Medical Journal of Australia

MJA The Medical Journal of Australia

RESEARCH OPEN ACCESS

Strategies for Reducing Access Block and Waiting Time for Patients Seeking Emergency Hospital Care: Results of a Ward-Level Discrete Event Simulation at Queensland's Largest Public Hospitals

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Received: 9 December 2024 | **Revised:** 11 September 2025 | **Accepted:** 22 September 2025

Keywords: delivery of healthcare | health policy | health services research | health systems | hospitals | medical emergency services

ABSTRACT

Objective: To assess the impact of strategies to improve public hospital emergency access using a detailed ward-level simulation modelling approach.

Design and Setting: Discrete event simulation was used to simulate patient flow at three principal referral Australian hospitals from 1 September 2021 to 31 August 2022. Models were developed and validated using every emergency department (ED) presentation, inpatient episode of care and patient ward movement at the study hospitals.

Main Outcome Measures: Mean and total ED length of stay, mean waiting time, access block rate, 4-h rule compliance and bed utilisation for patients admitted from the ED.

Results: Reducing ED demand via arrangements that accommodate the same proportion and types of admissions from the ED as the existing ED presenting population reduces access block, with larger impacts in winter than in summer. However, reducing 'general practitioner-type patients' in EDs has negligible impact on access block. Tangible impacts on improving patient flow can be achieved by removing maintenance care patients from hospitals (reducing the percentage of access block by up to a third) and reducing elective admissions. Strategies that emphasised morning, midday and early afternoon discharges led to large flow improvements. The strategy already practised by most hospitals of sharing patients among wards greatly improves emergency access, and gains are the same order of magnitude as reducing overall ED demand.

Conclusions: The study provides support to policymakers looking for evidence regarding strategies to improve emergency access to public hospital care.

JEL Classification: Emergency medicine, Health services administration

1 | Introduction

Overcrowding and access block in hospital emergency departments is a worldwide public health problem [1, 2], a crucial safety issue [3] and an indicator of health system functioning [4]. Over time, emergency department (ED) demand has increased faster than population growth [5], and the performance of EDs in terms of waiting times has declined since

Plain Language Summary

The known: The mean time a patient spends in an Australian emergency department (ED) continues to climb, especially for patients who require admission to an inpatient bed, and creates excessive risks to patients due to congestion-related waiting.

The new: This study quantifies the magnitude of impacts of actionable strategies to improve access to emergency hospital care via simulation. Among the results is the first demonstration that diversion of non-admitted ED patients has negligible impact on access block.

The implications: The results enable decisions about the future application of such strategies in times of a capacity crisis to be informed by site-specific historical flow patterns and facilitates the assessment of the relative merits of potential interventions.

the coronavirus disease 2019 pandemic [6]. The association between access block, which is the number of patients admitted from the ED with an ED length of stay more than 8 h, overcrowding and poor health outcomes is accepted to be causative by most medical authorities and all emergency medicine colleges [7]. Access block has been described by the Australasian College for Emergency Medicine (ACEM) as the single most serious issue facing health systems in Australia and New Zealand [8].

It has been recognised that access block is best addressed by increasing the capacity of the system, most directly by increasing the number of beds available at all levels of care within hospitals and optimising patient flow processes to increase bed availability [9]. However, the gap in knowledge is that while many initiatives have been developed to improve patient flow, most have not been evaluated and most focus on the ED and not the remainder of a patient's hospital journey [10, 11]. To implement strategies to improve emergency access, hospital administrators and policymakers require evidence on the relative merits of potential interventions to improve access to hospital beds and reduce the risks to patients associated with congestion-related waiting. Consequently, this study quantifies the impact of candidate strategies on improving whole-of-hospital patient flow and reducing access block. This aim was achieved using computer simulation [12] (discrete event simulation [DES]), which has been recommended as a prime strategy for improving flow [11, 13–15].

2 | Methods

2.1 | Data and Setting

The input data to the simulation models comprised all ED presentations, inpatient episodes of care and ward transfer movements at three principal referral Australian hospitals with over 900 beds each. These sites were chosen based on their high patient volume and access block challenges as well as the availability of timestamps capturing the sequence and timing of ward movements, which was necessary for the modelling. The study period for the simulation activities was from 1 March 2021 to 31 August 2022. The first 6 months of the study period was used as the warm-up period for the models, with results reported for the 12 months spanning 1 September 2021 to 31 August 2022. Further details about data preparation can be found in Supporting Information S1.

2.1.1 | Ward-Level Patient Flow Simulation

The developed simulation model considered all ED presentation types, either via ambulances or self-presentation, and all patients regardless of their discharge disposition. All individual movements of patients within inpatient wards were included in the simulation, for both elective admissions and those patients that were admitted from the ED. The queues for inpatient wards were managed using a first-in, first-out queuing strategy. All wards with verified capacities during the study period were included in the modelling [16]. The simulation was programmed in the Python 3 programming language using the SimPy 4.1.1 discrete event simulation library.

2.1.2 | Performance Measures

Table 1 shows the ED measures that were calculated to quantify the impact of each scenario. The ED measures were only calculated and shown for patients admitted from the ED.

TABLE 1 | Definition of key performance indicators/measures for patients admitted from the emergency department (ED).

Measure	Definition
ED length of stay (mean and total)	The time from ED presentation to the end of ED journey or physical departure
Access block (count and proportion)	Admitted patients with ED length of stay > 8 h
Waiting time (mean)	The time spent from when a patient was identified as ready to depart the ED to the time the patient physically left the ED (mean over patients admitted from ED)
4-h rule compliance (proportion)	ED length of stay ≤ 240 min
Bed utilisation	Actual bed days (i.e., sum of the lengths of stay of patients admitted from the ED and elective patients) over available bed days (i.e., the number of beds multiplied by the number of days)

2.1.3 | Baseline Simulation Model and Validation

The baseline model for each hospital was defined as a simulation of all participating wards with a set of adjusted capacities that produced the closest results to actual calculated measures from the data.

The logic of the model was validated by comparing patient journeys within the model against the actual pathways in the data. Queue lengths and waiting times were both checked visually and against the baseline figures. The hourly counts of patients in individual wards were plotted and compared with those from the original data. The baseline simulation results were compared with the actual values during a year-long reporting period. Further details of simulation model validation can be found in Supporting Information S2.

2.1.4 | Policy Scenarios

2.1.4.1 | Ward Clustering Scenario. In certain situations, some wards within a hospital might be full while other wards may have capacity to accommodate more patients. In this scenario, optimal use of inpatient beds was investigated by clustering eligible wards together. Clustering of wards refers to load sharing within each cluster so that a single queue is formed for multiple wards, instead of a separate queue per ward in a normal (non-clustered) setting.

Two variations of clustering were investigated: using original capacities of wards, and a variation of attempting to achieve baseline flow performance but with a reduced bed stock.

2.1.4.2 | Early Discharging Scenario. Earlier discharge within a day is known for its link with improved patient flow [16–18]. Patients who have completed their treatment and are clinically fit for discharge may experience longer stays due to delays in the discharge process. Hypothetically, such discharge delays can be reduced and patients can be discharged earlier in the day. This scenario quantifies the impact of such downstream mitigations at the front end of the hospital, that is, on ED measures. Seven different early discharge scenarios (Scenarios A–G) were investigated and these are summarised in Table 2.

TABLE 2 | Summary of early discharging scenarios.

Scenario	Definition
A	Discharge patients 1 h earlier than their original discharge time
B	Discharge patients 2 h earlier than their original discharge time
C	Discharge 50% by 10 AM, 80% by 12 PM, 100% by 2 PM
D	Discharge 35% by 11 AM, 70% by 2 PM, 100% by 5 PM
E	Discharge 50% by 11 AM, 70% by 2 PM, 100% by 5 PM
F	Discharge 80% by 11 AM
G	Discharge 50% by 10 AM, 70% by 2 PM, 90% by 5 PM, 100% by 10 PM

2.1.4.3 | Removing Maintenance Care Patients Scenario. Sometimes the type of care delivered to a patient changes while they are staying in the hospital, for example, a patient may start off having an acute care episode, but then may change to geriatric evaluation and management, rehabilitation care, etc. One of these care types (maintenance care) reflects patients who do not require acute hospital medical care but cannot return home. If community support or alternative step-down care was available, these patients could be discharged from an acute facility, freeing a bed for emergency admissions. In this study, we quantify the impact on ED flow measures if maintenance care patients could be treated outside the acute hospital setting.

2.1.4.4 | Reducing/Redirecting Elective Admissions. When all capacity has been exhausted with no ability to manage ongoing demand, one of the levers to protect the safety of other patients within the system is to cancel elective admissions. Although sometimes necessary, reducing or redirecting elective admissions may adversely impact the lengths of elective waiting lists and patient experience metrics. Instead of cancelling procedures, a reduced or redirected admission stream might be serviced by satellite hospitals or through contracts with private hospitals, but in either case, this scenario quantifies the impact from reducing elective cases at public hospitals by 5% versus 10% on access block, ED length of stay and other flow measures.

2.1.4.5 | Reducing/Redirecting ED Presentations Scenario. In this scenario, overall ED demand (and hence the number of admitted patients) is reduced by 5% and 10%. Such a strategy could be operationally realised by contracted arrangements with private hospitals, or through public awareness campaigns, incentives paid to general practitioners, etc. These alternative demand reduction arrangements would need to accommodate the same proportion and types of admissions from the ED as the existing ED presenting population for these findings to be valid.

In addition to assessing impacts associated with reducing demand by 5% versus 10%, two additional sensitivity analyses were undertaken to explore the impact of this strategy. The first analysis was that to better understand seasonality effects of this strategy, demand was reduced for 3 months over winter and 3 months over summer, with reductions over the southern hemisphere winter months (June, July, August) hypothesised to have greater impacts than reductions in summer (December, January, February). The second analysis was to explore nuances of reducing overall ED demand versus reducing the cohort admitted from the ED only, versus reducing non-admitted ED patients only.

2.1.4.6 | 7-Day Healthcare Scenario. Currently, elective admissions occur more frequently on weekdays compared with weekends. This scenario quantifies the impact of levelled elective admission rates on weekends in relation to weekdays. The scenario of increasing electives on the weekend is an attempt to align with the concept of 7-day healthcare. Outside of normal business hours, hospitals have limited decision makers, no command and control coordinators, and processes that get started on a Friday get paused until the full complement of staff come back on a Monday morning. Staffing patterns are very different afterhours. In the modelling for this scenario, elective admissions occurring on a weekday are moved to the preceding weekend. Only electives are moved as the data shows that patients are admitted from the EDs of the study sites 7 days a week (albeit at slightly reduced rates on weekends).

Further details of the above-mentioned scenarios can be found in Supporting Information S3.

2.2 | Ethics Statement

An ethics exemption for the study was obtained from the Metro South Human Research Ethics Committee (EX/2022/QMS/89905).

3 | Results

Figure 1 and supporting tables in Supporting Information S4 compare the impacts of the considered scenarios on the three target hospitals. This figure highlights the performance gains, which are defined by the percentage difference between a given scenario's results and the baseline results. Green shading indicates improvements, with darker green being better (the scale of percentage improvement differs across hospitals), while red shading indicates degradations, with darker red shading being worse. All the results in the results section are for admitted ED patients.

3.1 | Clustering

Clustering selected wards using their original capacities led to one of the highest improvements in ED access measures for all study sites, including a reduction from 15 to 9 (38%) in access block rate at Hospital C. When considering the variation of reducing the original capacities of the underlying wards, the hospitals could still reach their baseline performance using fewer beds by adopting a clustering approach. This scenario also resulted in bed utilisation improvements, for example, at Hospital A from 78 to 87 (11%).

3.2 | Reduced ED Demand

Reducing ED demand resulted in major flow improvements for all three hospitals. A 5% reduction in ED demand resulted in approximately 30, 25 and 100 min (over 50%) reductions in mean waiting time for Hospitals A to C, respectively. As expected, reducing ED demand in winter had a greater impact than in summer, and only one of the three study sites demonstrated relatively improved performance when demand was simulated to be reduced in summer (e.g., a 7-min [16%] reduction in mean waiting time for Hospital B).

It is important to highlight that demand reduction arrangements would need to accommodate the same proportion and types of admissions from the ED as the existing ED presenting population for these findings to be valid. To illustrate this, Table 3 compares the differences associated with reducing 5% of all ED presentations versus 5% of only the admitted stream versus 5% of non-admitted patients. We observed that the gains in reducing access block by reducing non-admitted ED patients were negligible.

3.3 | Maintenance Care Removal

Maintenance care comprised around 1% of all inpatient episodes, with most inpatient episodes being elective. However, removing maintenance care episodes had considerable impact on many ED measures, including access block rates that were reduced from 27 to 25, 17 to 15 and 15 to 10 (10%–32% reductions) for Hospitals A to C, respectively.

3.4 | Early Discharge

Early discharging scenarios were shown to have beneficial effects on measures of ED and hospital access measures, for example, at least a 10-min reduction in mean waiting time across hospitals. Scenarios C and G generally resulted in more performance gains compared with other early discharging scenarios. None of the early discharge scenarios resulted in improved bed utilisation over baseline conditions.

3.5 | Reduced Elective Admissions

Reducing elective admissions by 5% and 10% also resulted in improved access measures, including access block rates, which were reduced by as much as 40%. As expected, bed utilisation decreased for this scenario across hospitals. Comparing the 5% and 10% elective reduction scenarios shows that the performance gains are not linear, and a reduction of 5% results in considerable improvement in emergency access, particularly for Hospital C.

3.6 | 7-Day Healthcare

The simulation model for applying the concept of 7-day healthcare did not show considerable flow improvements. No performance gain was observed for Hospital A and Hospital B and negligible improvements were observed in Hospital C.

4 | Discussion

Simulating patient flow in the three target facilities has quantified the type and magnitude of impacts that might be realised from local application of candidate strategies to improve emergency access. The results enable decisions about future application in times of a capacity crisis to be informed by site-specific historical flow patterns and facilitates the assessment of the relative merits of potential interventions. Differences in the simulated performance gains across hospitals may be attributed to differences in location, catchment size, services that they provide, staffing and culture.

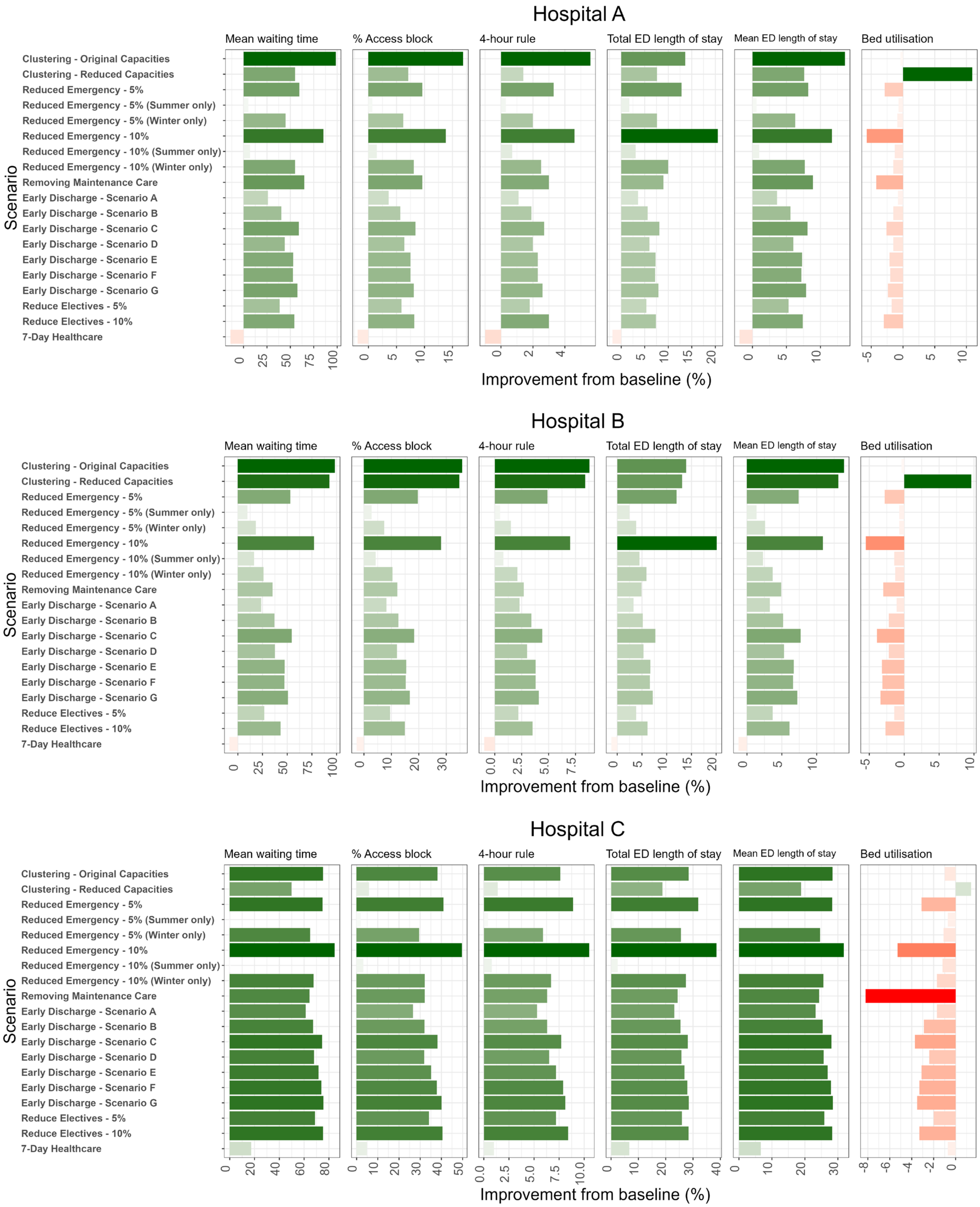

FIGURE 1 | Comparing performance gains across different scenarios in hospital-level simulation. ED, emergency department.

Maintaining support of early discharge practices is important—even discharging 1 h earlier makes a difference to flow. The gains associated with discharging patients earlier in the day are evident, as is the benefit of seeking alternative care pathways for maintenance care patients. Sharing beds across wards is a practice that many hospitals follow to achieve good flow. Although patients may be admitted to a ward faster, thus freeing up the ED, such outlier patients may not receive treatment and specialised care in the way it was designed, and longer stays, disruptions to continuity of care, and staffing

TABLE 3 | Impact of demand reduction on different emergency department (ED) cohorts.

Scenario	Bed utilisation	Number of patients admitted from ED	4-h rule	Mean ED length of stay	Total ED length of stay	% Access block	Mean waiting time
Hospital A							
5% reduction of non-admitted ED patients	0.0%	0.0%	0.0%	0.0%	0.0%	−0.1%[a]	−0.2%[a]
5% reduction of admitted ED patients	−2.8%	−4.9%	2.9%	−8.7%	−13.1%	−9.7%	−62.7%
5% reduction of all ED patients	−2.9%	−5.0%	3.3%	−8.2%	−12.8%	−9.6%	−59.8%
Hospital B							
5% reduction of non-admitted ED patients	0.0%	0.0%	0.0%	0.0%	0.0%	−0.1%[a]	−0.2%[a]
5% reduction of admitted ED patients	−3.0%	−5.1%	5.3%	−8.4%	−13.0%	−21.9%	−59.3%
5% reduction of all ED patients	−2.8%	−4.9%	4.9%	−7.4%	−12.0%	−19.7%	−53.2%
Hospital C							
5% reduction of non-admitted ED patients	0.0%	0.0%	0.1%	0.7%	0.7%	−0.1%[a]	1.8%[a]
5% reduction of admitted ED patients	−2.8%	−5.0%	8.0%	−27.5%	−31.1%	−39.0%	−73.2%
5% reduction of all ED patients	−3.1%	−4.9%	8.9%	−28.3%	−31.9%	−41.0%	−74.9%

[a]Negligible reductions in access block and mean waiting time associated with reducing non-admitted emergency patients.

challenges have been associated with patients who are admitted to non-ideal wards [19–22]. However, there is scant evidence on whether it is less harmful to a patient's outcome for them to be treated as an outlier patient rather than having to wait in the ED for the best bed to become available. The results of the simulation show that although load sharing is a current practice in many facilities governed under sophisticated outlier management rules, there is the possibility of even greater gains in flow improvement if clinically appropriate care could be delivered regardless of which ward a patient ended up in (i.e., where wards can be grouped into clusters). The gains associated with this can be as much as strategies that aim to divert patients away from hospital (such as private sector bed use, cancelling electives and diversion via awareness of primary health alternatives and health promotion).

A key contribution of this study is providing evidence that reducing non-admitted ED patients has negligible impact on access block. Quantifying the impacts on emergency access associated with diverting patients away from the ED reinforced that demand reduction strategies need to reduce the ED cohort admitted into hospitals to result in tangible impact on access block. Access block and ED overcrowding are often framed as problems attributable to an excess of lower acuity care, or 'general practitioner-type' patients in the ED [8]. The results from our study further help dispel this notion—that diverting non-admitted ED patients away from the ED will reduce access block—as a myth, and reinforces that general practitioner-type patients are not the root cause of access block [8]. Quantifying the specific impact that reducing general practitioner-type patients has on access block complements other related investigations that explored less specific ED impacts. For example, Sprivulus [23] proposed a method to estimate the numbers of low acuity patients that a general practitioner would not be expected to refer to an ED, and concluded that efforts to reduce such attendances were unlikely to significantly change ED workload [23, 24]. Dent and colleagues defined a criterion for ED-appropriate attendances and tested a hypothesis that high-use repeat ED presenters could be diverted to a general practitioner [25]. They found that diversion of a small subset of at best 25% of these presentations to a general practitioner may be possible, and could increase patient satisfaction, but would have a minimal impact on ED overcrowding. A more recent study involved a retrospective chart review over 1 month at the Nepean Hospital ED found that more than three-quarters of patients deemed suitable for primary care by Australian Institute of Health and Welfare (AIHW) criteria [26] were potentially unsuitable, and its authors concluded that the AIHW definition should not be used when formulating health policy, planning or allocating resources [27]. These related studies did not assess the specific outcome of access block, and to the best of our knowledge, our results reported herein represent the first demonstration that diversion of non-admitted ED patients has negligible impact on this specific metric.

We acknowledge that there is a range of operational plausibility among the scenarios investigated in this study, and every attempt was made to define realistic what-if scenarios. For example, the policies that assessed the impact that inpatient discharge timing has on ED flow and bed utilisation ranged from a blanket approach of all patients discharged 1 h earlier, to more achievable time-based targets. However, in all cases, simulation involved detailed analysis of a patient's ED journey and, where applicable, every ward until hospital discharge, and assessing how making changes downstream from the ED can impact ED flow metrics, thereby providing a whole-of-hospital response to patient flow improvement.

4.1 | Limitations

The study was undertaken at three principal referral hospitals and flow patterns may not translate to other sites. Further, simulation only quantifies immediate system responses and long-term implications are unknown.

No staffing information was available for consideration in the simulation modelling. Although the ED–inpatient interface suffers mainly due to bottlenecks caused by appropriate beds being unavailable, it was advised by domain experts that ED departure delays could also be due to the lack of available, appropriately qualified staff. Given that the staffing information was unavailable, ED departure queues in our simulation modelling only formed when the destination beds were unavailable. For this reason, waiting times in the simulation modelling may be lower than actual waiting times.

Data relating to the sequence of inpatient wards that a patient might traverse included a single timestamp indicating the time that the inpatient bed was allocated to a patient. It was assumed that the time of releasing a bed was the same as the time that a patient was admitted to the next ward in their journey, or, discharged from hospital if they were at the final stage of their hospital stay. A released bed immediately became available for other patients in a queue for that bed, that is, no bed preparation time was considered in the simulation as a result of this missing information.

The simulation modelling used a fixed capacity per ward throughout the simulation period and dynamic changes in capacity were not available.

This simulation model is deterministic. Although it inherits the limitations of such models, such as their inability to provide confidence intervals, the relative impact of different policy scenarios can be better understood from its outputs.

Finally, the metrics selected for access to emergency care are related to timeliness and efficiency and it is crucial to emphasise that quality and patient experience of care are also essential outcome measures to guide system changes and decision-making.

5 | Conclusions

Despite efforts and accumulated knowledge, the problem of ED overcrowding remains a global challenge, indicating the limited success in implementing evidence-based solutions for improving emergency access. By quantifying the impact of local solutions, this study supports policy based on evidence and enables decisions about the future application of such strategies in times of a capacity crisis to be informed by site-specific historical flow patterns and facilitates the assessment of the relative merits of potential interventions.

Author Contributions

Hamed Hassanzadeh, Justin Boyle and Vahid Riahi: conceptualisation, investigation, formal analysis, methodology, writing (original draft), writing (review and editing). Hwan-Jin Yoon: investigation, formal analysis, writing (review and editing). Ibrahima Diouf, Mahnaz Samadbeik and James F. Lind: investigation, writing (review and editing). Sankalp Khanna, Clair Sullivan, Andrew Staib and Emma Bosley: conceptualisation, investigation, writing (review and editing).

Acknowledgements

We acknowledge the support of this work from the Emergency Medicine Foundation and Queensland Health's Healthcare Improvement Unit. We thank members of Queensland Health's Statistical Services Branch and the Queensland Ambulance Service for facilitating extracts of data used in this study. We are indebted to bed managers and flow controllers who contributed their time, advice and expertise to the analysis. We pay respect to the traditional custodians, past and present, of the lands where this study was carried out.

Funding

A grant from the Emergency Medicine Foundation and Queensland Health (Healthcare Improvement Unit) supported the research activities in this study.

Disclosure

Not commissioned; externally peer reviewed.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data relating to the analysis of ambulance and hospital records are unable to be shared due to ethics and regulatory limitations.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Data S1:** mja270142-sup-0001-DataS1.docx.