

Emergency department crowding

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ABSTRACT

Background Emergency department (ED) crowding is a significant international problem. There is increasing overseas research into this field. In the UK, the focus has been on waiting times in EDs, and on the government's 4 h standard, rather than on crowding itself.

Aims To examine the causes and effects of ED crowding, along with solutions. To consider whether the 4 h standard has had an effect on ED crowding in the UK.

Methods A structured literature review on ED crowding.

Results The evidence base largely consists of retrospective or descriptive studies (65% combined) from North America and Australasia (89% combined).

Measurement of crowding is not well developed, and the lack of a gold standard additionally limits the quality of research. The main cause of crowding is access block, because of high levels of hospital occupancy. Crowding carries a number of adverse consequences for patients and staff. Many solutions are described, but with weak evidence behind them. Most of these focus on interventions in the ED, despite the fact that the main causes lie outside. Solutions aimed at achieving the 4 h standard may mitigate crowding.

Conclusion The extent of ED crowding in the UK is unknown. The problem is probably mitigated by process standards such as the 4 h standard. The causes and effects of crowding are likely to be the same as overseas, but there is little research to validate this. The best solutions are not known.

INTRODUCTION

One of the most critical issues affecting emergency departments (EDs) worldwide is crowding. The terms 'crowding' and 'overcrowding' are not widely used in the UK, where the problem has been framed as one of 'waits'. Such waits were a key focus of the NHS plan¹ in 2000. The '4 h target' became a key feature of emergency medicine (EM) practice in the UK. Interestingly, this standard attracted attention from around the world as a potential tool to help tackle crowding²⁻⁴ at the same time as it was de-emphasised in England within a new suite of quality indicators introduced in 2011 (box 1).⁵

While emergency physicians (EPs) in the UK have been focusing on the 4 h standard, the broader subject of crowding has been extensively studied overseas. This article attempts to examine the causes effects of, and solutions for, ED crowding. I will also consider whether the 4 h standard has had an effect on ED crowding in the UK.

SEARCH STRATEGY AND RESULTS

This paper is a summary of a structured literature review undertaken during early 2010. The full search strategy is available in online appendix 1. I searched the Medline, Cochrane and Business

Source Premier databases using terms relating to crowding. The reference lists from the two most recent reviews^{6,7} were also scrutinised. In total, 125 articles were reviewed. The evidence base is predominantly made up of retrospective observational or descriptive studies (65% combined) from North America and Australasia (89% combined). Most studies (69%) are from single institutions, mainly urban academic units. Paediatric EDs are poorly represented. Only five papers originated from the UK. The overall quality of the literature is therefore limited, with questions over generalisability in the UK.

DEFINITIONS OF ED CROWDING

The three main EM societies outside the UK have published definitions of crowding or overcrowding (table 1). There is no recognised definition for crowding in the UK.

The terms crowding and overcrowding are essentially synonymous, except that crowding implies a continuum, whereas overcrowding implies the more extreme end of the spectrum.

In 2004, Hwang and Concato¹¹ identified 23 different definitions in their well-conducted review. They suggested that the 'definition of overcrowding should focus on standardised criteria and use operational definitions that are easily understood and based on events that occur within the ED itself'.

Beniuk *et al*¹² have since published an international Delphi-based operational definition comprising

- Impaired ability of ambulances to offload
- Patients leaving without being seen
- Delays to triage
- High ED occupancy rate
- Patients staying more than 4 h in the ED
- Delays to seeing an EP
- Delays to admission once a decision to admit has been made
- High proportion of patients in the department awaiting a bed.

This definition has not yet been validated.

IS ED CROWDING A PROBLEM IN THE UK?

In the USA, a government Accountability Office report¹³ concluded that since 2003, when they found crowding to affect most hospitals in the USA, 'crowding continues to occur and some patients wait longer than recommended time frames'. In 2006, the Canadian Agency for Drugs and Technology in Health, reported that 62% of ED directors regarded crowding as a significant problem.¹⁴ In Australasia, a recent spot survey of all major EDs found 76% experiencing 'access block' in the morning/early afternoon.¹⁵

Box 1 The 4 h standard, and the new UK emergency department (ED) quality indicators**The 4 h standard**

Introduced in 2000, this standard required that 98% of patients attending emergency departments (EDs) were assessed, treated and admitted or discharged within 4 h of arrival.

New ED quality indicators¹¹⁸

- ▶ Ambulatory care: admission rates for cellulitis and deep vein thrombosis.
- ▶ Unplanned reattendance rate within 7 days.
- ▶ Total time spent in an ED: median, 95th centile and longest total time spent in the ED (the standard is now that the 95th centile should be 4 hours).
- ▶ 'Left without being seen' rate.
- ▶ Service experience.
- ▶ Time to initial assessment for ambulance arrivals (brief history, pain and early warning scores).
- ▶ Time to treatment: time from arrival to start of treatment by a decision-making clinician.
- ▶ Consultant sign off (index conditions: adults with non-traumatic chest pain, febrile children less than 1 year old, and patients making an unscheduled return visit with the same condition within 72 h of discharge).

The UK model of EM differs from many North American and Australasian models in that admissions from, for example, general practitioners, often do not come through the ED but may go directly to other acute units. It is possible that models of care where patients are funnelled through a single entry point create conditions that favour crowding. In addition, the buffers provided by downstream admission units, along with the potential effect of the 4 h standard, may have an impact on crowding in the UK. This, and other differences, means that figures from overseas cannot be generalised to the UK.

I have been unable to identify any published prevalence studies looking at crowding in the UK. Indeed, without a definition, it cannot be measured. Although attainment against national process standards are routinely measured,¹⁶ this gives no indication of crowding, and has, at least in the past, been subjected to manipulation.¹⁷ Anecdotally, many, if not most, EDs in the UK experience crowding at some times. The definition of Beniuk *et al*¹² offers an opportunity, since at least some of

the criteria are starting to be routinely measured as part of national quality indicators. At the time of writing, only provisional data are available.¹⁸

Measurement of crowding

A fundamental weakness is the lack of a measurement gold standard. There is a weak literature base describing scoring systems of crowding. They are summarised in online appendix 2.

The problems associated with the measurement of crowding feed through into the research. Proxy measures, which are open to influences other than crowding themselves, are commonly used. The most popular proxy measures are listed.

1. Ambulance diversion: subject to multiple influences such as institutional policy, proximity of neighbouring departments, financial considerations, and system-wide agreements.
2. Left without being seen (LWBS) rate: this is a proxy measure of waiting time, and is again subject to multiple influences such as patient attitudes and expectations, information offered, time of day, age, acuity, etc.
3. ED length of stay (LOS): there is an accepted association between increased ED LOS for admitted patients and crowding. This is on the basis that access block/ED boarding result in increased ED LOS. However, increased ED LOS will also contribute to crowding. The complicated relationship between ED LOS, ED efficiency, ED capacity and crowding has not been fully explored or established.

Causes of crowding

General weaknesses in these mostly small studies include variable definition of hospital occupancy, use of surrogate markers of crowding, and implied causal relationship through demonstration of correlation.

Input factors

Flottesmesch *et al* offer a computer simulation of ED occupancy.¹⁹ The model would need validating elsewhere. The most striking feature was the long-lasting effect of arrivals surges on ED census. This has congruence with a study demonstrating 'entry overload' as the most common reason for ambulance diversion in one Australian unit.²⁰ As far as case mix is concerned, the same study described some episodes of ambulance bypass because of high-acuity patients. However, two studies attempting to examine whether lower-complexity patients had an effect on crowding found no effect.^{21 22}

Throughput factors

Asaro *et al*²³ linked deterioration in ED process times with numbers of admitted patients, boarders and inpatient bed utilisation. Harris and Sharma²⁴ argue that mean patient care time in the ED is linked to both hospital capacity and numbers of ED doctors and nurses.

Output factors

The only UK study that looked at causes found a correlation between hospital occupancy figures and the number of patients waiting more than 4 h in the ED.²⁵ However, the study was undertaken at a time when doubt was being expressed over the reliability of reported data around 4 h figures.¹⁷

Dunn demonstrated improved ED performance, and reduced ED crowding as measured by ED occupancy rate, during a hospital strike in Australia.²⁶ During the strike, hospital elective activity was suspended, and inpatient occupancy fell. Although there is potential for confounding variables (reduced inpatient activity will increase availability of inpatient teams to

Table 1 International definitions of crowding

Learned society	Definition of crowding
American College of Emergency Physicians ⁸	Crowding occurs when the identified need for emergency services exceeds available resources for patient care in the emergency department (ED), hospital, or both.
Canadian Association of Emergency Physicians ⁹	Emergency department (ED) overcrowding occurs when the demand for emergency services exceeds the ability of an emergency department to provide quality care within appropriate time frames.
Australasian College of Emergency Medicine ¹⁰	Emergency department overcrowding refers to the situation where emergency department function is impeded primarily because the number of patients waiting to be seen, undergoing assessment and treatment, or waiting for departure exceeds the physical bed and/or staffing capacity of the emergency department.

attend ED and may improve access to diagnostics, etc) the effect was impressive. Schull *et al*²⁷ also showed a striking relationship between systemic hospital capacity and ED crowding, after hospital restructuring in Toronto.

Other papers examined the effect of hospital occupancy on ED performance.^{28–35} The general trend is for an association between increasing hospital occupancy and increased access block or LOS in EDs. The point at which crowding develops is uncertain. Hillier *et al*³³ detected an inflection point in ED performance from levels of hospital occupancy above 80%, and Forster *et al*²⁸ at 90%.

I found two attempts to link access to specialised beds with ED crowding, neither of which were of sufficient quality to allow conclusions to be drawn.^{36 37}

EFFECTS OF CROWDING

There is extensive literature on a variety of potential effects of crowding. Most are retrospective observational studies, often from single EDs/research groups and usually focused on adult populations. None of these papers originate from the UK. Most of the papers demonstrate a negative effect on patient care, suggesting potential publication bias. General weaknesses include use of surrogate markers of crowding and implied causal relationship. However, it is striking that there is an array of articles, many of high quality, demonstrating adverse consequences of crowding.

The accepted relationship between ED LOS and crowding has been examined. Bazarian *et al* found shorter stays for discharged patients after the opening of a short stay unit for boarding admitted patients.³⁸ Five other authors demonstrated relationships between process times and proxy measures of crowding, although the methodology was variable.^{39–43}

Three studies have demonstrated increased inpatient LOS for patients admitted during periods of access block. The two Australian papers were well controlled,^{44 45} although the older paper from the USA used much more crude data.⁴⁶

If patients stay longer, either in ED or in hospital, there will be an associated opportunity cost. Several papers from the USA attempt to quantify this and do show a cost.^{47–50} Stuart demonstrates how the case mix model used to fund Australasian EDs underestimates the activity associated with providing care for patients boarding in the ED.⁵¹ This financial model is more applicable to our setting, although the calculations are based on longer ED stays than we experience in the UK.

If crowding creates delays and unpleasant conditions in EDs, one would expect it to be associated with poor patient experience. A number of papers have examined this.^{41 43 52–58} There seems to be a clear relationship between crowding and patients leaving without being seen, or having reduced satisfaction. Crowding is also reported to reduce physician job satisfaction.^{59 60}

Clinical outcomes have received substantial attention. A collection of papers have examined whether analgesia practice is affected by crowding.^{61–65} All except one small study demonstrated delays to analgesia. Other papers have shown: a small increase in ambulance transport time due to diversion (clinical significance uncertain)^{66 67}; delays in getting antibiotics in pneumonia^{68 69}; increased risk of ventilator-associated pneumonia in trauma⁶⁸; delays, reduced compliance with guidelines and worse outcomes in patients with chest pain^{70–73}; delays to surgery in fractured neck of femur⁷⁴; and increased risk of dying from necrotising fasciitis.⁷⁵ Finally, three studies have looked at mortality associated with crowding. Two papers from Australia have shown increased mortality in patients admitted from

overcrowded departments,^{34 76} although the definition used in one of these papers is a little hazy. Two papers I found,^{77 78} along with two reported by Pham *et al*,⁶⁷ failed to find an association between ambulance diversion and increased mortality, although the results may be confounded by system factors (even during diversion many centres will still receive critically ill patients).

Bernstein *et al*⁷⁹ conducted a review of the literature examining the effect of crowding on clinically orientated outcomes. There was good crossover of studies identified by this group and those included here. Of the additional papers identified, one reported an association between crowding and increased frequency of medical error, and one suggested that crowding was more common in hospitals used by socially disadvantaged patients.

Why should crowding be associated with poorer outcomes for some groups of patients? One can hypothesise:

- ▶ There are delays getting patients into ED spaces to allow assessment and treatment.
- ▶ Patients spend longer in EDs than in the specialised environments best adapted for their ongoing care. Bundles of care specific to their needs (eg, intensive care unit ventilator care) may therefore be delayed.
- ▶ Resources are diverted towards caring for patients who should be in other environments, rather than for new arrivals.
- ▶ Staff are busier and therefore more likely to be prone to error/will have less time for each individual patient.
- ▶ General working conditions become suboptimal.
- ▶ Access block is typically a daytime phenomenon, so that patients are admitted to hospital in the evenings and nights/weekends, when inpatient resource levels also drop.
- ▶ If crowding affects hospitals with more vulnerable patient groups, the risk of adverse outcomes will be higher.

SOLUTIONS FOR CROWDING

The complexity of the crowding problem is evident in the number of solutions proposed. Most of the literature is from overseas and characterised by the same difficulties with measurement and proxy markers as I have previously described. There are two systematic reviews in this group. Most interventional studies are retrospective, although there are some prospective trials and even a couple of randomised controlled trials.

Reviews and multipronged solutions

Cooke *et al*⁸⁰ examined ED waits in 2004. They identified multiple potential interventions, while acknowledging that many had limited or no evidence behind them. A subsequent Canadian systematic review, specifically into crowding,⁸¹ highlighted similar breadth in potential interventions.

Cameron *et al*,⁸² Burns *et al*⁸³ and Yancer *et al*⁸⁴ have demonstrated the potential efficacy of a broad strategy. Munro *et al*,⁸⁵ in a paper from the UK, described a multiplicity of temporary interventions used to bring EDs under the 4 h standard during a 'monitoring week'. This work carried financial as well as performance management consequences if hospitals did not succeed. Cameron *et al*⁸⁶ also describes how financial incentives can drive improvements, although subsequent research from the same health system seems to suggest that crowding remained an ongoing problem despite such persuasion.

Input factors

Redirection of patients to alternative facilities from triage is described in four papers from the USA.^{87–90} These studies predominantly looked at feasibility and safety, although one did

describe reduced overall ED LOS and LWBS rate during the intervention period.

Ambulance diversion is described in one paper as a potential solution for crowding, rather than an effect of it.⁹¹ Initially, the intervention was successful, but further into the study this success was reversed. Proudlove *et al*,⁹² in a paper on bed management, present a possible reason for this, arguing that ambulance diversion or its equivalents may prevent hospitals from 'consuming their own smoke'. For example, in order to protect its elective capacity, a hospital may elect to divert patients away, instead of managing such elective capacity differently.

Throughput factors

Sinreich and Marmor⁹³ offer a computer model suggesting that the major causes of process delays in ED are imaging, waiting for blood tests, and waiting for a physician evaluation. Several authors have shown improvements in ED LOS +/- LWBS rate from individual process improvements directed at these components within EDs. These include the use of bedside registration,^{94 95} senior physicians seeing patients at triage,⁹⁶ and improved laboratory systems offering faster turnaround.⁹⁷⁻⁹⁹ Queue management systems based on lean ('streaming'),¹⁰⁰ and structural reorganisation to bring teams forward in the process,¹⁰¹ have both been shown to reduce ED census. Thornton and Hazell¹⁰² describe how ED efficiency and occupancy were improved when junior doctors went on strike. The suggestion is that senior doctors are better. The confounding factor here was that elective surgery was cancelled, and emergency capacity therefore increased. Finally, Boyle *et al*¹⁰³ describe an ambitious redesign of a complete ED system. Unfortunately, no ED-based process measures were included beyond continued success in meeting the 4 h standard.

Output factors

Most of the literature I identified in this domain examined relatively small-scale solutions to output issues, compared with the systemic nature of the problem. The survey of Bazzoli *et al*¹⁰⁴ confirms the feeling among stakeholders in US health markets that hospital capacity constraints impact on EDs. Staffing was identified as a key component of capacity. Khare *et al*¹⁰⁵ modelled an ED and showed that the departure rate was the key factor in ED LOS, and that simply increasing ED physical capacity would not cure crowding. This proposition was supported in the real world by Han *et al*,¹⁰⁶ who reported no change in ambulance diversion and an increase in ED LOS, when the number of beds in their ED was doubled. Viccelio *et al*¹⁰⁷ have demonstrated the safety of a protocol allowing patients to be 'pushed' into inpatient hallways, but did not study the effect on crowding, while Hung and Kissoon¹⁰⁸ (computer modelling) and Quinn *et al*¹⁰⁹ (real world) demonstrated a small reduction in ED LOS +/- ambulance diversion when patients were transferred directly into inpatient beds without waiting to be reviewed by inpatient teams. The best-studied intervention is the use of holding units, observation units or assessment units to decant patients from the ED. The computer model¹⁰⁸ and five studies^{38 110-113} describing this change demonstrate some potential benefits, although three of the real-world studies used weak outcome measures, and the effects across all studies were variable.

Finally, Frank *et al*¹¹⁴ describe an innovative psychiatric emergency centre designed to stream away psychiatric patients. This important subset of patients can consume disproportionate

resources, and tolerate waits poorly. Unfortunately, the paper does not describe the effect on crowding, or waits, for this group of patients.

Overall

Multiple solutions have been studied, but few have been studied well. Solutions aiming to manipulate input have not been shown to be effective. Improving processes in the ED has been shown to reduce LOS, although the effect on crowding is uncertain. Increasing the physical size of the ED is of uncertain benefit. The use of downstream assessment units, which act as buffers between the ED and the main hospital, has been shown to be effective. There is a paucity of research directed at the known key causes.

HAS THE 4 H STANDARD BEEN AN EFFECTIVE TOOL FOR COMBATING ED CROWDING?

ED crowding is not measured in the UK. It is therefore not possible to state whether the 4 h standard has reduced it. It is possible to state that the 4 h standard has resulted in most patients spending <4 h in EDs (table 2).

There is a theoretical basis to understanding the potential effect of the 4 h standard on ED crowding. Little's law, used to describe flow on production lines, can be rewritten for the ED:

Mean number of patients in the ED = mean arrival rate × mean time spent in the system.¹¹⁶

For an ED, the arrival rate is not open to control. Reducing overall time in the ED by limiting stays to, for example, 4 h will reduce the number of patients in the ED, and hence crowding.

The standard has been a powerful driver for multiple interventions designed to manage demand, improve ED efficiency and throughput, and drive improved flow through hospitals. As there is strong crossover between interventions designed to help achieve the 4 h standard and those that are proposed to reduce crowding, it is reasonable to assume that crowding has been reduced as a result. It should be stressed, however, that I found no objective evidence to support this assertion.

WHAT NEXT?

This study triangulates well with other published research in this field. In addition, Morris *et al*¹¹⁷ have recently published a detailed 'conceptual synthesis' aiming to review potential solutions for ED crowding. They concluded that the 'literature on solutions is less well developed and therefore less useful to practice'. There is a disconnect between research looking at causes and that studying solutions. While the causes of ED crowding appear to lie outside the ED, the solutions studied have predominantly been within EDs. One might speculate that this is because EPs will research what they can influence (processes within the ED), or, because other known factors such as hospital occupancy are extremely difficult to influence and study. Future research needs to be directed more clearly at the principal causes.

Table 2 Reported national performance against 4 h standard¹¹⁵

Period covered by data	Percentage of patients spending <4 h in EDs
Oct-Dec 2002 (oldest data available)	78
Oct-Dec 2009	97.84

ED, emergency department.

SUMMARY

Crowding is a significant problem in EDs around the world. There is a substantial but relatively weak evidence base, largely made up of retrospective observational studies from North America and Australasia. Most of the research in this area has been carried out by EPs, with potential for bias.

Measurement of crowding is not well developed, with poor derivation/validation and gold standards that can be questioned. Measures that have been developed are not generally used in crowding research.

Access to inpatient beds is the likely main cause of ED crowding. There is a reasonable body of evidence correlating hospital occupancy/capacity with ED crowding. Access to specialised hospital beds has not been established as a contributory factor. Arrivals surges can lead to prolonged increases in ED census. There is no evidence suggesting that low-acuity patients cause ED crowding, although high-acuity patients may do so.

A wide range of effects due to crowding have been demonstrated, and there seems little doubt that it is harmful. Crowding reduces departmental efficiency and may increase ED LOS in and of itself. It has been associated with increased inpatient LOS and poor patient/physician satisfaction. A variety of effects on morbidity and mortality have been demonstrated. There is direct and opportunity cost associated with the phenomenon. Ability to respond to major disasters and emergencies may be affected.

Multiple potential solutions are described, both individual and multipronged. There is limited evidence in this domain. Multipronged solutions may be more effective. These are directed at input, throughput and output domains. The effect of the 4 h standard on ED crowding in the UK is not known, but is likely to be beneficial.

Recommendations for action are listed below.

- ▶ The problem of 'waits' in EDs in the UK should be reframed as one of 'crowding,' to bring us into line with international EM.

- ▶ In your EDs, hospitals and local health communities, educate clinicians and managers that crowding is a systemic disease that harms patients.
- ▶ Develop a culture in your ED/hospital that crowding is unacceptable for quality reasons, rather than because it is associated with failure to hit particular performance standards.
- ▶ Measure ED occupancy frequently/in real time so that the extent of the problem becomes visible.
- ▶ Measure hospital occupancy more frequently/in real time so that high levels of occupancy, when it matters operationally, are recognised.
- ▶ Include consideration of crowding and access block in emergency preparedness planning, especially for events such as pandemic flu.

The following are recommendations for research.

- ▶ Develop a definition for crowding.
- ▶ Develop a simple validated measure of crowding, based on that definition, that can be incorporated into the recommended datasets for UK EDs (the opportunity to do this currently exists).
- ▶ Research systems-wide solutions on the basis of existing evidence and operations theory, with the aim of mitigating the risk/problem of crowding (box 2).

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Box 2 Jargon buster

Jargon	Definition
Ambulance diversion	Where ambulances are diverted to another emergency department (ED) from the one they would normally have gone to under normal circumstances
Access block	Access to hospital beds is blocked, meaning that patients cannot be admitted to them. The term 'exit block' is synonymous
Assessment unit	Typically medical, surgical, paediatric case mix. Usually run by inpatient teams as short stay assessment and treatment areas for their admitted patients
Boarding	Patients are deemed to need admission to hospital, but there is no bed for them to be transferred to. They are said to be boarding in the ED
Census	Head count of either number of patients presenting to an ED over a given time period (eg, annual census), or number of patients in the ED itself at a given point in time
Left without being seen	Left without being seen (LWBS)/left without treatment (LWT)/did not wait (DNW): when patients choose to leave the ED before their care has been completed
Occupancy	Generally taken to mean the number of occupied beds divided by the total number of beds, and expressed as a percentage. For example, hospital occupancy of 95% implies the beds have a patient in them 95% of the time

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