: <https://www.ihl.org/resources/Pages/Tools/PatientSafetySelfAssessmentTool.aspx>. Accessed February 12, 2023.
21. Pearce S, Marchand T, Shannon T, Ganshorn H, Lang E. Emergency department crowding: an overview of reviews describing measures causes, and harms. *Intern Emerg Med.* 2023;1:1–22.
22. Derlet RW, Richards JR. Emergency department crowding in Florida, New York, and Texas. *South Med J.* 2002;95:846–849. doi:10.1097/00007611-200295080-00013
23. van der Linden N, van der Linden MC, Richards JR, Derlet RW, Grootendorst DC, van den Brand CL. Effects of emergency department crowding on the delivery of timely care in an inner-city hospital in the Netherlands. *Eur J Emerg Med.* 2016;23:337–343. doi:10.1097/MEJ.0000000000000268
24. Park CW, Ahn JY, Seo KS, et al. Relationship between emergency department crowding and initial management, mortality of severe trauma patients. *J Korean Soc Emerg Med.* 2018;29:624–635.
25. Alemu GH, Negari KG, Rodamo KM, Hirigo AT. Factors associated with the length of stay in emergency departments in Southern-Ethiopia. *BMC Res Notes.* 2019;12:1–5. doi:10.1186/s13104-019-4271-7
26. McKenna P, Heslin SM, Viccellio P, Mallon WK, Hernandez C, Morley EJ. Emergency department and hospital crowding: causes, consequences, and cures. *Clin Exp Emerg Med.* 2019;6:189–195. doi:10.15441/ceem.18.022
27. Erenler AK, Akbulut S, Guzel M, et al. Reasons for crowding in the emergency department: experiences and suggestions of an education and research hospital. *Turk J Emerg Med.* 2014;14:59–63. doi:10.5505/1304.7361.2014.48802
28. Forero R, McCarthy S, Hillman K. Access block and emergency department crowding. *Crit Care.* 2011;15:216. doi:10.1186/cc9998
29. Rosen MA, Goeschel CA, Che XX, et al. Simulation in the executive suite: lessons learned for building patient safety leadership. *Simul Healthc.* 2015;10:372–377. doi:10.1097/SIH.0000000000000122
30. Negarandeh R, Pedram Razi S, Khosravinezhad M. Effect of clinically competent nurses services on safety and patients' satisfaction in an emergency department. *Hayat.* 2013;19:53–64.
31. Babatabar-Darzi H, Jafari-Iraqi I, Mahmoudi H, Ebadi A. Crowding management and patient safety: an application of the stabilization model. *Iran J Nurs Midwifery Res.* 2020;25:382–386. doi:10.4103/ijnmr.IJNMR_254_19
32. Gaieski DF, Agarwal AK, Mikkelsen ME, et al. The impact of ED crowding on early interventions and mortality in patients with severe sepsis. *Am J Emerg Med.* 2017;35:953–960. doi:10.1016/j.ajem.2017.01.061
33. Berg LM, Ehrenberg A, Florin J, Östergren J, Discacciati A, Göransson KE. Associations between crowding and ten-day mortality among patients allocated lower triage acuity levels without need of acute hospital care on departure from the emergency department. *Ann Emerg Med.* 2019;74:345–356. doi:10.1016/j.annemergmed.2019.04.012

Risk Management and Healthcare Policy

Publish your work in this journal

Risk Management and Healthcare Policy is an international, peer-reviewed, open access journal focusing on all aspects of public health, policy, and preventative measures to promote good health and improve morbidity and mortality in the population. The journal welcomes submitted papers covering original research, basic science, clinical & epidemiological studies, reviews and evaluations, guidelines, expert opinion and commentary, case reports and extended reports. The manuscript management system is completely online and includes a very quick and fair peer-review system, which is all easy to use. Visit <http://www.dovepress.com/testimonials.php> to read real quotes from published authors.

Submit your manuscript here: <https://www.dovepress.com/risk-management-and-healthcare-policy-journal>

Dovepress
Taylor & Francis Group