Emergency Department Overcrowding: Causes, Consequences, and Strategies for Saudi Arabia

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ABSTRACT

To review the causes, consequences, measurement tools, and interventions for emergency department (ED) overcrowding, with a focus on Saudi Arabia. Narrative review of existing literature and healthcare reforms. Emergency departments worldwide, with emphasis on Saudi Arabia's healthcare system. Analysis of factors influencing ED input, throughput, and output; evaluation of impacts on patients, staff, and health systems; and assessment of interventions and emerging approaches. ED overcrowding stems from pressures at multiple stages of patient flow. Input factors include rising demand, aging populations, chronic disease, and non-urgent visits. Within the ED, throughput challenges such as diagnostic delays, staffing shortages, and prolonged consultations extend patient stays. Output failure, especially access block and inpatient boarding, remains the leading driver of crowding. These conditions delay time-sensitive care, worsen clinical outcomes, and increase rates of patients leaving without being seen. Staff are exposed to higher levels of stress, burnout, and workplace violence, while healthcare systems face greater costs, inefficient resource utilization, and erosion of public trust. Interventions include ED-based measures such as fast-track units, provider-in-triage, and point-of-care testing, as well as broader reforms like discharge lounges, admission smoothing, capacity protocols, and digital health adoption. Emerging solutions, including predictive analytics and telemedicine, show additional promise. ED overcrowding is multifactorial, with output failure as the critical driver. In Saudi Arabia, non-urgent ED use and prolonged ICU boarding are pressing issues. Vision 2030 reforms provide an opportunity to implement evidence-based strategies, strengthen primary care, and achieve sustainable solutions to improve patient outcomes.

Keywords: Emergency Service; Hospital; Crowding; Patient Flow; Bed Occupancy; Length of Stay; Saudi Arabia

INTRODUCTION

Emergency department overcrowding has become one of the most visible markers of strain in healthcare systems worldwide. It occurs when demand for services exceeds available capacity, resulting in delayed, unsafe, or compromised care[1]. Although the ED is where the problem manifests, crowding reflects broader system dysfunction, particularly bottlenecks in patient flow between the ED and inpatient wards[2-4].

In high-income countries, ED visits have grown steadily. In the United States, more than 130 million visits occur annually, with over 10% requiring admission[5]. Across Europe and Asia, rising demand and constrained inpatient capacity have produced similar challenges[6,7]. In Saudi Arabia, the issue is compounded by high rates of non-urgent visits, gaps in PHC utilization, and cultural preferences for hospital-based care[8-10]. Limited inpatient and ICU capacity further prolongs ED boarding, with direct links. Recent studies confirm this trend: in Al-Qassim, more than half of ED visits were low-acuity[11], while in Al Madina, urgent care centers have been shown to successfully divert non-urgent cases[12]. A national review also emphasized that PHC underuse and uneven distribution of urgent care remain central challenges[13].

The consequences of crowding are severe. Patients face delayed treatment for time-sensitive conditions such as sepsis, myocardial infarction, and stroke, leading to increased morbidity and mortality[14-16]. Rates of LWBS rise, while staff experience burnout and higher risk of violence. At the system level, importantly, inefficiency translates into longer admissions, higher costs, and diminished trust in healthcare[17-19].

To better understand and address this issue, researchers and policymakers rely on the input–throughput–output model[1,3,4]. This framework has guided both measurement tools and interventions, from triage redesign and diagnostic innovation to hospital-wide reforms targeting inpatient flow[20-23].

This review synthesizes international and regional literature on the causes, metrics, consequences, and strategies for ED overcrowding, with particular emphasis on the Saudi context. It also outlines how reforms under Vision 2030 could be leveraged to create sustainable solutions.

LITERATURE REVIEW

Emergency department (ED) overcrowding is a complex and global challenge that threatens patient safety and health system performance[1]. The input–throughput–output model remains the most widely used framework to describe this phenomenon[2-4]. Input refers to patient arrivals and overall demand, throughput covers the internal processes of the ED, and output relates to the ability to transfer patients to inpatient wards. Among these, output constraints—particularly boarding—are consistently recognized as the most significant driver of crowding[5,7].

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Causes of ED Overcrowding

Input factors

The volume and profile of patients presenting to EDs are major contributors to crowding. Global demand has risen due to population growth, aging demographics, and the increasing prevalence of chronic diseases.6 Elderly patients often require more investigations and longer stays, which adds to congestion. In Saudi Arabia, evidence shows that a large proportion of visits are non-urgent and could be managed in primary healthcare (PHC) settings[8,10]. This reflects limited PHC access, cultural expectations of rapid care, and the perception that hospital-based services are superior.9 This aligns with findings from Jeddah, where urgent care initiatives reduced inappropriate ED use[24].

Epidemics also magnify input pressures. Influenza surges and COVID-19 peaks have produced sharp rises in attendances, often overwhelming existing capacity[25,26]. Ambulance inflows contribute significantly, particularly in large trauma centers[27]. Repeat attendances within 72 hours, usually related to incomplete discharge planning or lack of follow-up, further add to demand[28]. Similar findings were reported in Najran, where diagnostic delays and staffing shortages were shown to prolong LOS[29].

Throughput factors

Throughput refers to internal ED processes. Inefficient triage remains a recognized bottleneck. Conventional systems delay physician input, while alternatives such as provider-in-triage (PIT) and triage liaison physician (TLP) have been shown to shorten waiting times and reduce left-without-being-seen (LWBS) rates[30-33].

Diagnostic delays are another key cause. Laboratory and imaging turnaround times directly influence length of stay[34]. The use of point-of-care testing (POCT) shortens decision-making by up to an hour per patient[35]. Dedicated imaging slots during evenings have also improved patient flow[36].

Staffing issues play an important role. Shortages of emergency physicians and nurses, combined with burnout and turnover, slow down throughput[37]. Delays in inpatient specialty consultations, especially in tertiary centers, extend ED stays[38].

Output factors

The inability to move admitted patients into hospital wards—known as boarding—is the dominant cause of crowding[2-4]. Boarding prevents new patients from being accommodated, increases LOS, and worsens outcomes[39,40].

Output bottlenecks include:

- High inpatient occupancy, often above 90%, which leaves no flexibility for admissions[41].
- Delayed inpatient discharges, where administrative tasks or social arrangements slow bed turnover[42].
- Elective admissions clustered on weekdays, which create bed shortages[43].
- Limited ICU and step-down capacity, leading to critically ill patients being held in EDs—an issue especially relevant in Saudi hospitals.39 Saudi studies now document the impact of boarding more directly: prolonged ED stays increased mortality in Riyadh[44]. and Abha[45], while crowding was linked to higher adverse event rates in tertiary hospitals[46].

Metrics of ED Crowding

Crowding is difficult to compare across settings because no universal definition exists[47]. Measures fall into three categories:

1. Time-based metrics such as ED LOS, door-to-doctor time, and time to disposition[36]. The four-hour rule in the UK and Australia improved accountability but has been criticized for creating unintended effects[48].
2. Census/occupancy measures including ED occupancy ratios and the number of boarders. These are easy to track and strongly linked with outcomes[49]. Safe occupancy thresholds are estimated around 85–90%[50,51].
3. Composite indices like the National ED Overcrowding Score (NEDOCS) and Emergency Department Work Index (EDWIN). NEDOCS correlates with LWBS, while EDWIN emphasizes workload[20,22,23]. The SONET score has also shown promise in large centers[21].

Most experts recommend a dashboard approach, combining operational and patient-centered measures. This should include occupancy, LOS, boarding, LWBS, and one composite score for situational awareness[52].

Consequences of Overcrowding

The harms of ED crowding are clear and well documented: Patient outcomes. Delays in sepsis management, myocardial infarction reperfusion, and stroke thrombolysis increase mortality[14-16]. Importantly, boarding is associated with higher in-hospital mortality and adverse events[53]. Crowding also contributes to delays in analgesia, missed medications, and prolonged suffering[33].

Behavioral consequences: LWBS rates increase under crowding, sometimes exceeding 10% in peak periods. These patients often represent with worsened conditions, increasing the burden on hospitals[19].

Staff outcomes: Overcrowding heightens stress, fuels burnout, and increases workplace violence, which erodes morale and worsens retention[18].

System-level outcomes: Hospitals face higher costs due to longer admissions, inefficient resource use, and downstream complications[17]. Public trust is also undermined when EDs are perceived as unsafe or inequitable.

Interventions and Strategies

ED-focused interventions

Frontline solutions target throughput and timeliness:

- PIT and TLP models shorten door-to-doctor times and reduce LWBS[30-33].
- Fast-track and observation units manage low-acuity and short-stay patients outside core ED spaces[54].
- POCT and clinical pathways for sepsis, chest pain, and stroke expedite care[14,35].
- Lean redesigns streamline workflow and reduce duplication[10].

Hospital and system-wide reforms

Larger impacts come from whole-hospital strategies:

- Full Capacity Protocol (FCP): redistributes admitted patients to inpatient surge areas with safeguards, reducing ED boarding[14,15,30,52,53].
- Discharge lounges and early discharges increase bed availability[42].
- Smoothing elective admissions prevents weekday peaks[14,33,53].
- Real-time bed management uses dashboards and capacity centers to coordinate hospital flow[18,19].

Emerging innovations

Recent studies highlight predictive analytics and simulation models that forecast surges and optimize staffing[19]. Machine learning has predicted demand hours ahead with high accuracy[54]. Telemedicine platforms, including Saudi Arabia's Seha app, help redirect non-urgent cases and support follow-up[10,18,19].

Regional Insights: Saudi Arabia and the Gulf

Regional studies emphasize unique challenges. In Saudi Arabia, non-urgent ED visits remain common, linked to PHC gaps and cultural preferences for hospital-based care[8-10]. ICU boarding is another critical issue, with longer delays directly associated with poorer outcomes[55].

Policy initiatives under Vision 2030 aim to strengthen PHC, expand digital health, and modernize hospital operations. Integrating evidence-based solutions—such as FCP, discharge protocols, urgent care integration, and ICU surge capacity—into these reforms offers Saudi Arabia a chance to reduce crowding sustainably and serve as a model in the region.

DISCUSSION

Emergency department overcrowding is no longer seen as a challenge limited to emergency medicine. It is increasingly recognized as a failure of patient flow across the entire health system[1,3,4]. The evidence reviewed here demonstrates that although input and throughput issues play roles, output constraints—especially inpatient boarding—remain the dominant driver[39-41]. This perspective shifts the focus from ED-based solutions toward hospital- and system-wide reforms.

Integrating Evidence Across Domains

Crowding arises from multiple points of stress. Input-related interventions, such as redirecting low-acuity patients to PHC or urgent care, can reduce some pressure but rarely resolve congestion alone[8-10]. Throughput changes, including provider-in-triage, team triage, and point-of-care diagnostics, improve timeliness but are easily offset if patients cannot be moved out of the ED[30-38].

The strongest evidence indicates that output solutions are the most impactful. Studies consistently show that prolonged boarding, delayed discharges, and high occupancy correlate with worse outcomes[39-43,55]. This means sustainable relief from crowding requires action beyond the ED—through inpatient flow reform, critical care surge planning, and capacity management at the hospital level[14,15,30,52,53].

Measurement Challenges

Crowding is difficult to quantify. Simple indicators such as ED LOS and occupancy ratios are reproducible, but they provide only a partial view[48,49,56]. Composite scores like NEDOCS, EDWIN, and SONET add nuance but vary in their validation[20-23].

The consensus in recent reviews is that no single measure is sufficient. Instead, a dashboard approach is recommended, combining operational and clinical metrics. For Saudi hospitals, this could include occupancy, median boarding time, LOS by disposition, and LWBS, alongside a composite score[52]. Such dashboards would allow for benchmarking across tertiary, MOH, and military hospitals, aligning with Vision 2030's emphasis on accountability and transparency.

Why Urgency is Justified

The consequences of crowding make it a high-priority issue. Multiple studies have linked for example, delays in antibiotics for sepsis, reperfusion in myocardial infarction, and thrombolysis in stroke with higher mortality[14-16]. Boarding has been directly associated with increased in-hospital deaths in systematic reviews[53].

Crowding also drives behavioral consequences. LWBS rates rise significantly during crowded conditions, creating a hidden burden when patients return with more advanced illness[19]. For staff, working in overcrowded conditions increases burnout and workplace violence, fueling turnover and worsening shortages[18]. For systems, inefficiency translates into prolonged admissions, higher costs, and lower patient trust[17].

In Saudi Arabia, the evidence is especially urgent. Studies show that ICU boarding times are longer and more strongly associated with adverse outcomes compared to international reports[55]. Combined with high non-urgent demand and limited PHC uptake, this creates a dual challenge that must be addressed at the system level.

Policy and Operational Lessons

International evidence points to interventions with the strongest yield:

- Full Capacity Protocols (FCP), which transfer admitted ED patients into inpatient surge spaces, consistently reduce boarding[14-16,30,52,53].
- Earlier and weekend discharges, which ensure beds are available before peak ED surges[42].
- Smoothing elective admissions, which reduces weekday peaks that worsen ED boarding[14,33,53].
- Real-time bed management through dashboards and capacity command centers, which allow early action before crisis points[18,19].

These interventions rely on collaboration between ED, inpatient services, and hospital administration. Without hospital leadership and clear governance, ED-specific reforms risk being temporary or symbolic.

Saudi Arabia in Focus

The Saudi context introduces additional complexity. Non-urgent visits remain common, reflecting gaps in PHC accessibility and patient trust[8-10]. Expanding family medicine, urgent care clinics, and tele-triage via the national Seha platform could reduce these pressures, but these must be coupled with patient education campaigns.

At the same time, ICU and critical care bottlenecks are among the most pressing issues. Prolonged ED boarding of critically ill patients has been directly tied to worse survival[55]. Without predefined surge plans for ICU and step-down capacity, EDs will remain unsafe holding areas for high-acuity patients.

Vision 2030 reforms—focused on PHC expansion, digital health, and corporatization of hospitals—create opportunities to embed ED flow reforms at the policy level. By making occupancy and boarding metrics part of hospital performance indicators, reforms can shift from theoretical to measurable improvements.

Research Gaps and Future Directions

Despite abundant international literature, several gaps remain for Saudi Arabia:

- Few multi-center studies assess bundled interventions (e.g., PIT + FCP + discharge lounge).
- No Saudi-specific boarding thresholds or occupancy targets exist; imported benchmarks (~85–90%) may not fully reflect local realities[50,51].
- Patient-reported outcomes, such as satisfaction and trust, remain understudied but are vital for culturally relevant policy.

Addressing these gaps will provide locally relevant evidence and help Saudi Arabia contribute to global discussions on ED crowding.

Synthesis and Outlook: The evidence is clear: ED overcrowding is predictable, measurable, and preventable. Effective solutions exist, but they require political will, hospital governance, and alignment with broader health reforms. Saudi Arabia is in a strong position to act, with Vision 2030 providing a national framework that values accountability and digital innovation.

Embedding boarding limits, FCP adoption, and standardized dashboards into hospital operations will be essential. Coupling these with PHC strengthening and critical care surge planning can transform ED crowding from a persistent problem into a manageable challenge.
Key Messages

- ED crowding is a system-wide failure, with output constraints (boarding, access block) as the dominant driver[39-41].
- Crowding worsens outcomes: delays in sepsis, myocardial infarction, and stroke care increase mortality; boarding is independently linked with higher in-hospital deaths[14-16,53].
- Throughput interventions (triage reform, POCT, observation units) improve timeliness but are insufficient without hospital-wide reforms[23,30-38].
- High-yield strategies include Full Capacity Protocols (FCP), early and weekend discharges, discharge lounges, and smoothing elective admissions[14,33,42,43,53].
- Saudi-specific issues: high non-urgent ED use due to weak PHC, and prolonged ICU boarding linked with adverse outcomes[8-10,55].
- Vision 2030 reforms (PHC strengthening, digital health, hospital corporatization) provide a unique opportunity to embed sustainable, evidence-based crowding solutions into national policy.

Saudi Implications & Recommendations: Emergency department crowding in Saudi Arabia reflects both global trends and unique national challenges. Two themes stand out in the local literature: (1) the high proportion of non-urgent visits, often due to limited use of PHC and patient preference for hospital-based services, and (2) prolonged ICU boarding, which has been directly linked with worse survival[35,36,55]. Addressing these requires reform at multiple levels of the healthcare system.

Policy Level

Saudi Arabia's Vision 2030 Health Sector Transformation provides a timely platform for reform. Priority should be given to:

- Strengthening PHC networks through expansion of family medicine and urgent care clinics. This would reduce unnecessary ED demand and improve continuity of care.
- Integration of digital health, particularly the Seha app and tele-triage services, which can filter low-acuity patients before arrival and provide structured follow-up care.
- National benchmarking of ED performance using standardized dashboards (occupancy, boarding time, LOS, LWBS, NEDOCS) to drive accountability across MOH, military, and university hospitals.

Hospital Level

Hospital administrators play a critical role in relieving output constraints:

- Full Capacity Protocols (FCP) should be adopted to redistribute admitted patients from ED hallways to inpatient surge areas with safety safeguards[14-16,30,52,53].
- Earlier discharges and discharge lounges can improve bed turnover. Targets such as ≥40% discharges before noon should be pursued consistently[40].
- Weekend discharge planning must be normalized to prevent Monday bottlenecks.
- Critical care surge planning is essential, given evidence that prolonged ICU boarding is particularly harmful in Saudi centers[55].

ED Level

Within the ED, operational changes can enhance flow and patient experience:

- Provider-in-triage and team-based triage shorten waiting times and reduce LWBS[30-33].
- Short-stay or observation units for chest pain, syncope, COPD, and cellulitis can decompress core ED areas[54].
- POCT and protected imaging slots in the evenings help offset diagnostic delays[35,36].

Community & Public Engagement

Sustainable solutions must also involve the community:

- Health literacy campaigns should educate the public about appropriate ED use and the role of PHC.
- Transparent wait-time boards and SMS updates can improve tolerance for waiting and reduce frustration, especially during peaks.

Research Priorities

Despite growing attention, Saudi data remain fragmented. Future work should focus on:

- Multi-center evaluations of bundled interventions rather than isolated measures.
- Establishing Saudi-specific thresholds for boarding and safe occupancy.
- Studying patient-reported outcomes to capture cultural perspectives and expectations.

Summary: In Saudi Arabia, solutions to ED crowding must go beyond the walls of the ED. Strengthening PHC, embedding telemedicine, adopting FCPs, and planning for ICU surges are essential. By aligning these strategies with Vision 2030 reforms, Saudi hospitals can achieve measurable reductions in crowding while improving patient safety and staff well-being.

CONCLUSION

Emergency department overcrowding is one of the most visible indicators of stress in modern healthcare systems. It compromises patient outcomes, strains staff, and raises costs. The literature consistently shows that while input and throughput factors contribute, output constraints—especially inpatient boarding—are the dominant cause39-41.

The consequences are wide-ranging. For patients, crowding delays time-sensitive therapies such as antibiotics in sepsis, reperfusion in myocardial infarction, and thrombolysis in stroke. Each delay increases morbidity and mortality14-16. Systematic reviews confirm that boarding independently raises in-hospital deaths53. For clinicians, working in overcrowded environments accelerates burnout and increases exposure to violence.18 For health systems, inefficiencies translate into longer hospital stays, greater expenditure, and reduced public confidence17.

The evidence also highlights strategies with proven benefit. Full Capacity Protocols (FCP), which shift admitted patients to inpatient surge areas, reduce ED boarding and improve flow14-

16,30,52,53. Earlier and weekend discharges ensure capacity is available when demand peaks42. Smoothing elective admissions levels inpatient demand across the week and prevents mid-week crises14,33,53. Discharge lounges and real-time bed management have shown measurable improvements in multiple settings18,19,40. These interventions require coordination and governance, but they are achievable with leadership support.

Saudi Arabia faces specific challenges. A significant proportion of ED visits are non-urgent, reflecting limited PHC use and patient preference for hospital-based care8-10. At the same time, ICU boarding times are prolonged, and this has been linked directly with poorer survival55. Addressing these requires both supply- and demand-side reforms. Expanding PHC, urgent care clinics, and tele-triage through platforms like Seha will help reduce inappropriate demand. Meanwhile, defining ICU surge protocols and step-down units will protect critically ill patients from unsafe boarding.

The national reform agenda under Vision 2030 offers a unique opportunity. Health sector transformation already prioritizes PHC, digital health, and hospital corporatization. Embedding ED flow metrics into these reforms would create accountability. Hospitals could be benchmarked on occupancy, boarding times, and LWBS rates, alongside traditional indicators.

Future work should also address gaps in Saudi-specific evidence. Multi-center studies of bundled interventions, development of local boarding thresholds, and incorporation of patient-reported outcomes will make solutions more relevant and sustainable.

In summary, ED overcrowding is not inevitable. It is a predictable and preventable systems failure. By implementing proven strategies—supported by national reforms—Saudi Arabia can reduce overcrowding, safeguard patients, protect staff, and set a regional example in acute care delivery.

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