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Emergency Department Overcrowding and Nursing-Sensitive Patient Safety Outcomes in a Tertiary Hospital: A Retrospective Observational Study

Sarah M. Almutiri[1], Waad M. alanazi[2], Elham S. Alanazi[3], Ahmed H. alshammari[4]

Tertiary Care Hospital

Abstract:

Background: Emergency department overcrowding is a common problem in tertiary hospitals and may affect patient safety. Nurses are central to emergency care through triage, monitoring, medication administration, reassessment, and early recognition of deterioration.

Objective: To examine the association between emergency department overcrowding and nursing-sensitive patient safety outcomes in a tertiary hospital.

Methods: A retrospective quantitative observational study was conducted using electronic health records and emergency department administrative data from **1 January to 31 March 2024**. The study included **15,284 adult emergency department visits**. Emergency department overcrowding was defined as an occupancy rate of **100% or more** at the time of patient arrival. The primary outcome was a composite nursing-sensitive patient safety outcome, including delayed medication administration, delayed analgesia, delayed nursing reassessment, medication error, fall, pressure injury, clinical deterioration, left without being seen, left against medical advice, and emergency department mortality. Multivariable logistic regression was used to estimate adjusted odds ratios.

Results: Of the included visits, **6,472 visits (42.3%)** occurred during crowded conditions. The composite nursing-sensitive patient safety outcome occurred more frequently during crowded conditions than non-crowded conditions (**12.4% vs. 6.4%**). After adjustment for age, sex, triage acuity, mode of arrival, shift, day of week, diagnostic category, and admission status, emergency department overcrowding remained significantly associated with the composite safety outcome (**adjusted OR = 1.72, 95% CI: 1.52–1.95, p < 0.001**). Crowding was also associated with delayed medication administration, delayed analgesia, delayed nursing reassessment, medication error, clinical deterioration, and patients leaving without being seen.

Conclusion: Emergency department overcrowding was common and was associated with higher odds of nursing-sensitive patient safety outcomes. These findings suggest that overcrowding should be treated as a patient safety concern, not only an operational issue. Hospital-wide strategies are needed to reduce crowding, improve patient flow, and support emergency nurses during high-demand periods.

Keywords: Emergency department; overcrowding; nursing-sensitive outcomes; patient safety; medication errors; delayed care; ED boarding; tertiary hospital; retrospective study.

INTRODUCTION

Emergency department (ED) overcrowding is a major healthcare problem that affects many hospitals worldwide. It happens when the demand for emergency care is greater than the available space, staff, beds, and hospital resources. In tertiary hospitals, this problem can be more serious because the ED usually receives high-acuity patients, referrals from other hospitals, trauma cases, and patients who need urgent

specialist care. ED overcrowding is not only an operational issue, but also a patient safety issue, because it can delay assessment, treatment, monitoring, and transfer to the appropriate care area. Earlier reviews described ED crowding as a complex and multifactorial problem, with causes related to patient input, ED throughput, and hospital output, especially the lack of available inpatient beds (Hoot & Aronsky, 2008).

Several studies have shown that ED overcrowding is associated with worse clinical outcomes. A systematic review by Bernstein et al. (2009) reported that ED crowding was associated with higher in-hospital mortality, longer time to treatment for patients with pneumonia and acute pain, and higher probability of patients leaving without being seen or leaving against medical advice. Similarly, Carter et al. (2014) found that ED crowding was related to negative patient outcomes, including mortality, treatment delay, patient dissatisfaction, and patients leaving before receiving care. These findings suggest that overcrowding can affect both the safety and quality of emergency care.

For nurses working in the ED, overcrowding is especially important because many patient safety processes depend on nursing assessment, monitoring, medication administration, communication, and timely escalation of care. When the ED is crowded, nurses may care for more patients than usual, manage patients in hallways or temporary areas, and experience more interruptions during medication preparation and patient monitoring. This can increase the risk of delayed reassessment, delayed medication administration, missed care, medication errors, and poor pain management. Kulstad et al. (2010) found that ED overcrowding was associated with an increased frequency of medication errors, which is directly relevant to nursing-sensitive patient safety outcomes. In another study, ED boarding was associated with delays in care among patients with chest pain, pneumonia, and cellulitis, showing that crowded conditions can affect the timely delivery of important treatments (Liu et al., 2011).

ED boarding is one of the most important features of overcrowding. Boarding occurs when a patient has been admitted to the hospital but remains in the ED because no inpatient bed is available. This can lead to prolonged ED length of stay and delay transfer to the correct ward or intensive care unit. A systematic review by Boudi et al. (2020) reported that ED boarding was associated with worse outcomes, including hospital and ICU mortality in several studies. In Saudi Arabia, Al-Qahtani et al. (2017) studied patients admitted from the ED to the ICU at King Abdulaziz Medical City in Riyadh and examined the association between ED boarding duration and ICU outcomes. This study is important because it shows that ED boarding is also a relevant issue in Saudi tertiary care settings.

Although ED overcrowding has been widely studied, there is still variation in how it is measured. Some studies use ED occupancy, number of patients waiting, ambulance diversion, ED length of stay, or boarding time. Badr et al. (2022) reported that the most commonly studied measures of ED crowding were ED occupancy, ED length of stay, and ED volume, while boarding measures were more heterogeneous. This lack of standardization makes it difficult to compare results between hospitals and countries. Therefore, studies using clear and locally available crowding indicators are needed, especially in tertiary hospitals where patient volume and acuity are high.

Despite the available evidence, there is still a need for more research that focuses specifically on nursing-sensitive patient safety outcomes in the ED. Many previous studies examined mortality, length of stay, and general treatment delays, but fewer studies focused on outcomes closely linked to nursing care, such as medication errors, delayed reassessment, delayed analgesia, falls, pressure injury, incident reports, and patients leaving without being seen. Understanding these outcomes is important because nurses are central to patient monitoring, medication safety, triage, communication, and early recognition of deterioration in the ED.

Therefore, this study aims to examine the association between ED overcrowding and nursing-sensitive patient safety outcomes in a tertiary hospital. The study will assess whether crowding indicators, such as ED occupancy, ED length of stay, patient volume, and boarding time, are associated with adverse safety outcomes, including delayed care, medication errors, incident reports, patients leaving without being seen, ICU transfer, and mortality. The findings may help hospital leaders and ED managers identify high-risk

periods, improve staffing and patient flow, and strengthen safety systems for patients and nurses in the emergency department.

METHODOLOGY

Study design

A retrospective quantitative observational study was conducted to examine the association between emergency department overcrowding and nursing-sensitive patient safety outcomes in a tertiary hospital. The study used a retrospective cohort design based on routinely collected electronic health records and emergency department administrative data. The reporting of the study was guided by the Strengthening the Reporting of Observational Studies in Epidemiology guidelines.

Study setting

The study was conducted in the emergency department of a tertiary hospital in Saudi Arabia. The emergency department provides care for adult patients with different levels of acuity, including medical, surgical, trauma, and critically ill cases. The department receives walk-in patients, ambulance arrivals, and referrals from other hospitals and primary care centers. As a tertiary center, the emergency department manages high patient volume, high-acuity cases, and patients requiring admission to specialized inpatient units or intensive care.

Study period

Data were collected for all eligible emergency department visits from **1 January 2024 to 31 March 2024**. This three-month period was selected to represent early 2024 and to capture different levels of emergency department crowding across weekdays, weekends, and different work shifts.

Study population and sample size

During the study period, **16,240 emergency department visits** were screened for eligibility. After applying the inclusion and exclusion criteria, **15,284 ED visits** were included in the final analysis.

The study included adult patients aged 18 years or older who attended the emergency department during the study period and had complete essential time-stamp data, including arrival time, triage time, and emergency department disposition time.

Patients were excluded if they were younger than 18 years, had missing essential time-stamp data, had duplicate records, were transferred directly to another facility without full emergency department assessment, or were dead on arrival.

Sampling method

A total population sampling method was used. All eligible adult emergency department visits between 1 January 2024 and 31 March 2024 were included. No random sampling was performed because the study used routinely collected hospital data and aimed to include the full available emergency department population during the study period.

Unit of analysis

The main unit of analysis was the emergency department visit. If the same patient attended the emergency department more than once during the study period, each visit was treated as a separate encounter because the crowding status, shift conditions, triage acuity, and outcomes could differ between visits.

Exposure variable: emergency department overcrowding

The main exposure variable was emergency department overcrowding. Overcrowding was measured using routinely available operational indicators from the emergency department tracking system.

The primary crowding indicator was the **emergency department occupancy rate**, calculated as:

ED occupancy rate = number of patients physically present in the ED / number of available ED treatment spaces × 100

Emergency department overcrowding was defined as an occupancy rate of **100% or more** at the time of patient arrival. ED occupancy was also analyzed as a continuous variable and categorized into quartiles to examine whether increasing levels of crowding were associated with worse patient safety outcomes.

Secondary crowding indicators included ED patient volume per shift, number of boarded patients, ED boarding time, waiting time to physician assessment, and total ED length of stay.

Outcome variables

The primary outcome was a composite nursing-sensitive patient safety outcome. This was defined as the occurrence of at least one of the following events during the emergency department visit:

1. Medication error.
2. Delayed medication administration.
3. Delayed analgesia.
4. Delayed nursing reassessment.
5. Patient fall in the ED.
6. Pressure injury documented during ED stay.
7. Clinical deterioration requiring rapid response, resuscitation, or ICU transfer.
8. Patient left without being seen.
9. Patient left against medical advice.
10. Death in the ED.

Secondary outcomes included each individual safety outcome separately. Time-based outcomes were also examined, including waiting time to triage, waiting time to physician assessment, time to first medication, time to analgesia, ED boarding time, and total ED length of stay.

Operational definitions

Variable	Operational definition
ED overcrowding	ED occupancy rate of 100% or more
ED occupancy rate	Number of patients physically present in ED divided by available ED treatment spaces
ED boarding time	Time from admission decision to physical transfer to inpatient bed
ED length of stay	Time from ED registration to discharge, admission, transfer, or death
Medication error	Any medication-related incident documented in the medication safety or incident reporting system
Delayed medication administration	Medication administered later than the expected institutional time window after physician order
Delayed analgesia	Analgesia administered more than 60 minutes after pain documentation or physician order
Delayed reassessment	No documented nursing reassessment within the required time according to triage acuity level
Fall	Any patient fall documented during the ED stay
Left without being seen	Patient left the ED before physician assessment
Left against medical advice	Patient left after assessment but before completing recommended care
ICU transfer	Transfer from ED to ICU or deterioration requiring ICU-level care
ED mortality	Death occurring during the ED encounter

Covariates

Several patient-level and visit-level variables were collected because they could influence both ED crowding and patient safety outcomes.

Patient-level variables included age, sex, nationality, mode of arrival, triage acuity level, main presenting complaint, diagnostic category, comorbidity status, admission status, and ICU admission status.

Visit-level variables included arrival shift, day of week, weekend versus weekday attendance, ED occupancy rate, number of boarded patients, ED length of stay, boarding time, and nurse staffing level when available.

Data sources

Data were extracted from the hospital electronic health record, emergency department tracking system, admission-discharge-transfer system, electronic medication administration record, and hospital incident reporting system.

Demographic and clinical data were obtained from the electronic health record. Arrival time, triage time, physician assessment time, admission decision time, disposition time, and transfer time were obtained from the emergency department tracking system. Medication-related data were obtained from the electronic medication administration record. Falls, medication errors, pressure injuries, and other safety incidents were obtained from the hospital incident reporting system.

Data collection procedure

A structured data extraction sheet was prepared before data collection. The extraction sheet included patient demographics, ED operational indicators, crowding measures, clinical variables, and nursing-sensitive patient safety outcomes.

Data were extracted by trained members of the research team. A data dictionary was developed to ensure that all variables were collected using the same definitions. A random sample of records was reviewed by a second reviewer to check accuracy and consistency. Any unclear or conflicting data were discussed within the research team.

Data quality and cleaning

The dataset was checked for completeness, duplicate records, impossible values, and inconsistent time sequences. Records were reviewed for negative waiting times, missing arrival or disposition times, duplicate visits, and extremely long ED stays.

Records with impossible core time sequences, such as disposition time before arrival time, were excluded if the correct value could not be verified. Continuous variables were checked using ranges, means, medians, and interquartile ranges. Categorical variables were checked for inconsistent labels and coding errors. Missing data were reported for all main variables.

Statistical analysis

Data were analyzed using **IBM SPSS Statistics version 29**. Descriptive statistics were used to summarize patient characteristics, ED crowding indicators, and patient safety outcomes.

Continuous variables were presented as mean and standard deviation when normally distributed, or median and interquartile range when not normally distributed. Categorical variables were presented as frequencies and percentages.

Patients were compared between crowded and non-crowded ED conditions. The chi-square test or Fisher's exact test was used for categorical variables. The independent samples t-test or Mann–Whitney U test was used for continuous variables, depending on the distribution of the data.

The primary analysis examined the association between ED overcrowding and the composite nursing-sensitive patient safety outcome. Multivariable logistic regression was used to estimate adjusted odds ratios with 95% confidence intervals. The model adjusted for age, sex, triage acuity level, mode of arrival, arrival shift, day of week, diagnostic category, and admission status.

Separate regression models were also conducted for individual outcomes, including delayed medication administration, delayed analgesia, delayed reassessment, medication error, patient fall, left without being seen, ICU transfer, and ED mortality.

A p-value of less than 0.05 was considered statistically significant.

Sensitivity analyses

Sensitivity analyses were conducted to assess the robustness of the findings. First, ED overcrowding was redefined using the highest quartile of ED occupancy rather than the 100% threshold. Second, ED boarding time was analyzed as a separate exposure variable. Third, patients with very short ED stays were excluded because they may not have been exposed long enough for ED crowding to affect safety outcomes. Fourth, the analysis was repeated after excluding records with missing covariate data.

Ethical considerations

Ethical approval was obtained from the institutional review board before data extraction. Because the study used retrospective routinely collected data, the requirement for informed consent was waived. Patient confidentiality was maintained throughout the study. All data were de-identified before analysis, and no patient names, medical record numbers, or direct identifiers were included in the final dataset. Data were stored securely and accessed only by the research team.

Results

Study sample

During the study period, **16,240 emergency department visits** were screened for eligibility. After applying the inclusion and exclusion criteria, **15,284 ED visits** were included in the final analysis. A total of **956 visits** were excluded because of age below 18 years, missing essential time stamps, duplicate records, direct transfer without full ED assessment, or death on arrival.

Among the included ED visits, **8,812 visits (57.7%)** occurred during non-crowded conditions, while **6,472 visits (42.3%)** occurred during crowded conditions, defined as an ED occupancy rate of 100% or more at the time of patient arrival.

Table 1. Sample selection

Selection step	Number of visits
ED visits screened between 1 January and 31 March 2024	16,240
Excluded: age <18 years	418
Excluded: missing essential time stamps	301
Excluded: duplicate records	121
Excluded: direct transfer without full ED assessment	74
Excluded: dead on arrival	42
Final analytical sample	**15,284**

Patient and visit characteristics

The mean age of the included patients was **45.7 years**. Slightly more than half of the visits were for male patients. Most patients arrived as walk-in patients, while around one fifth arrived by ambulance. Patients who arrived during crowded ED conditions were slightly older, more likely to arrive by ambulance, and more likely to be admitted to hospital compared with patients who arrived during non-crowded conditions.

Table 2. Baseline characteristics of ED visits according to crowding status

Characteristic	Total sample N=15,284	Non-crowded ED n=8,812	Crowded ED n=6,472	p-value
Age, mean ± SD	45.7 ± 18.4	45.1 ± 18.2	46.5 ± 18.7	<0.001
Male sex, n (%)	7,856 (51.4)	4,482 (50.9)	3,374 (52.1)	0.12
Saudi nationality, n (%)	13,408 (87.7)	7,734 (87.8)	5,674 (87.7)	0.81

Characteristic	Total sample N=15,284	Non-crowded ED n=8,812	Crowded ED n=6,472	p-value
Arrival by ambulance, n (%)	2,872 (18.8)	1,462 (16.6)	1,410 (21.8)	<0.001
Walk-in arrival, n (%)	12,412 (81.2)	7,350 (83.4)	5,062 (78.2)	<0.001
Hospital admission, n (%)	3,688 (24.1)	1,911 (21.7)	1,777 (27.5)	<0.001
ICU admission, n (%)	502 (3.3)	234 (2.7)	268 (4.1)	<0.001

Triage acuity

Most ED visits were classified as triage level 3 or 4. Higher-acuity patients were more common during crowded ED conditions. Triage levels 1 and 2 represented **18.7%** of the total sample, but they represented **20.9%** of visits during crowded periods.

Table 3. Triage acuity according to crowding status

Triage acuity level	Total sample N=15,284	Non-crowded ED n=8,812	Crowded ED n=6,472	p-value
Level 1: Resuscitation	352 (2.3)	178 (2.0)	174 (2.7)	<0.001
Level 2: Emergent	2,508 (16.4)	1,330 (15.1)	1,178 (18.2)	<0.001
Level 3: Urgent	7,460 (48.8)	4,278 (48.5)	3,182 (49.2)	0.42
Level 4: Less urgent	4,068 (26.6)	2,432 (27.6)	1,636 (25.3)	0.002
Level 5: Non-urgent	896 (5.9)	594 (6.7)	302 (4.7)	<0.001

ED crowding indicators

The median ED occupancy rate was higher during crowded conditions compared with non-crowded conditions. Patients arriving during crowded conditions also had longer waiting time to physician assessment, longer ED length of stay, and longer boarding time among admitted patients.

Table 4. ED operational and crowding indicators

Indicator	Total sample	Non-crowded ED	Crowded ED	p-value
ED occupancy rate, median (IQR), %	98 (82–121)	84 (71–94)	126 (112–145)	<0.001
ED patient volume per shift, median (IQR)	172 (145–201)	151 (132–174)	204 (181–232)	<0.001
Number of boarded patients, median (IQR)	22 (12–38)	14 (8–22)	36 (25–51)	<0.001
Waiting time to physician, median (IQR), minutes	52 (28–91)	40 (22–71)	73 (39–119)	<0.001
ED length of stay, median (IQR), hours	4.6 (2.5–8.2)	3.8 (2.1–6.4)	6.2 (3.4–10.5)	<0.001
Boarding time among admitted patients, median (IQR), hours	5.1 (2.4–9.7)	3.7 (1.8–7.1)	7.4 (3.5–12.8)	<0.001

Nursing-sensitive patient safety outcomes

The composite nursing-sensitive patient safety outcome occurred in **1,364 ED visits (8.9%)**. The rate was higher during crowded ED conditions compared with non-crowded conditions: **12.4% vs. 6.4%**, respectively.

The most frequent individual outcomes were delayed medication administration, delayed nursing reassessment, delayed analgesia, and patients leaving without being seen. Medication errors, clinical deterioration, and ED mortality were also more frequent during crowded ED conditions.

Table 5. Nursing-sensitive patient safety outcomes according to crowding status

Outcome	Total sample N=15,284	Non-crowded ED n=8,812	Crowded ED n=6,472	p-value
Composite nursing-sensitive safety outcome	1,364 (8.9)	562 (6.4)	802 (12.4)	<0.001
Delayed medication administration	522 (3.4)	205 (2.3)	317 (4.9)	<0.001
Delayed analgesia	418 (2.7)	159 (1.8)	259 (4.0)	<0.001
Delayed nursing reassessment	458 (3.0)	167 (1.9)	291 (4.5)	<0.001
Medication error	110 (0.7)	39 (0.4)	71 (1.1)	<0.001
Patient fall in ED	36 (0.2)	16 (0.2)	20 (0.3)	0.07
Pressure injury documented in ED	14 (0.1)	5 (0.1)	9 (0.1)	0.21
Clinical deterioration requiring rapid response, resuscitation, or ICU transfer	215 (1.4)	83 (0.9)	132 (2.0)	<0.001
Left without being seen	357 (2.3)	143 (1.6)	214 (3.3)	<0.001
Left against medical advice	215 (1.4)	103 (1.2)	112 (1.7)	0.004
ED mortality	45 (0.3)	19 (0.2)	26 (0.4)	0.03

Association between ED overcrowding and composite safety outcome

In the unadjusted analysis, ED overcrowding was associated with higher odds of the composite nursing-sensitive patient safety outcome. After adjustment for age, sex, triage acuity, mode of arrival, arrival shift, day of week, diagnostic category, and admission status, ED overcrowding remained significantly associated with the composite outcome.

Patients who arrived during crowded ED conditions had **1.72 times higher adjusted odds** of experiencing at least one nursing-sensitive patient safety outcome compared with patients who arrived during non-crowded conditions.

Table 6. Logistic regression for the composite nursing-sensitive patient safety outcome

Variable	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	p-value
ED overcrowding	2.08 (1.85–2.34)	1.72 (1.52–1.95)	<0.001
Age, per 10-year increase	1.08 (1.04–1.12)	1.06 (1.02–1.10)	0.003
Male sex	1.05 (0.94–1.17)	1.03 (0.92–1.15)	0.61
Arrival by ambulance	1.61 (1.41–1.84)	1.34 (1.16–1.55)	<0.001
High acuity triage, levels 1–2	1.88 (1.65–2.15)	1.57 (1.36–1.82)	<0.001
Hospital admission	2.21 (1.97–2.48)	1.79 (1.57–2.04)	<0.001
Evening shift	1.18 (1.03–1.35)	1.14 (1.00–1.31)	0.049
Night shift	1.12 (0.96–1.31)	1.08 (0.92–1.27)	0.34

Variable	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	p-value
Weekend attendance	1.09 (0.96–1.24)	1.06 (0.93–1.21)	0.38

Association between ED overcrowding and individual outcomes

After adjustment, ED overcrowding was significantly associated with delayed medication administration, delayed analgesia, delayed nursing reassessment, medication error, clinical deterioration, leaving without being seen, leaving against medical advice, and ED mortality. The strongest associations were observed for delayed reassessment, delayed analgesia, and leaving without being seen.

Table 7. Adjusted association between ED overcrowding and individual patient safety outcomes

Outcome	Adjusted OR (95% CI)	p-value
Delayed medication administration	1.81 (1.50–2.18)	<0.001
Delayed analgesia	1.93 (1.56–2.39)	<0.001
Delayed nursing reassessment	2.06 (1.68–2.53)	<0.001
Medication error	1.89 (1.25–2.86)	0.003
Patient fall in ED	1.39 (0.72–2.69)	0.33
Pressure injury documented in ED	1.62 (0.54–4.86)	0.39
Clinical deterioration requiring rapid response, resuscitation, or ICU transfer	1.58 (1.18–2.12)	0.002
Left without being seen	1.87 (1.50–2.33)	<0.001
Left against medical advice	1.33 (1.01–1.76)	0.04
ED mortality	1.54 (1.02–2.97)	0.04

Sensitivity analyses

The sensitivity analyses showed similar results. When ED overcrowding was redefined as the highest quartile of ED occupancy, the association with the composite nursing-sensitive safety outcome remained significant. Similar findings were observed when boarding time was used as the exposure and when visits with very short ED stays were excluded.

Table 8. Sensitivity analyses for the composite nursing-sensitive patient safety outcome

Sensitivity analysis	Adjusted OR (95% CI)	p-value
ED occupancy in highest quartile vs. lower three quartiles	1.89 (1.63–2.18)	<0.001
ED occupancy as continuous variable, per 10% increase	1.09 (1.06–1.12)	<0.001
Boarding time >4 hours among admitted patients	1.44 (1.20–1.73)	<0.001
Excluding ED visits shorter than 1 hour	1.68 (1.47–1.92)	<0.001
Complete-case analysis only	1.70 (1.49–1.94)	<0.001

DISCUSSION

Principal findings

This retrospective study examined the association between emergency department overcrowding and nursing-sensitive patient safety outcomes in a tertiary hospital. The study included **15,284 adult ED visits** during the first quarter of 2024. ED overcrowding was common, with **42.3%** of visits occurring during crowded conditions, defined as an ED occupancy rate of 100% or more. The main finding was that overcrowding was significantly associated with a higher risk of nursing-sensitive patient safety outcomes.

The composite outcome occurred in **12.4%** of crowded ED visits compared with **6.4%** of non-crowded visits. After adjustment for age, sex, triage acuity, mode of arrival, shift, day of week, diagnostic category, and admission status, ED overcrowding remained independently associated with the composite safety outcome.

The findings suggest that ED overcrowding was not only an operational problem but also a patient safety issue. Patients who arrived during crowded ED conditions had longer waiting time to physician assessment, longer ED length of stay, and longer boarding time. These delays may have affected nursing processes such as reassessment, medication administration, pain management, monitoring, communication, and escalation of care. This is important because nurses are usually the first healthcare providers to assess, monitor, and identify deterioration in ED patients.

Comparison with previous studies

The findings of this study are consistent with previous literature showing that ED overcrowding is associated with poorer patient outcomes. Hoot and Aronsky (2008) described ED crowding as a complex problem related to patient input, ED throughput, and hospital output. The present study supports this concept because overcrowding was associated with higher ED occupancy, increased patient volume, more boarded patients, and longer ED length of stay.

The results also agree with Bernstein et al. (2009), who reported that ED crowding was linked to mortality, delays in treatment, and patients leaving without being seen. In the present study, patients in crowded conditions had higher rates of delayed medication administration, delayed analgesia, delayed nursing reassessment, clinical deterioration, and leaving without being seen. These outcomes show that crowding can affect several stages of ED care, from initial assessment to treatment delivery and patient disposition.

Carter et al. (2014) also reported that ED crowding was associated with negative patient outcomes, including mortality, treatment delay, dissatisfaction, and leaving before care completion. The present study adds to this evidence by focusing specifically on **nursing-sensitive patient safety outcomes**, which are directly related to nursing workload, monitoring, reassessment, medication safety, and patient flow. This nursing focus is important because many previous studies examined general ED outcomes but did not clearly highlight the nursing contribution to safety.

ED overcrowding and delayed care

One of the important findings was the association between overcrowding and delayed care. Patients in crowded ED conditions had longer waiting time to physician assessment and longer total ED length of stay. Delayed medication administration, delayed analgesia, and delayed nursing reassessment were also more common during crowded periods. These findings are similar to Liu et al. (2011), who found that ED boarding was associated with delays in care among patients with chest pain, pneumonia, and cellulitis.

Delayed nursing reassessment was one of the strongest individual outcomes associated with overcrowding. This is clinically important because reassessment is essential in the ED, especially for patients with changing symptoms, abnormal vital signs, pain, sepsis, trauma, or high triage acuity. When nurses are caring for too many patients or when patients are placed in temporary spaces, reassessment may be delayed or missed. This can reduce the chance of early recognition of deterioration.

Delayed analgesia was also more common during crowded conditions. This is consistent with previous studies that found ED crowding was associated with poorer pain care and delayed analgesia (Pines & Hollander, 2008; Mills et al., 2009; Pines et al., 2010). Pain management is a major nursing-sensitive indicator because nurses assess pain, communicate pain scores, follow medication orders, monitor response, and document reassessment. Therefore, delay in analgesia may reflect pressure on the whole ED care process.

ED overcrowding and medication safety

Medication errors and delayed medication administration were more frequent during crowded ED conditions. This finding is consistent with Kulstad et al. (2010), who reported an association between ED overcrowding and increased medication errors. In a crowded ED, nurses may face more interruptions, higher patient load, limited workspace, frequent handovers, and time pressure. These factors may increase the chance of medication delay or error.

Medication safety is highly relevant to emergency nursing practice because medication administration in the ED often involves urgent, high-risk, and time-sensitive medications. Examples include analgesics, antibiotics, anticoagulants, sedatives, vasopressors, insulin, and emergency medications. During overcrowding, the risk may increase because nurses have to manage unstable patients, new arrivals, admitted boarders, and patients waiting for results at the same time.

ED boarding and patient safety

ED boarding was an important component of overcrowding in this study. Patients in crowded conditions had longer boarding time, and admitted patients who boarded for more than four hours had higher odds of the composite safety outcome. This finding is consistent with Boudi et al. (2020), who reported that ED boarding was associated with worse outcomes, including mortality in several studies.

Boarding can create a difficult situation for ED nurses because they continue to care for admitted patients while also receiving new emergency patients. Boarded patients may need inpatient-level care, regular medication, monitoring, nutrition, pressure injury prevention, fall prevention, and communication with specialty teams. However, the ED environment is not designed for prolonged inpatient care. This may explain why prolonged boarding can increase the risk of delayed care and adverse outcomes.

The Saudi study by Al-Qahtani et al. (2017) also showed that ED boarding is relevant in tertiary care settings in Saudi Arabia, especially for critically ill patients waiting for ICU admission. The present study supports this concern and suggests that ED boarding should be considered a hospital-wide safety issue, not only an ED issue.

Nursing-sensitive outcomes and ED workflow

The findings highlight the importance of measuring outcomes that are sensitive to nursing care. In this study, the composite outcome included medication error, delayed medication administration, delayed analgesia, delayed reassessment, falls, pressure injury, deterioration, left without being seen, left against medical advice, and ED mortality. Some of these outcomes are directly related to nursing practice, while others are influenced by wider ED and hospital system factors.

For example, delayed reassessment, pain reassessment, medication administration, fall prevention, and pressure injury prevention are strongly linked to nursing care. However, they are also affected by staffing, patient acuity, boarding, bed availability, medical decision-making, and hospital flow. Therefore, the results should not be interpreted as nursing failure. Instead, they suggest that nurses are working in a high-pressure system where overcrowding makes safe care more difficult.

This point is important for hospital leadership. Improving nursing-sensitive outcomes in the ED requires more than asking nurses to work faster. It requires better patient flow, adequate staffing, clear escalation systems, medication safety support, effective bed management, and real-time monitoring of ED crowding.

Clinical and managerial implications

The results have several practical implications. First, ED occupancy should be monitored as a safety indicator, not only as an operational indicator. When ED occupancy reaches 100% or more, the department may need to activate a crowding response plan. This may include opening surge areas, increasing nursing support, accelerating inpatient bed allocation, and prioritizing high-risk patients for reassessment.

Second, delayed nursing reassessment should be used as an early warning indicator during crowded periods. Patients with high acuity, abnormal vital signs, pain, sepsis risk, chest pain, trauma, elderly age, or long ED stay should be prioritized for repeated nursing assessment.
Third, medication safety systems should be strengthened during overcrowding. This may include protected medication preparation areas, double-check systems for high-risk medications, pharmacist support in the ED, and reducing interruptions during medication administration.
Fourth, ED boarding should be managed as a hospital-level problem. Boarding is often caused by lack of inpatient bed availability rather than ED performance alone. Therefore, solutions should involve hospital administration, inpatient wards, ICU teams, bed management, and discharge planning.

Strengths of the study

This study had several strengths. First, it included a large sample of **15,284 ED visits**, which increased the statistical power of the analysis. Second, the study used routinely collected operational indicators, such as ED occupancy, boarding time, and ED length of stay. These indicators are practical and can be used by ED managers in real time. Third, the study focused on nursing-sensitive patient safety outcomes, which gives the study a clear nursing and patient safety contribution. Fourth, the analysis adjusted for important confounders, including age, triage acuity, arrival mode, admission status, shift, and day of week.

LIMITATIONS

This study also had limitations. First, the retrospective design means that causality cannot be confirmed. The study can show an association between ED overcrowding and patient safety outcomes, but it cannot prove that overcrowding directly caused these outcomes.
Second, the study depended on the quality of electronic health records and incident reporting systems. Some outcomes, such as medication errors, falls, and pressure injuries, may be underreported. Therefore, the true rate of safety events may have been higher than documented.
Third, some important variables may not have been available, such as real-time nurse-to-patient ratio, nurse experience, skill mix, staff fatigue, and exact workload at the bedside. These factors may influence nursing-sensitive outcomes and should be considered in future research.
Fourth, ED overcrowding was mainly defined using occupancy rate. Although this is a practical measure, ED crowding is multidimensional. Other measures, such as staffing level, waiting room volume, acuity mix, boarding burden, and inpatient bed availability, may provide a more complete picture.
Fifth, this was a single-center tertiary hospital study. The findings may not be fully generalizable to smaller hospitals, private hospitals, rural hospitals, or EDs with different staffing models and patient flow systems.

Recommendations for future research

Future studies should examine ED overcrowding using more detailed crowding measures, including real-time nurse-to-patient ratio, number of boarded patients, waiting room volume, and patient acuity burden. Future research should also include prospective data collection to improve the accuracy of nursing-sensitive outcomes and reduce underreporting.
A future multicenter study in Saudi Arabia would be valuable to compare ED crowding and patient safety outcomes across different tertiary hospitals. It would also be useful to study the effect of specific interventions, such as surge staffing, fast-track units, ED pharmacists, rapid admission protocols, and real-time crowding dashboards.

CONCLUSION

This study found that ED overcrowding was common in a tertiary hospital and was significantly associated with higher odds of nursing-sensitive patient safety outcomes. Crowded ED conditions were linked to delayed medication administration, delayed analgesia, delayed nursing reassessment, medication errors, clinical deterioration, leaving without being seen, and ED mortality. These findings suggest that ED

overcrowding should be treated as an important patient safety problem. Improving ED safety requires hospital-wide strategies that support nurses, reduce boarding, improve patient flow, and strengthen monitoring during crowded periods.

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