Submission

No 27

INQUIRY INTO THE ROYAL NORTH SHORE HOSPITAL

Organisation: Royal North Shore Hospital Emergency Department

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Date Received: 8/11/2007

Submission by Royal North Shore Emergency Department to the Parliamentary Joint Select Committee Inquiry Into Royal North Shore Hospital

Executive Summary

- RNSH ED is dynamic and innovative department with staff dedicated to providing excellent patient care.

- Over the past 2 years a number of successful new strategies have been implemented to improve patient care including an ED short stay unit, a fast track area, a communication clerk, intravenous cannulation nurses and triage protocols for administering analgesia and early X-ray.

- Most of the complaints that have come through the media have been caused by a stretched, overloaded workforce and a chronically overcrowded ED due to admitted patients waiting for ward beds.

- Over the last two years patient presentations to the ED have increased by 7,500, with almost 4,000 extra ambulance attendances.

- Overcrowding and access block are the major impediments to providing best practice patient care at RNSH ED. The major cause of access block in the ED is the unsustainably high bed occupancy at RNSH. Bed occupancy urgently needs to be reduced to below 85% by providing sufficient beds in the wards.

- Extra senior medical cover on evenings and weekends will improve patient care. The current 9.8 FTE Emergency Specialist positions at RNSH ED should be immediately increased to the AMWAC recommendation of 11 to 16.

- The ED faces an ongoing major issue in recruiting and retaining nursing and medical staff. Working in Emergency Department is a high stress job with significant burn out rates. Key issues are:

    - There is a preponderance of junior nursing staff employed in ED. The majority of senior nurses work part time.

    - There needs to be an increase in nursing education resources within the ED to ensure junior nurses rapidly improve their skills.

    - To reduce the workload for both nurses and doctors by reducing access block.

Introduction

The staff of the Emergency Department of Royal North Shore Hospital welcome the inquiry into the operation of Royal North Shore Hospital (RNSH). We are pleased to able to make a submission to the Inquiry as we believe that there are a number of underlying structural and workforce problems at RNSH which need to be urgently addressed by the Hospital, Area Health Service and Department of Health in order to improve services for patients presenting to RNSH through the Emergency Department (ED). We hope that this inquiry will make strong recommendations which will provide the basis for real improvements in patient care.

RNSH ED is faced by a number of challenges that affect our ability to give all patients the quality of care they deserve. In this submission we wish to concentrate on the two biggest issues: maintaining the ED workforce and ED overcrowding or access block. Solving these two problems would alleviate many of the pressures on the ED.

A series of reviews over the past few years have highlighted the issues facing RNSH ED but action on the recommendations has been slow or absent. These reviews have highlighted that ED overcrowding is a whole of hospital problem and many of the causes are outside the control of the ED.

RNSH ED is staffed by skilled, dedicated and committed professionals who are deeply affected by allegations of poor patient care. There have been accusations of a lack of compassion which we know is not true. The cause of most of the complaints that have come from patients or through the media is a stretched, overloaded workforce and a chronically overcrowded ED. What has not been reported is the large number of letters and emails of support that have been sent by current and former patients over the last 2 months.

Overview of RNSH Emergency Department

The Facility

The current ED facility opened in 2003. It has separate adult and paediatric areas. The Adult Emergency has 19 beds in the main area, three resuscitation beds (used for both children and adults), 6 consultation rooms used for a variety of purposes (eg mental health, ophthalmology examinations), a fast track area and a short stay Emergency Medical Unit. The Paediatric Emergency has 7 beds and a chairs area.

The Emergency Department is generally well equipped. Much of our newer equipment has been donated by individuals and charitable organisations such as the Humpty Dumpty Foundation.

What services for patients does the ED currently provide?

- A 24 hour Level 6 Emergency Service seeing both adult and paediatric patients requiring unscheduled treatment for acute illness. Patients from the local area may self present, be referred by their General Practitioner from the local community or present via the Ambulance Service for treatment.

- Tertiary role:
  - The ED is the designated Trauma Centre for the Northern Sydney Area
  - The ED guarantees immediate transfer of patients with certain time critical conditions requiring tertiary care within the AHS
- State wide Role:
  - Acute assessment and/or resuscitation of patients with acute burns and spinal injuries as part of the state-wide referral role of RNS Burn Service.
- Interpretation of ECGs faxed by ambulance and decision making regarding hospital transfer as part of the RNSH 24 hour cardiac interventional service for patients having heart attacks
- A 5 bed Emergency Medical Unit where patients can be admitted under an Emergency Specialist for up to 24 hours
- An Emergency Treatment (fast track) area to allow rapid treatment of ambulatory patients
- Storage and maintenance of the RNS/Ryde Disaster Equipment
- Maintenance of a 24 hour disaster and Chemical Biological Radiological (CBR) response capability as part of the RNS Mass Casualty Incident Plan.
- A Medical Emergency Team to attend to in ground emergencies within the hospital grounds, all outlying buildings including Outpatients and the Douglas building and levels 1-5 and level 13 of the Main Block as well as parts of North Shore Private Hospital.

<u>Core Teaching and Training Role</u>

The ED provides a major teaching and ongoing education role for:

- Emergency Registrars in the Australasian College for Emergency Medicine (ACEM) training program,
- Nursing staff working in the ED through inservice and credentialing
- Resident Medical Officers and Interns rotating through the ED
- Medical students in the Sydney University Graduate Medical Program
- Observers both local and international

<u>Research</u>

- The ED promotes an active research program encompassing multicentre, interdepartmental and intradepartmental research across a range of disciplines.
- Assistance and mentoring of ACEM Advanced trainees towards gaining their 4:10 College research requirement.

<u>Quality and complaint management</u>

- The ED participates in the hospital wide Incident Information Management System and Quality Assurance RNS (QARNS) programs.
- Regular auditing of key indicator groups within the ED including:
  - ED deaths
  - Interhospital and ICU transfers
- All direct or referred complaints are investigated by senior ED staff and replies coordinated through the hospital Patient Representative

<u>Work Practice Changes</u>

RNSH ED has been innovative and a leader in its adoption new ED work practices. Over the past few years many new work practices have been implemented:

- Development of a fast track area which now sees over 800 patients per month from April 2006
- Opening of a 5 bed short stay (Emergency Medical Unit) in December 2006
- Introduction of intravenous cannulation enrolled nurses to take blood tests and intravenously cannulate patients when they arrive, thus speeding up assessment.
- Introduction of a communication clerk in the main adult area
- Introduction of processes to ensure triage category 2 patients are seen within 10 minutes
- Introduction of advanced nurse protocols at triage to allow rapid provision of analgesia and X-ray ordering.
- Appointment of extended hours Psychiatric Clinical Nurse Consultants to enable early assessment of mental health patients.
- Development of processes to improve demand management and offload ambulances presenting to the ED.
- A leading national role in the development and credentialing of Emergency Department ultrasound services

ACCESS BLOCK AND ED OVERCROWDING

The current state of RNSH ED can be characterised as an attempt by dedicated staff to maintain high standards of care in the face of ever increasing demands on the service. This is despite the numerous process changes listed above that we have implemented.

ED overcrowding is primarily being caused by two factors: increasing demand for ED services and more importantly the lack of available beds in the hospital to shift admitted patients out of ED so that new patients can be seen.

We strongly believe that dignity and privacy is a right of all patients presenting to ED, including for example those waiting on ambulance trolleys for a bed. The recent incident at RNSH where a patient unfortunately completed a miscarriage in the waiting room was caused by ED overcrowding. At the time of the event there were 46 patients in ED, with all beds occupied, and 16 admitted patients waiting to go to the ward. If a bed had been immediately available, then even though the miscarriage was inevitable, the patient could have been treated with more dignity and privacy.

The Emergency Department currently sees 120-140 patients per day, which can increase to 180/day on busy weekends. About 35% of patients are admitted to the wards.

It needs to be stressed that patients presenting with a condition which could be treated by a GP are not a problem at RNSH ED. Most patients have their own GP and see them appropriately when available. GP type patients make up less than 5% of our presentations and are a negligible part of our workload as they are seen and discharged through the fast track area.

Another important reason for increasing demand at RNSH ED is the decreasing ability of the surrounding major urban hospitals (particularly Ryde, Manly and Mona Vale hospitals) to provide subspecialty surgical services such as neurosurgery, urology, plastic surgery, hand surgery and vascular surgery. Many of these patients present to ED and require admission.

Manly and Ryde Hospitals no longer have paediatric inpatient units and many more children now present to ED at RNSH.

Evidence of Increasing demand on RNS ED

Over a number of years, particularly since 2004, the ED has been dealing with steadily increasing demand which has caused increasing pressure on the unit. Over the last two years (2005/6 and 2006/7) the numbers of patients have increased dramatically.

Age	00-01	01-02	02-03	03-04	04-05	05-06	06-07	Change 04-05 to 06--07
0 – 15	9,288	9,829	9,704	10,365	10,380	10,954	12,069	
16 – 69	24,414	23,782	23,397	24,129	24,346	27,233	28,774	
70 – 84	6,033	5,746	5,485	5,583	5,395	5,953	6,024	
85+	3,071	2,683	2,362	2,361	2,191	2,555	3,036	
Total	**42,806**	**42,040**	**40,948**	**42,438**	**42,312**	**46,695**	**49,903**	**+7,591**

The number of patients arriving by ambulance was falling until the introduction of the ambulance matrix system in 2005. Since then Ambulance numbers have increased from 26 per day in 2003/4 to an average of 37 per day in 2006/7. So far in 2007/8 the average ambulance arrivals per day is 41.

Royal North Shore ED Arrival by Ambulance 2000-01 to 2006-07

	00-01	01-02	02-03	03-04	04-05	05-06	06-07	Change 04-05 to 06--07
State Ambulance Vehicle	**11,637**	**11,204**	**10,130**	**10,049**	**9,483**	**11,187**	**13,417**	**+3,934**

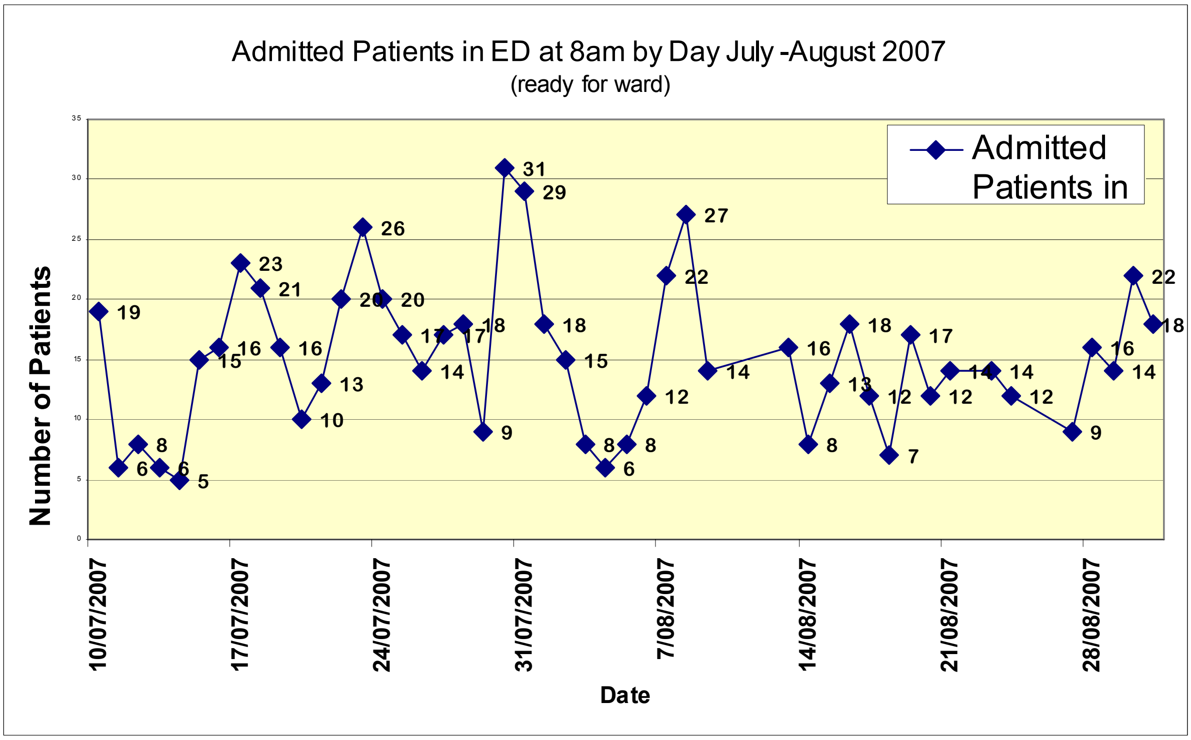
About 35% of the patients presenting to ED need to be admitted to hospital. The number of admissions that come through ED has also risen substantially in the last two years:

	00-01	01-02	02-03	03-04	04-05	05-06	06-07
Number of admitted patients via ED:	15,439	14,959	14,330	14,608	14,705	16,175	18,915

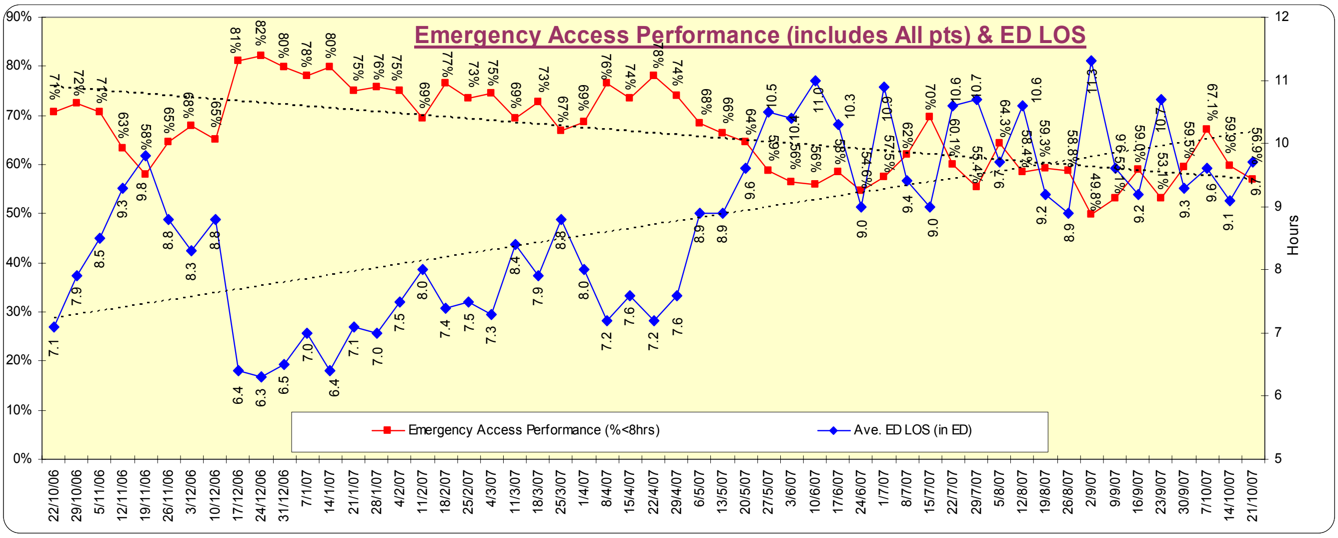
Evidence of ED Overcrowding

Access block is the lack of available inpatient beds for emergency department patients. Access block and ED overcrowding are a major impediment to health care at most if not all EDs in NSW. There is good evidence that access block causes increased length of hospital stay and possibly even increased mortality (Richardson, Sprivulis MJA 2006 – attachment 1). Apart from this it is inhumane to have patients lying on uncomfortable emergency beds, with the noise, light and sleep disruption of a busy ED when they should be able to be cared for in a ward environment.

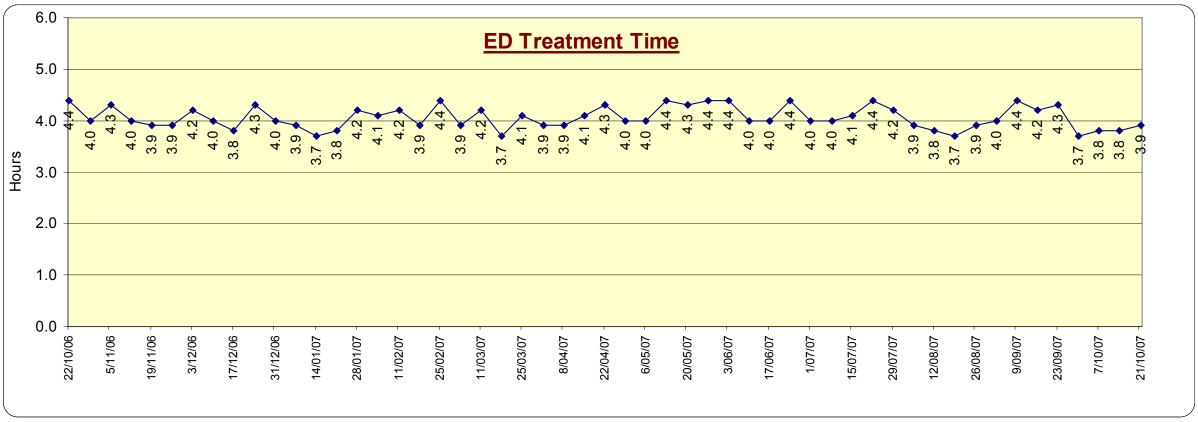
Over two months from July to August 2007 there was an average of 15 admitted patients waiting for a hospital ward bed at 8am each morning.



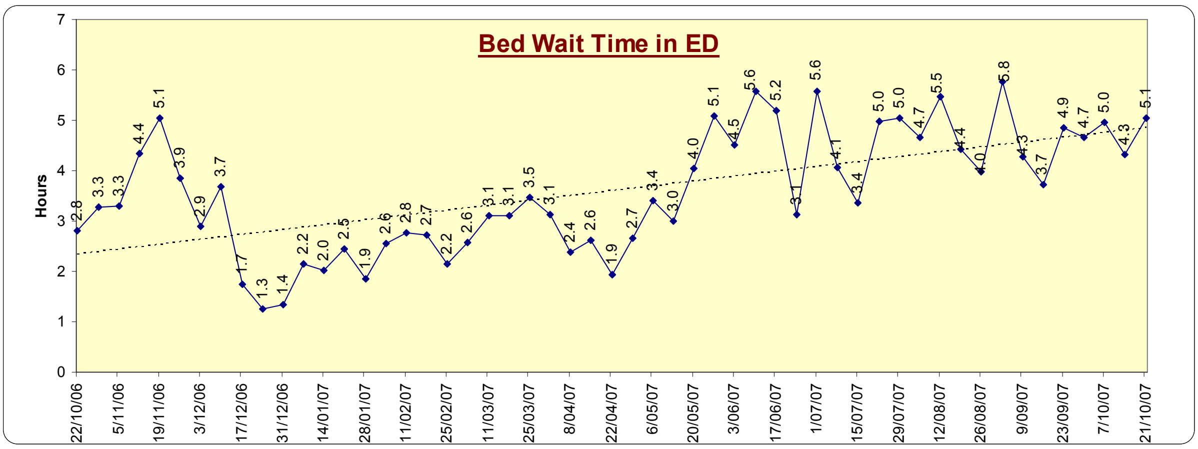
The Department of Health expects over 80% of admitted patients to be able to get to the ward within 8 hours of being seen. Access block has been a major impediment to patient care for many years at RNSH. The following graph from the last 12 months shows the continuing difficulty that RNSH has in reaching this target. The red line is the percentage of patients that get to the ward from ED in less than the 8 hour target. The blue line is the average number of hours that admitted patients stay in the ED prior to going to the ward.



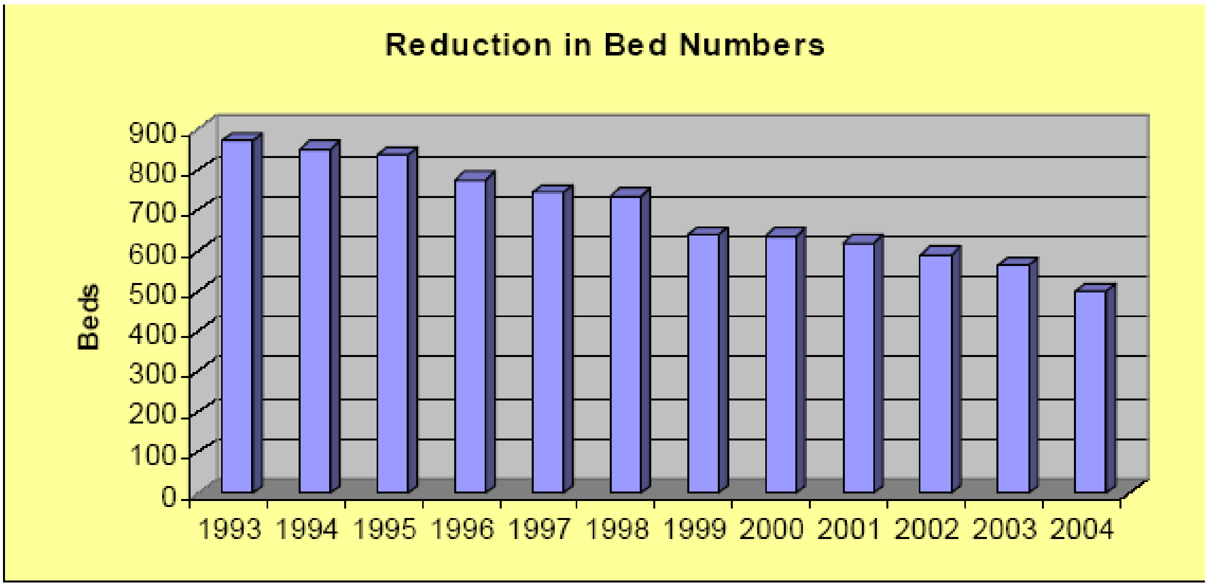
The time actually taken to treat and admit patients by ED staff within in the ED has remained steady, averaging 4 hours over the last year.



ED overcrowding is due to the extra time taken to find a bed when patients have been admitted. This is due patients on the ward needing to be discharged before a new bed becomes available for Emergency Department patients.

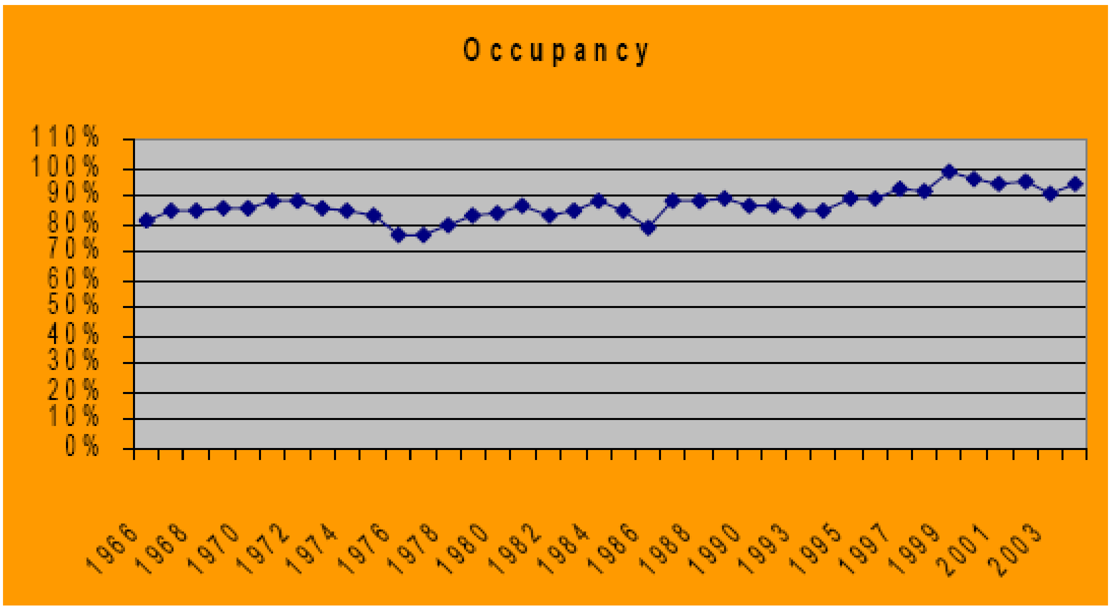


The number of available beds for Emergency patients at RNSH has steadily decreased over a number of years.

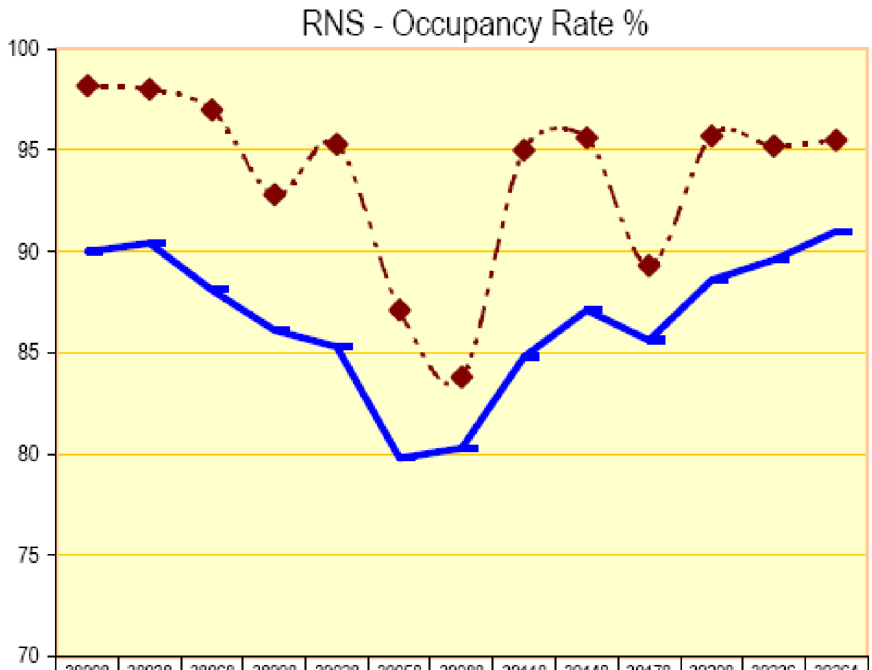


The critical threshold for bed occupancy is 85%. If bed occupancy is over 85% then ED overcrowding will occur. This is well recognised in the literature (see attachment 2). A conclusion from this article in the British Medical Journal was "At 85% average occupancy a hospital can expect to run out of beds about 4 days per year. At 90% the system is regularly subject to bed crisis."

Since the late 1990's RNSH has run on a bed occupancy of well over 90%.



The average bed occupancy rate at RNSH is much higher than the average across the rest of the Northern Sydney Central Coast Health Area. This graph shows the RNS Hospital occupancy rate for July 2006 to June 2007 by month. It only dips below 85% during the Christmas bed closure period.



	38908	38938	38968	38998	39028	39058	39088	39118	39148	39178	39208	39236	39264
Royal North Shore Hospital	98.2	98	97	92.8	95.3	87.1	83.8	95	95.6	89.3	95.7	95.2	95.5
Area	90	90.4	88.1	86.1	85.3	79.8	80.3	84.8	87.1	85.6	88.6	89.6	91

Successive reviews of RNSH ED by Accenture (2004) and PA Consulting (2005) and by a Department of Health team (2007) have shown that the causes of access block lie outside the ED and are a whole of hospital problem. The report also stated that “RNSH has made a concerted effort over a number of years to reduce beds and to reduce length of stay. It appears that it has reached a point where further efficiencies cannot be achieved with the current demands on the system.”

The most important solutions to ED overcrowding are:

- An increase in the bed base of RNSH to ensure occupancy is usually less than 85%.
- Development of service plans to ensure appropriate referral patterns to RNSH from within and outside of the area. The workload of the Hospital including its tertiary and quaternary roles needs to be examined. At the moment elective and emergency patients are in direct competition for the same bed and similarly primary care local patients are directly competing with statewide superspecialties for the same bed. Beds need to be allocated in sufficient numbers and types to be available for all who require them.
- Further work at a hospital level to ensure better patient flow through the hospital and efficient discharge processes.
- Better after hours availability of diagnostic services such as CT scanning to allow the ED to meet patient demand.

Emergency Department Workforce Issues

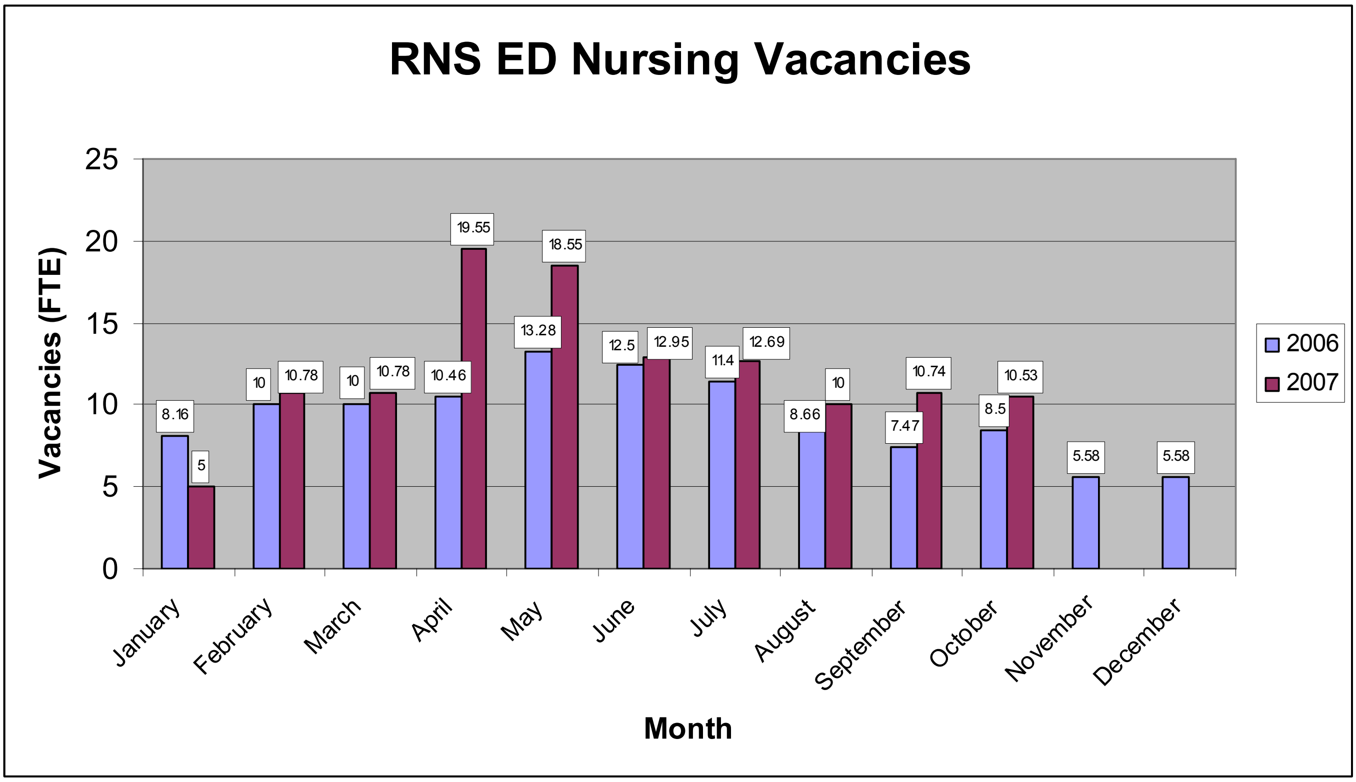
The ED has continuing problems with recruitment and retention of both experienced nursing and medical staff. Working in Emergency Department is a high stress job with significant burn out rates, due to the demanding and constant nature of the work. Reducing overcrowding is vital in attracting skilled staff to work in EDs.

Nursing

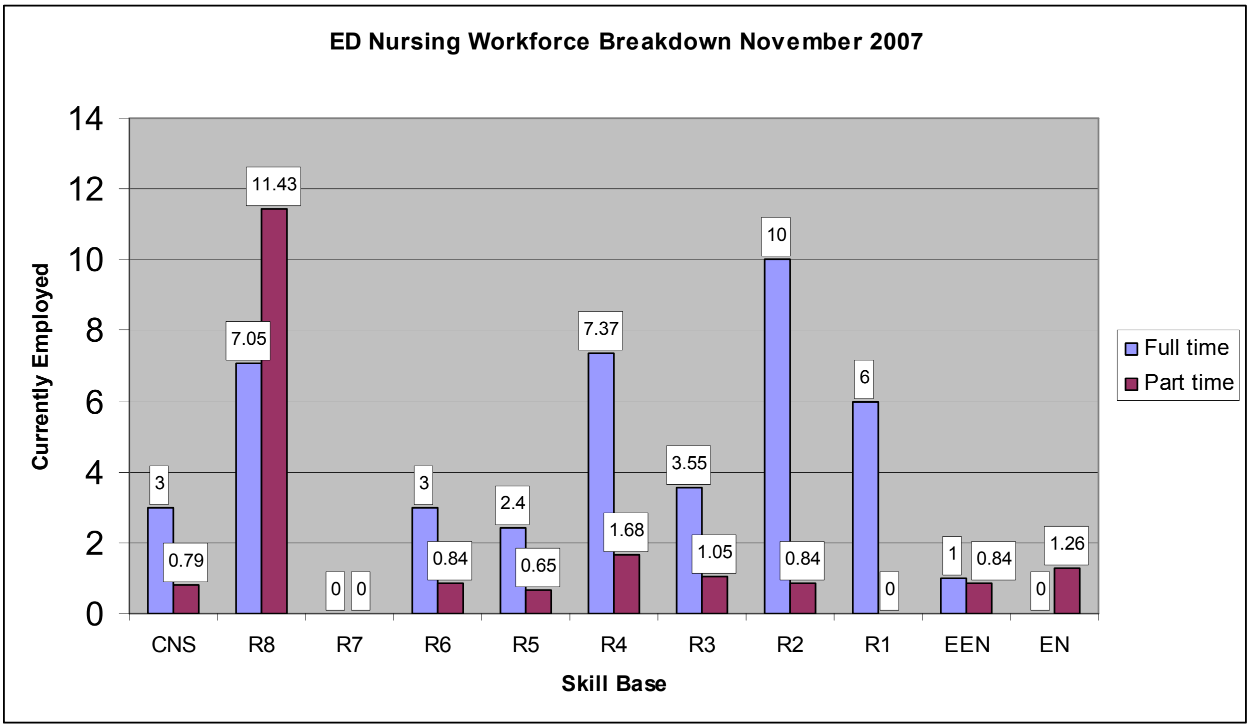
RNSH ED is a critical care area where patients with major trauma or life threatening disease need to be recognized and treated rapidly. To be able to provide safe and effective care, highly trained, skilled nurses are needed. Well trained staff working in a good environment will promote patient satisfaction and staff retention.

The major issues are:

- Continued high levels of nursing vacancies. There are 86.46 FTE (full time equivalent) nursing staff in the ED. Vacancies have ranged between 5 and 20 positions over the past 2 years with 2007 being worse than 2006. This has meant regular usage of Agency Nursing staff, who have variable skills, have poor knowledge of the ED policies and procedures, have a higher incidence of adverse events and require extra supervision by senior nurses.



- The ED Nursing workforce has become much less experienced on average. There has been a shift from Registered Nurses (RNs) with predominantly 8 years or more experience to a majority of staff now being in their junior years. Many senior staff now work part time. This has meant that the skill base of the Department has suffered.



- Increased resources for Clinical Nurse Educators (CNEs) and a Nurse Educator are needed to meet the current and ongoing education needs of the ED. Education plays a vital role in giving junior nurses the skills to practice safe care. Providing junior RNs with skills will increase job satisfaction, result in career growth opportunities and help retain nurses. Currently RNSH ED has 2 FTE CNEs who provide ongoing education and support to 86.46 FTE nurses. The Intensive Care Unit at RNSH currently has 4 FTE CNE's for a similar workforce.

- ED overcrowding has resulted in increased staff sick leave and poor morale.

<u>Medical Staffing - Registrar</u>

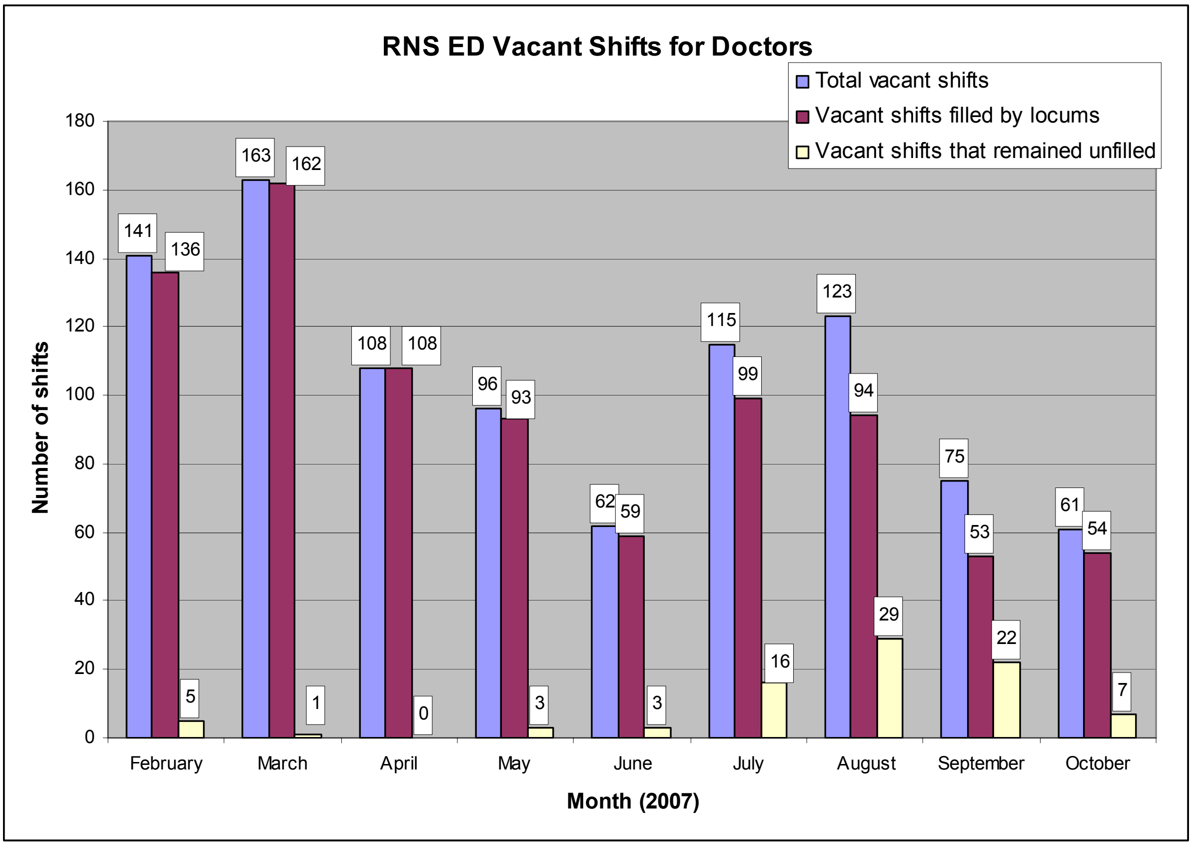
Currently the establishment for ED Trainee Registrars is:

- 14 FTE Basic Emergency Trainees (3 are on secondment at any time):
- 15 FTE Emergency Registrars (4 on secondment)

Training Registrar vacancy rates have varied between 1 and 7 FTE over 2007. In 2008 there are between 3 and 6.5 FTE vacancies.

A number of new strategies to attract medical staff have been put in place, however the market for Emergency Registrars in NSW is very competitive. Medical staff do not wish to work in an environment where they are constantly overloaded and feel that they are exposed to increased medicolegal risk as a result. There is no doubt that RNSH ED is seen to be much busier than many other EDs and registrars have left to work at other hospitals as a result.

Vacant registrar shifts are filled by locum staff when they are obtainable. Locum medical staff do not know local systems and their level of skill levels is variable. Locums are also extremely costly, being paid $100-$130 per hour. There is good evidence that locum staff are associated with more adverse events and complaints. The following graph shows the number of vacant doctor shifts and the medical locum use at RNSH ED from February to October 2007. Prior to 2005 medical locums were not used at all in ED at RNSH.



<u>Medical Staffing - Specialist</u>

There are currently 9.8 FTE funded positions for Emergency Specialists. Currently 8.8 positions are filled. Advertising to fill the vacancy has been unsuccessful to date.

Currently there are ED specialists on duty from 08:00 – midnight Monday to Friday. Weekend cover is a single specialist rostered for 10 hours Saturday and Sunday but frequently working longer hours. Outside this time ED specialists are on call.

The Australasian Medical Workforce Advisory Committee (AMWAC) report of 2003 recommended minimum specialist staffing levels of between 11 and 16 Emergency Physicians at each major referral ED. It was also recommended that this be considered an immediate priority. Raising the level of ED specialist staff at RNSH to this level would mean that there was 16 hour cover over weekends when the ED is at its busiest.

In 2004 the Emergency Specialists in the Northern Sydney Area wrote a position paper suggesting that many of the workforce shortages in the area could be addressed by providing a mixture of Visiting Medical Officer as well as Staff Specialist positions in the Area EDs. Combined Staff specialist and VMO positions at different hospital EDs should be able to be offered to individuals within the Health Service. To date this idea has not been taken up by NSCCHS due to Department of Health opposition to the idea, even though it has been demonstrated to be cost neutral. We believe it is a solution which would help alleviate the specialist workforce shortage.

Attachments

1. Medical Journal of Australia editorial and articles by Richardson and Sprivulis regarding link between poor patient outcomes and ED overcrowding.

2. British Medical Journal Article by Bagust regarding the dangers of high bed occupancy.

Letters of Appreciation received by ED during September and October 2007 are available if required.

This submission was prepared in consultation with ED staff who support the views expressed.

Dr Robert Day

Director of Emergency Medicine

8 November 2007

Attachment 1

Hospital overcrowding: a threat to patient safety?

Peter A Cameron

MJA 2006; 184 (5): 203-204

Managing access block involves reducing hospital demand and optimising bed capacity

Hospital overcrowding causing "access block" — a lack of available inpatient beds for emergency department patients — remains a major impediment to the delivery of good health care both in Australia and overseas. It is obvious that making elderly or disabled patients wait on uncomfortable emergency trolleys in corridors, with sleep deprivation and minimal privacy, is inhumane. Previous research has shown that hospital overcrowding is actually inefficient: it is associated with increased length of hospital stay,[1,2] thus potentially reducing throughput. The number of adverse events has also been shown to increase with worsening access block.[3,4]

An overcrowded hospital should now be regarded as an unsafe hospital

Two articles in this issue of the Journal have put pressure on efforts to solve this problem. Sprivulis and colleagues[5] and Richardson,[6] using different methods and different populations, have shown a strong association between access block and mortality rate. Their findings now make access block a patient safety issue for which all health care workers and the community must be responsible. It is incumbent on governments and administrators to prevent overcrowding by improving management of the health care system and, where necessary, providing increased resources.

These two studies have certain methodological issues that require comment. Firstly, both studies used administrative databases. These are convenient and allow very large populations to be studied. Sprivulis et al, in their study, have also taken advantage of the linked databases in Western Australia and looked at outcomes beyond hospital admission, thus avoiding the potential bias of only studying outcomes in hospital.

Unfortunately, many data elements are not available on administrative databases. Data on physiological variables, details of treatment and past medical history, for example, were not available to more accurately adjust for risk within patient groups. It is also likely that unknown confounders may have been present, such as changing referral patterns, patient choice, and non-seasonal changes to illness patterns. Despite this, the association between periods of overcrowding and increased mortality is quite strong. Both studies have attempted to adjust for obvious confounders such as age, type of illness, seasonal effect, and so on.

What Sprivulis et al and Richardson have shown is that there is an association between overcrowding and mortality, not that overcrowding causes mortality. It is possible (but unlikely) that an influx of sick, elderly patients at high risk of death may actually cause overcrowding, thus resulting in the apparent association. Without a controlled intervention study, it is not possible to conclude that reducing overcrowding would reduce mortality. There are good reasons for assuming a causal relationship: known effects of overcrowding include delays in patient management, poor hospital processes, poor infection control, patients not being placed on the appropriate ward, and so forth. Given that it is logical that there is a causal relationship and that there is no known increased risk to patients under conditions of normal hospital bed occupancy, it is unacceptable to continue to allow hospital overcrowding to occur.

There have been many attempts to ameliorate the problem of access block across Australia[7] and internationally.[8] The exacerbation of access block seen in the past few years is symptomatic of much larger changes occurring within the health system. Changes to workforce, working hours, aged care, and funding, as well as fewer hospital beds, and increasing demand for seemingly limitless new treatments and procedures, have all contributed to access block. Governments have responded to these challenges by increasing resources (health care now consumes 9.6 % of Australia's gross domestic product[9]), improved monitoring of performance through various indicators, and myriad initiatives to improve efficiency within hospitals as well as divert some patients away from hospitals. This effort has alleviated access block in some jurisdictions,[10] but there are still major difficulties across Australia.

What should be done?

There are two broad strategies for managing access block resulting from hospital overcrowding — reducing hospital demand and optimising hospital bed capacity.

Reduce hospital demand

Diversion/substitution: The major focus of this strategy has been to divert patients to community services and provide more services in the community that traditionally occur in hospital (eg, hospital outreach programs, hospital in the home, and improved after-hours general practice services).

Reducing expectations: Reducing community expectations of what a public hospital system can provide is a politically sensitive strategy that has not been systematically addressed. Access block cannot be controlled without some limits being placed on the provision of services. Demand for health care is elastic and potentially unlimited, especially in an essentially free health care system. There must be public debate about what is essential versus what is desirable, and how much the community is willing to pay.

Prevention: There is potential to reduce demand by disease prevention strategies, and improved management of patients with chronic ill health.

Optimise hospital bed capacity

- *Improved processes:* There has been an enormous effort by health care workers to increase capacity by improved efficiency of health care delivery. Many initiatives with quick returns have already been implemented. Further significant improvements will need major investments in infrastructure, especially information technology. Workforce reform is necessary to increase the flexibility of the workforce and the capacity of the health care system. There is presently a shortage of virtually every type of skilled worker in the health care sector.
- *Balancing elective and emergency workload:* Contrary to popular opinion, the emergency workload is highly predictable across metropolitan areas. Elective treatment must be tailored to match the capacity allowed by predicted emergency work.

- *Better discharge:* Moving patients quickly from acute hospitals to more appropriate facilities increases hospital bed availability. Access to rehabilitation, residential aged care and community outreach programs is an essential component of an efficient and well managed health system. Addressing physical, social and psychological issues through care coordination in the emergency department and after hospital discharge can also help reduce hospital length of stay and readmission.
- *Increased bed numbers:* It is important to note that access block does not correlate well with the absolute number of hospital beds. Increasing the number of hospital beds temporarily alleviates access block, but does not solve the problem — the beds quickly fill and the problem recurs. Nevertheless, governments must fund an adequate number of beds to provide the health care that the community demands.

An overcrowded hospital should now be regarded as an unsafe hospital. Health care workers should not have to provide services in an environment that potentially jeopardises patient safety. Government and communities must decide whether they want a well managed, adequately resourced health care system where demand is matched to available resources or to take their chances with the present system.

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Research

The association between hospital overcrowding and mortality among patients admitted via Western Australian emergency departments

Peter C Sprivulis, Julie-Ann Da Silva, Ian G Jacobs, Amanda R L Frazer and George A Jelinek

MJA 2006; 184 (5): 208-212

Abstract

Objective:

To examine the relationship between hospital and emergency department (ED) occupancy, as indicators of hospital overcrowding, and mortality after emergency admission.

Design:

Retrospective analysis of 62 495 probabilistically linked emergency hospital admissions and death records.

Setting:

Three tertiary metropolitan hospitals between July 2000 and June 2003.

Participants:

All patients 18 years or older whose first ED attendance resulted in hospital admission during the study period.

Main outcome measures:

Deaths on days 2, 7 and 30 were evaluated against an Overcrowding Hazard Scale based on hospital and ED occupancy, after adjusting for age, diagnosis, referral source, urgency and mode of transport to hospital.

Results:

There was a linear relationship between the Overcrowding Hazard Scale and deaths on Day 7 (r = 0.98; 95% CI, 0.79–1.00). An Overcrowding Hazard Scale > 2 was associated with an increased Day 2, Day 7 and Day 30 hazard ratio for death of 1.3 (95% CI, 1.1–1.6), 1.3 (95% CI, 1.2–1.5) and 1.2 (95% CI, 1.1–1.3), respectively. Deaths at 30 days associated with an Overcrowding Hazard Scale > 2 compared with one of < 3 were undifferentiated with respect to age, diagnosis, urgency, transport mode, referral source or hospital length of stay, but had longer ED durations of stay (risk ratio per hour of ED stay, 1.1; 95% CI, 1.1–1.1; P < 0.001) and longer physician waiting times (risk ratio per hour of ED wait, 1.2; 95% CI, 1.1–1.3; P = 0.01).

Conclusions:

Hospital and ED overcrowding is associated with increased mortality. The Overcrowding Hazard Scale may be used to assess the hazard associated with hospital and ED overcrowding. Reducing overcrowding may improve outcomes for patients requiring emergency hospital admission.

Emergency department (ED) overcrowding is common in North America, the United Kingdom and Australasia.[1-3] Overcrowding results in ambulance diversion and impaired ED responsiveness.[2,4,5]

Inpatient bed “access block” is the principal cause of ED overcrowding.[1,4,6] Access block is defined as the proportion of ED patients requiring admission whose total time within the ED exceeds 8 hours.[7] Access block is correlated with total hospital inpatient bed occupancy of 90% or more, as measured by a midnight bed census.[7-9] A target occupancy of 85% has been suggested as a balance between unused bed capacity and efficient inpatient flow.[8,10]

Some studies have identified a relationship between high occupancy, access block and adverse patient outcomes, as measured by inpatient length of stay, hospital readmission or reattendance for emergency care.[11-13]

Our study examines whether high hospital occupancy and ED access block is also associated with increased patient mortality.

Methods

The Emergency Care, Hospitalisation and Outcome Study (ECHO)

Western Australia’s population at 30 June 2001 was 1.9 million, with 1.4 million people (77%) residing in metropolitan Perth.[14] Perth has seven public and three private hospitals with EDs. The Emergency Care, Hospitalisation and Outcome Study Project (ECHO) links all metropolitan Perth’s emergency care records, with sufficient information to allow linkage, to metropolitan prehospital care records and hospitalisation and mortality records for the whole state.

Data from the three 400- to 550-bed tertiary hospitals in metropolitan Perth accepting adult referrals were used. These hospitals accepted 81% of all metropolitan ambulance attendances, 67% of emergency inpatient admissions and were responsible for 74% of episodes of ambulance diversion during the study period. For the study, we used the emergency admission record of the first ED attendance during the study period at any of the hospitals’ EDs that resulted in the patient being formally admitted to the hospital.

Data sources

EDIS

EDIS (Emergency Department Information Systems, Version 10.0, Health Administration Solutions, Sydney) is the primary data source for ECHO. It is a patient tracking system, containing patient demographics, admissions, transfers, discharges, time-tracking information and clinical information entered by clinical staff in real time.

Hospital Morbidity Data System

Information on length of stay was obtained from the Western Australian Hospital Morbidity Data System, which contains patient information for all hospital inpatient care episodes in Western Australia.

Mortality Database

Death records were obtained from the Western Australian Mortality Database. The records contain death certificate information, including date of death and principal and secondary causes of death.[15]

Patient-based data linkage

EDIS, the Hospital Morbidity Data System, and the Mortality Database records were linked by the Western Australian Data Linkage Unit using probabilistic matching.[15,16] EDIS records for the period 1 July 2000 to 30 June 2003 were linked to morbidity and mortality records until 31 March 2004. A minimum of 42 000 records were needed to identify a 30-day mortality hazard ratio of 1.2 with a power of 0.9.

Statistical analysis

The Statistical Package for the Social Sciences (SPSS, Version 12.0, Chicago, Ill, USA) was used for the analysis.

Overcrowding and mortality analysis

Our analysis examined the effect on mortality of overcrowding, as indicated by high hospital occupancy and high ED occupancy of patients waiting for an inpatient bed. Box 1 illustrates the difference between uncrowded and overcrowded conditions.

Hospital occupancy was calculated from the admitted patient census at 23:59 on the day of attendance, divided by the 99th centile 23:59 patient census for the hospital during the first 6 months of the calendar year (eg, 400/500 = 80%). Access block occupancy was calculated as the percentage of ED cubicles occupied by patients experiencing access block (ie, waiting 8 hours or more for an inpatient bed) at the time of emergency attendance. The relationship between hospital occupancy, access block occupancy and other risk factors hypothesised as likely to influence mortality by Day 2 (Day 1 = day of attendance), Day 7 and Day 30 were evaluated using Cox regression analysis. Risk factors other than those indicative of hospital or ED occupancy or flow were chosen on the basis of a known relationship with emergency admission deaths, cost or hospital length of stay.[11,17] The model for the effect of overcrowding on mortality was developed manually. Deaths associated with overcrowding were calculated as the excess deaths in the exposed population.

Interaction between hospital occupancy and access block: the Overcrowding Hazard Scale

We developed an Overcrowding Hazard Scale to test the combined effects of hospital and ED overcrowding. Hospital occupancy was scored 1, 2 or 3 corresponding to occupancy levels < 90%, 90%–99% and ≥ 100%, levels known to affect ED function (90%) or to indicate absolute hospital overcrowding (100%). Access block occupancy was scored 1, 2 or 3 corresponding to < 10%, 10%–19% and ≥ 20% occupancy. The Overcrowding Hazard Scale score was calculated by multiplying the hospital occupancy score and the ED access block occupancy score, resulting in values ranging from

1 to 9 (eg, hospital occupancy 90%–99% and access block occupancy 10%–19% = 2 × 2 = 4). A second model for the effect of overcrowding on mortality was developed using the Overcrowding Hazard Scale instead of either hospital occupancy or access block.

Tests for confounding

Two potential confounders were tested.

- Confounding due to increased respiratory and cardiovascular diagnoses in winter was tested by removing admissions in the four peak respiratory/influenza months (June–September) of each year from the models.
- Confounding caused by admission selection (ie, hospitals operating at high occupancy may be less likely to admit patients at lower risk of death, resulting in a spurious association between overcrowding and mortality) was tested by assessing the relationship between overcrowding and the probability of admission for all adult index emergency attendances to the hospitals using binary logistic regression.

Clinical characteristics of overcrowding-associated deaths

Binary logistic regression was also used to evaluate differences in demographic, clinical and attendance characteristics of patients who died by Day 30 after experiencing an Overcrowding Hazard Scale score < 3, in comparision with those who experienced a score > 2.

Ethics approval

Ethical and record linkage approvals were obtained from the Human Research Ethics Committee at the University of Western Australia and the Confidentiality of Health Information Committee of Western Australia.

Results

Sample characteristics

There were 62 495 first emergency admissions and 3084 deaths by the Day 30 censoring date. The admission characteristics, grouped by hospital occupancy, are summarised in Box 2. Higher hospital occupancy was associated with a slightly higher proportion of elderly, female, illness admissions, and was more likely during weekdays and during winter. However, the hospital occupancy groupings were undifferentiated with respect to the proportion of physician-referred admissions, ambulance-transported admissions, triage urgency, or length of hospital stay.[18]

Hospital occupancy and mortality

Box 2 shows a positive relationship between level of hospital occupancy and death by days 2, 7 and 30 after index ED attendance, with a relative increase in mortality by Day 7 of 18% (95% CI, 0.5%–38%) for hospital occupancy of 90%–99% and 46% (95% CI, 14%–85%) for hospital occupancy of 100% or more.

Box 3 illustrates the 7-day survival stratified by hospital occupancy, adjusted for age, mode of transport, diagnosis (ICD-10-CM), triage urgency and referral source. In comparison with < 90% occupancy, the 7-day hazard ratio for 90%–99% hospital occupancy was 1.2 (95% CI, 1.1–1.3; *P* = 0.02), and for ≥ 100% hospital occupancy it was 1.3 (95% CI, 1.1–1.6; *P* = 0.001). Initially significant univariate associations between mortality and winter season, month of year, individual day of week and time of day were rendered non-significant after adjustment for the above variables. Adjustment for hospital attended (including use of an interaction term "hospital × occupancy") or length of hospital stay did not significantly change the hazard associated with hospital occupancy.

Relationship of hospital occupancy to access block

Mean ED access block occupancy at the time of ED attendance was 4.6% (95% CI, 4.5%–4.7%) for patients attending when hospital occupancy was < 90% and increased to 6.8% (95% CI, 6.7%–6.9%) for 90%–99% hospital occupancy and 9.7% (95% CI, 9.5%–10%) for ≥ 100% hospital occupancy.

The Overcrowding Hazard Scale and mortality

Box 4 presents the 7-day hazard ratios associated with the Overcrowding Hazard Scale, using an identical model to that used for Box 3, but with the Overcrowding Hazard Scale substituted for hospital occupancy. A linear relationship between the Overcrowding Hazard Scale and 7-day mortality hazard was demonstrated (r = 0.98; 95% CI, 0.79–1.00; P = 0.001), indicating that an Overcrowding Hazard Scale score > 2 (defining "overcrowded conditions") is associated with increased patient mortality.

Box 5 presents the hazard ratios associated with overcrowded conditions and the other factors associated with Day 7 deaths, and Box 6 presents the deaths associated with overcrowded conditions, censoring survival at 2, 7 and 30 days: 2.3 deaths per 1000 emergency admissions were associated with overcrowded conditions by Day 30 (95% CI, 1.2–3.2), or an estimated 120 deaths (95% CI, 60–170) among the 53 025 tertiary hospital emergency admissions (including non-index admissions) in Perth in 2003.

Tests for confounding

Testing for winter seasonal confounding revealed no significant effect. The Day 7 hazard ratio for overcrowded conditions after exclusion of 22 582 June to September admissions (36.1%) (hazard ratio, 1.3; 95% CI, 1.1–1.5; P =

0.002) was essentially identical to the Day 7 hazard ratio for the total study population in overcrowded conditions reported in Box 5.

In testing confounding caused by admission selection, neither hospital occupancy (risk ratio of admission when there was a 10% increase in occupancy: 1.0; 95% CI, 1.0–1.1) nor the presence of overcrowded conditions (risk ratio of admission with an Overcrowding Hazard Scale > 2: 1.0; 95% CI, 1.0–1.1) was associated with a reduction in the probability of admission among 194 362 ED attendees when adjusted for age, mode of transport, diagnosis, triage urgency, referral source and hospital attended.

Deaths associated with overcrowding

Deaths by Day 30 associated with overcrowded conditions were undifferentiated with respect to age, diagnosis, urgency, mode of transport, referral source or hospital length of stay compared with uncrowded conditions. However, patients dying who experienced overcrowded conditions were more likely to be male (risk ratio, 1.3; 95% CI, 1.1–1.5; $P = 0.007$) and to have attended during winter (risk ratio, 2.9; 95% CI, 2.4–3.5; $P < 0.001$), between Monday and Friday (risk ratio, 2.1; 95% CI, 1.7–2.6; $P < 0.001$) and between 08:00 and 15:59 (risk ratio, 1.7; 95% CI, 1.3–2.2; $P < 0.001$), consistent with the known weekly and seasonal variation in hospital overcrowding and ambulance diversion in metropolitan Perth (see Box 2). Patients dying who experienced overcrowded conditions had longer total durations of stay in the ED (risk ratio per hour of ED stay, 1.1; 95% CI, 1.1–1.1; $P < 0.001$) and slightly longer physician waiting times (risk ratio per hour of ED wait, 1.2; 95% CI, 1.1–1.3; $P = 0.01$).

Discussion

Overcrowding is associated with increased mortality

Our study showed that hospital and ED overcrowding is associated with a 30% relative increase in mortality by Day 2 and Day 7 for patients requiring admission via the ED to an inpatient bed. This increase in mortality appears to be independent of patient age, season, diagnosis or urgency. The estimate of 120 deaths per annum associated with overcrowding in metropolitan Perth hospitals suggests that overcrowding should be regarded as a patient safety issue rather than simply an issue of hospital workflow.

The finding of increased mortality associated with overcrowding is consistent with the known effects of overcrowding on emergency hospital admissions. Hospital occupancy above 90% has been demonstrated in our study to be closely associated with ED access block and is associated with an increased duration of ED stay.[9] The duration of stay in the ED was longer for patients who experienced overcrowded conditions and died.

The positive relationship between overcrowding and mortality is not explained by seasonal or admission selection confounding. For admission selection confounding, this counterintuitive finding may reflect the fact that hospital occupancy was measured at 23:59 each day and represents an outcome of all admission decisions made during the preceding 24 hours rather than perceived occupancy at the time of decision making about admission.

Understanding the relationship between overcrowding and patient harm

Our study did not examine the mechanisms by which overcrowding is associated with increased mortality. Examination of delays in the initiation of time-critical care, such as the administration of antibiotics in sepsis, may be a fruitful line of enquiry.[19] The longer physician waiting times and ED durations of stay among patients in our study who experienced overcrowded conditions and died may be acting as proxies for delays in the initiation of care. The presence of patients experiencing access block is strongly correlated with longer physician waiting times in EDs in both metropolitan Perth (r = 0.86) and internationally.[4,6]

Human error theory predicts that errors occur more often when systems are stressed by constraining resources; such as when a hospital is overcrowded.[20] Overcrowding is often associated with placing inpatients on an incorrect ward (eg, medical patients placed on surgical wards) where staff may be less familiar with standard service guidelines for care of the patient's condition or the clinical cues associated with potential adverse events. Such patient "outlying" may be a mediator of the association between overcrowding and increased mortality.

Given the association between the Overcrowding Hazard Scale and increased mortality, we suggest that the scale could be used to monitor the hazard associated with overcrowding in real-time. An Overcrowding Hazard Scale score > 2 may be considered prima facie evidence of an increased Day 7 mortality hazard.[8]

Solutions to overcrowding

Hospital overcrowding is a complex phenomenon. The prevalence of overcrowding may rise in health services in developed economies as age-related demand for hospital services grows over the next 10–15 years.[21] In addition, economic incentives tend to favour high occupancy.[21] Solutions may include the realignment of incentives that favour high levels of hospital occupancy at the expense of emergency access. Other solutions may include strategies that reduce waste, misuse and overuse of health services, and improved chronic disease management to reduce hospital bed demand.[22] In addition, better matching of bed supply with predictable emergency demand and optimisation of hospital inpatient flow are required.[22-24]

Limitations

This study used data from only one health system. Confirmation of a relationship between overcrowding and mortality and validation of the Overcrowding Hazard Scale requires replication of the findings of our study in other health care systems.

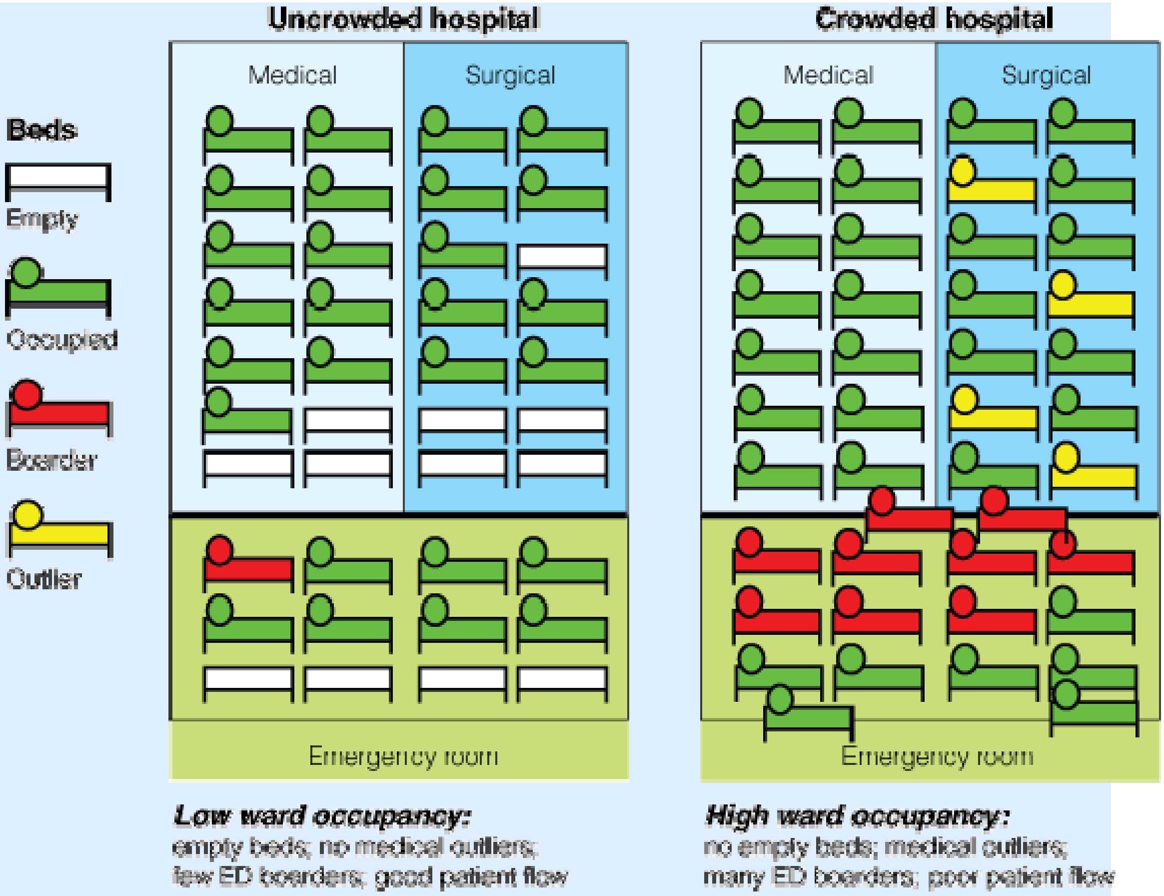
The estimate of the 7-day hazard ratio, and particularly the 30-day hazard ratio, should be considered conservative. The study methods only allowed a patient to enter the dataset once, at the first (index) hospital ED attendance. The mortality hazard associated with overcrowding could increase with repeated exposure. In addition, no estimate has been made of the mortality hazard associated with overcrowding among patients discharged from EDs.

Finally, despite showing an association between overcrowding and mortality, further studies are needed to examine the mediators of the relationship of hospital overcrowding and patient mortality. Research is required that examines specifically the impact of delays in care associated with overcrowding on patient outcomes; and the impact on adverse event rates and patient outcomes of placing patients in wards or corridor locations inappropriate for their care during overcrowded conditions.

Conclusion

Hospital and ED overcrowding is associated with increased mortality. The Overcrowding Hazard Scale may be used to assess the mortality hazard to patients associated with hospital and ED overcrowding. Reducing overcrowding may improve outcomes for patients requiring emergency hospital admission.

1 Hospital crowding states



ED = emergency department. Boarders = patients waiting for an inpatient bed. Outliers = patients unable to be admitted to the "correct" ward (eg, medical patients on surgical wards).

2 Characteristics of emergency hospital admissions grouped by hospital occupancy

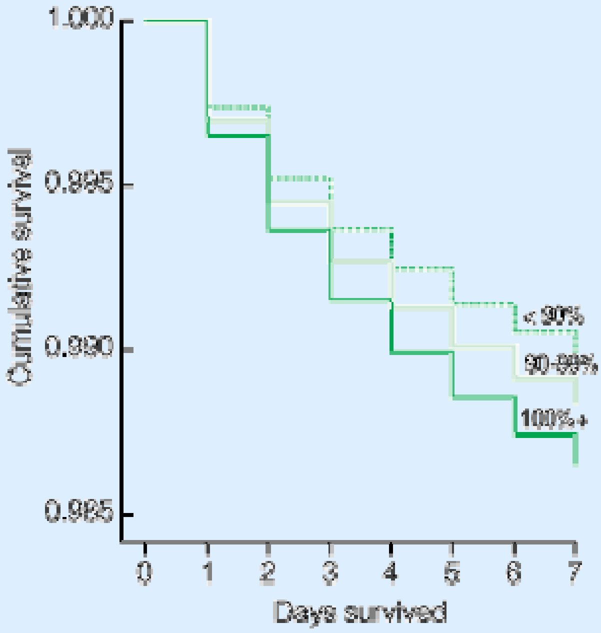
	Occupancy < 90%		Occupancy 90%–99%		Occupancy ≥ 100%		
Sample characteristic	***n* (%) or mean**	**95% CI**	***n* (%) or mean**	**95% CI**	***n* (%) or mean**	**95% CI**	***P***

Sex (% female)	7 464 (45.0%)	44.3%–45.8%	19 023 (47.5%)	47.0%–48.0%	2 959 (50.6%)	49.3%–51.9%	0.05
Age (% ≥ 50 years)	9 969 (60.1%)	59.4%–60.9%	25 805 (64.4%)	63.9%–64.9%	4 220 (72.1%)	71.0%–73.3%	< 0.001
Diagnosis (% injury)	4 130 (24.9%)	24.3%–25.6%	9 453 (23.6%)	23.2%–24.0%	1 343 (23.0%)	21.9%–24.0%	< 0.001
Shift (% 08:00–15:59 hours)	7 148 (43.1%)	42.4%–43.9%	18 123 (45.2%)	44.7%–45.7%	2 902 (49.6%)	48.3%–50.9%	0.12
Day (% Mon–Fri)	10 287 (62.0%)	61.3%–62.8%	30 043 (75.0%)	74.6%–75.4%	5 110 (87.4%)	86.5%–88.2%	< 0.001
Winter attendance (% Jun–Sep)	1 776 (10.7%)	10.2%–11.2%	16 192 (40.4%)	39.9%–40.9%	4 614 (78.9%)	77.8%–79.9%	< 0.001
Referral source (% physician-referred)	5 543 (33.4%)	32.7%–34.2%	13 603 (34.0%)	33.5%–34.4%	2 129 (36.4%)	35.2%–37.6%	0.36
Transport to emergency (% ambulance)	8 141 (49.1%)	48.3%–49.9%	20 653 (51.5%)	51.1%–52.0%	3 212 (54.9%)	53.6%–56.2%	0.09
Triage urgency (% resuscitation cases)	662 (4.0%)	3.7%–4.3%	1 546 (3.9%)	3.7%–4.0%	251 (4.3%)	3.8%–4.8%	0.27
Mean length of stay	6.60	6.44–6.76	6.72	6.61–6.83	6.76	6.49–7.04	> 0.2*
Mean length of stay, weighted for deaths	6.84	6.67–7.00	6.99	6.88–7.10	7.09	6.82–7.36	> 0.1*
Day 2 deaths (%)	179 (1.1%)	0.9%–1.2%	532 (1.3%)	1.2%–1.4%	91 (1.6%)	1.2%–1.9%	0.06
Day 7 deaths (%)	375 (2.3%)	2.0%–2.5%	1 065 (2.7%)	2.5%–2.8%	193 (3.3%)	2.8%–3.8%	0.002
Day 30 deaths (%)	725 (4.4%)	4.1%–4.7%	2 001 (5.0%)	4.8%–5.2%	358 (6.1%)	5.5%–6.7%	0.001
Total (% of	**16 579**		**40 067**		**5 849**		

62 495 admissions)	(26.5%)	(64.1%)	(9.4%)

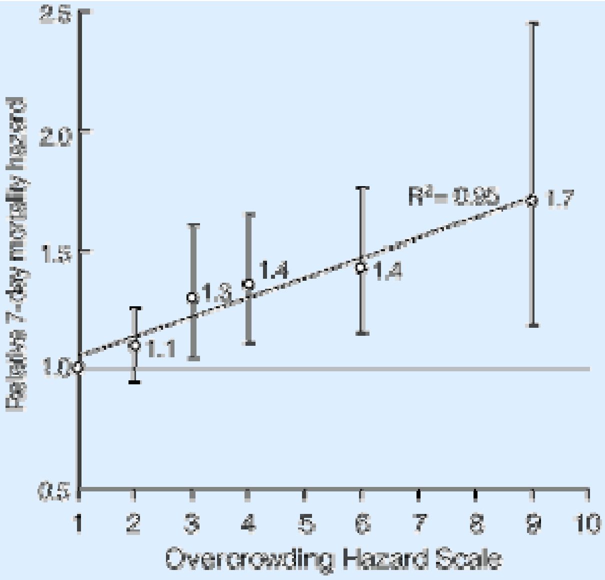
* For all between-group tests.

3 Seven-day survival* after emergency admission stratified by hospital occupancy on the day of admission



* Adjusted for age, mode of transport, diagnosis (ICD-10-CM), triage urgency, and referral source.

4 Relationship between the Overcrowding Hazard Scale and the 7-day mortality hazard for emergency admissions



5 Hazard ratios for variables used in 7-day mortality Overcrowding Hazard Scale model

Variable	Hazard ratio	95% CI	*P*
Age 50 years or older	3.3	2.8–4.0	< 0.001
Mode of transport (ambulance v not ambulance)	3.4	2.9–4.0	< 0.001
Diagnosis (illness v injury)	2.2	1.8–2.6	< 0.001
Australasian Triage Scale urgency Category 1 (resuscitation v less urgent categories 3, 4, 5)[18]	14.0	12.0–16.0	< 0.001
Australasian Triage Scale Category 2 (emergency v less urgent categories 3, 4, 5)[18]	1.6	1.4–1.8	< 0.001
Overcrowding Hazard Scale > 2	1.3	1.2–1.5	< 0.001
Referral source (physician v non-medical)	1.2	1.1–1.3	0.001

6 Cumulative deaths per 1000 new emergency hospital admissions associated with an Overcrowding Hazard Scale > 2

Censoring date	Hazard ratio (95% CI)	Deaths per 1000 emergency hospital admissions (95% CI)	*P*
Day 2	1.3 (1.1–1.6)	1.0 (0.4–1.4)	0.001
Day 7	1.3 (1.2–1.5)	1.9 (0.7–2.5)	< 0.001
Day 30	1.2 (1.1–1.3)	2.3 (1.2–3.2)	< 0.001

Competing interests

None identified.

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Research

Increase in patient mortality at 10 days associated with emergency department overcrowding

Drew B Richardson

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Abstract

Objective:

To quantify any relationship between emergency department (ED) overcrowding and 10-day patient mortality.

Design and setting:

Retrospective stratified cohort analysis of three 48-week periods in a tertiary mixed ED in 2002–2004. Mean “occupancy” (a measure of overcrowding based on number of patients receiving treatment) was calculated for 8-hour shifts and for 12-week periods. The shifts

of each type in the highest quartile of occupancy were classified as overcrowded.

Participants:

All presentations of patients (except those arriving by interstate ambulance) during “overcrowded” (OC) shifts and during an equivalent number of “not overcrowded” (NOC) shifts (same shift, weekday and period).

Main outcome measure:

In-hospital death of a patient recorded within 10 days of the most recent ED presentation.

Results:

There were 34 377 OC and 32 231 NOC presentations (736 shifts each); the presenting patients were well matched for age and sex. Mean occupancy was 21.6 on OC shifts and 16.4 on NOC shifts. There were 144 deaths in the OC cohort and 101 in the NOC cohort (0.42% and 0.31%, respectively; $P = 0.025$). The relative risk of death at 10 days was 1.34 (95% CI, 1.04–1.72). Subgroup analysis showed that, in the OC cohort, there were more presentations in more urgent triage categories, decreased treatment performance by standard measures, and a higher mortality rate by triage category.

Conclusions:

In this hospital, presentation during high ED occupancy was associated with increased in-hospital mortality at 10 days, after controlling for seasonal, shift, and day of the week effects. The magnitude of the effect is about 13 deaths per year. Further studies are warranted.

Overcrowding causes dysfunction in the emergency

department (ED): it is associated with longer waiting times,[1] increased delays in admission to hospital,[2] and even with transmission of infectious disease (during the outbreak of severe acute respiratory disease [SARS] in Canada).[3] Delays in transfer to an inpatient bed from the ED are associated with increased inpatient length of stay,[4,5] but there have been few studies of the relationship between ED overcrowding and patient outcomes. An understanding of the human cost of overcrowding is important to guide appropriate distribution of health care resources.

A recent study to validate a measure of ED overcrowding based on the number of patients receiving treatment ("occupancy")[6] noted a trend (P = 0.08) towards increased inpatient mortality at 10 days in patients presenting at times of ED overcrowding. This prompted further study, which is reported here, with the aim of quantifying any such relationship.

Of the possible definitions of ED overcrowding, the simplest and least subjective is occupancy with patients under treatment. Occupancy is included in all of the validated overcrowding measures in common use.[7] The 75th centile of occupancy for the time of day has been previously suggested as an overcrowding threshold for our hospital, based on an association with waiting times.[8]

Any study of the relationship between ED overcrowding and hospital mortality must take into account known confounding factors:

- *Long-term trends:* ED occupancy has increased over time due to access block (delay in obtaining inpatient beds), and mortality might be expected to increase because of the ageing population.

- *Seasonal:* Both ED occupancy and mortality rates increase in winter.
- *Day of the week:* ED activity and occupancy peak on Mondays in most centres.
- *Time of day:* ED occupancy usually peaks in the evening, absolute mortality (deaths per shift) during the day, and relative mortality (deaths per presentation) overnight.
- *Inter-hospital transfer:* Tertiary centres in particular are likely to delay inter-hospital transfers (ie, incoming patients) at times of overcrowding, or patients may be discharged early to their hospital of origin and death will not be recorded by the tertiary hospital.
- *Ambulance bypass:* Where bypass is a significant feature of the emergency medical system, there will be a decrease in presentations at times of overcrowding, but possibly an increase in the relative mortality of ambulance patients, as the most critically ill are transported to hospital regardless of bypass status.

Methods

This is a retrospective stratified cohort analysis of an existing dataset of patients who presented to the Canberra Hospital ED and were admitted to hospital in the calendar years 2002–2004. Canberra Hospital is a mixed adult and paediatric tertiary hospital, and the only centre in the Australian Capital Territory for some inpatient specialist treatment (eg, acute orthopaedics and paediatrics). The ED is the larger of two serving a city with a population of 300 000, and receives 50 000 presentations annually. Most inter-hospital transfers to the ED from within Canberra are not delayed because of ED overcrowding, but a significant number of transfers from surrounding areas of NSW are delayed or diverted to alternative centres.

Three 48-week periods beginning at 08:00 on the first Wednesday after junior medical staff changeover (a Monday in January) were divided into successive 12-week seasonal blocks and 8-hour shifts starting 00:00, 08:00 and 16:00. These periods were chosen because it was recognised that appropriately similar cohorts could not be obtained for shifts over the Christmas–New Year period, across the medical staff changeover boundary, or during a known disaster (the bushfires of 18–19 January 2003). The scale of the study was based on a power calculation indicating that at least 30 000 presentations would be needed in each group to detect a 25% change in a death rate of 0.4%.

The mean ED occupancy with patients under treatment was calculated for each shift as the sum of patient care time (from when assessment/treatment started to when the patient departed) for care actually delivered within that shift divided by 8 hours. For example, if one patient spent the whole shift being treated in the ED, one who started treatment before the shift began departed after 3 hours, and one started treatment at 3 hours and remained in ED for 12 hours, the mean occupancy for the shift would be two. For each 12-week block (252 shifts), the 21 shifts of each type with the highest occupancy were designated “overcrowded” (OC), representing the top quartile of occupancy. An equivalent number of “not overcrowded” (NOC) shifts of the same type and weekday were randomly selected from the remaining 189 shifts. When there were insufficient NOC shifts, OC shifts were randomly excluded to achieve a matching number of shifts.

Patients in the OC cohort consisted of all presentations not recorded as arriving by interstate ambulance during OC shifts, and the NOC cohort was equivalent for NOC shifts.

The primary outcome was in-hospital death within 10 days of presentation, defined as an ED disposition code of “died in ED” or an admission separation code of “died”. Patients arriving in the ED with no signs of life, or with cardiopulmonary resuscitation in progress, were excluded from the primary outcome. For patients with more than one ED presentation within 10 days of death, only the most recent one was included.

Results

Of the 756 OC shifts, 20 were excluded because an insufficient number of similar NOC shifts was available. The two cohorts were well matched for baseline characteristics (Box 1, Box 2), although there was a small but significant excess of presentations categorised into more urgent triage categories,[9] and a slight excess of presentations on night shift in the OC cohort. The latter is thought to represent delays in ambulance arrival on OC evening shifts.

Patients in the OC cohort received inferior care in terms of standard performance measures (Box 3). They were much less likely to commence treatment within Australasian College for Emergency Medicine triage threshold times,[9] much more likely to leave without being assessed, and much more likely to experience access block.

There were 245 deaths within 10 days of presentation as defined: 15 in the ED, 227 in hospital, and three in the community (who arrived at hospital with no signs of life). In the OC cohort, 144 patients died by Day 10 (0.42%) and in the NOC cohort 101 died (0.31%); *P* = 0.025; relative risk for 10-day mortality = 1.34 (95% CI, 1.04–1.72).

On subgroup analysis, the excess mortality was reasonably evenly distributed during the study period, although it was concentrated in older patients (Box 4). The mortality rate by triage category was significantly different between the groups (Box 4 and Box 5) (P = 0.014, excluding Category 5 because of low numbers). The mean occupancy was 21.6 in OC shifts and 16.4 in NOC shifts, with most of the excess being due to patients with prolonged ED stays (Box 6).

Discussion

The cohort of patients presenting when the ED was overcrowded had significantly higher 10-day in-hospital mortality than a similar cohort treated when the ED was not overcrowded, stratified for shift, day, season and year. This provides sufficient data to allow design of appropriate prospective studies.

More patients presented during OC shifts, they were triaged as having slightly higher acuity, and they received care at a much lower performance level by standard measures. Given the methods used, the possibility that a "sicker" cohort of patients contributed to both overcrowding (as defined) and to mortality rates cannot be excluded. However, the patients presenting during each shift (in whom mortality was measured) accounted for only a small proportion of the difference in occupancy between OC and NOC shifts (15% greater occupancy by new arrivals in OC shifts), most being due to patients already in the ED from previous shifts (58% greater occupancy by previous shift patients in OC shifts) (Box 6).

Subgroup analysis shows that mortality was higher even after accounting for triage differences, and suggests that there may even have been an element of "under-triage" on OC shifts, as the mortality rate was 70% higher in Triage Category 4, but the analysis method lacked sufficient power to properly distinguish the relative effects of presenting condition and ED treatment. Controlling for triage will be challenging in future studies if under-triage is an issue at times of overcrowding.

As a purely statistical analysis, my study does not provide data on actual quality of medical care nor on causes of mortality. Furthermore, the possibility that ED overcrowding is linked to increased deaths in one hospital, but decreased deaths in other settings cannot be excluded. Some level of "admission bias" might be expected, with a tendency to admit only the sicker patients to the wards when the hospital is overcrowded, but this would still have a net effect of reducing recorded total in-hospital mortality. Clearly, a study of all deaths regardless of location is required.

Physical and staff capacity is reached or exceeded at times of ED overcrowding,[12] and it is plausible that patients presenting at these times receive a lower quality of care because the available resources are stretched too thinly. ED overcrowding is caused by insufficient available inpatient beds (access block,[13] or high hospital occupancy[14]), and it is also plausible that the situation in the ED represents a marker of global hospital dysfunction and that some deaths are related to inpatient issues such as inappropriate discharge or admission to an "outlier" ward (as opposed to the "home" ward where staff are experienced in the relevant specialty). If reduced quality of care is the cause of increased mortality, it is likely to also cause increased morbidity. Further studies using recognised quality audit tools are justified.

The methods used have some limitations which may bias the estimate of relative risk, including the absence of patient data (eg, diagnosis). The definition of overcrowding used was necessarily weak to obtain similar cohorts. There was a 7%

annual increase in occupancy over the period, which was not matched by equivalent improvement in staffing. The average occupancy in NOC shifts in winter 2004 was higher than that of OC shifts in summer 2002. An absolute definition of overcrowding based on occupancy (or the occupancy : staffing ratio) might allow better understanding of the relationship between overcrowding and mortality, but in this dataset it would include too few 2002 presentations to be statistically useful.

Conclusions

Patients presenting during times of increased ED occupancy were reasonably similar to those presenting at other times, but had significantly higher short-term in-hospital mortality. This important finding demands further investigation through research at other sites, prospective studies, and consideration of all deaths after ED attendance, rather than only those occurring in hospital. Subgroup analysis suggests that both the acuity of presenting illness and hospital treatment performance contribute, but the study methods did not enable identification of the causes of excess mortality.

The magnitude of the association is around 13 excess in-hospital deaths annually, similar to the number of people killed on the roads in the ACT. If replicated in other studies, this association represents a significant public health issue.

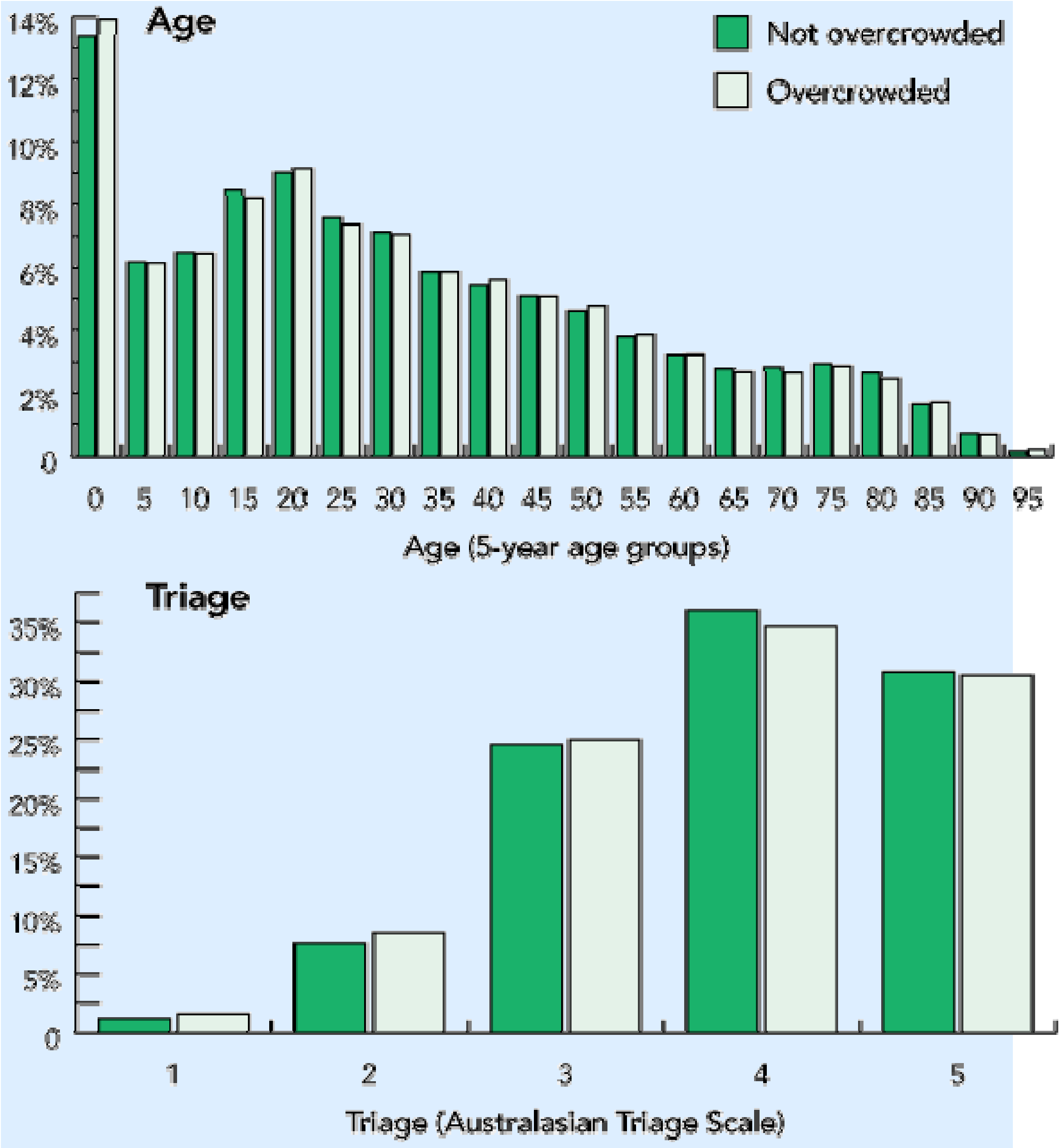
1 Characteristics of the shifts and patient cohorts*

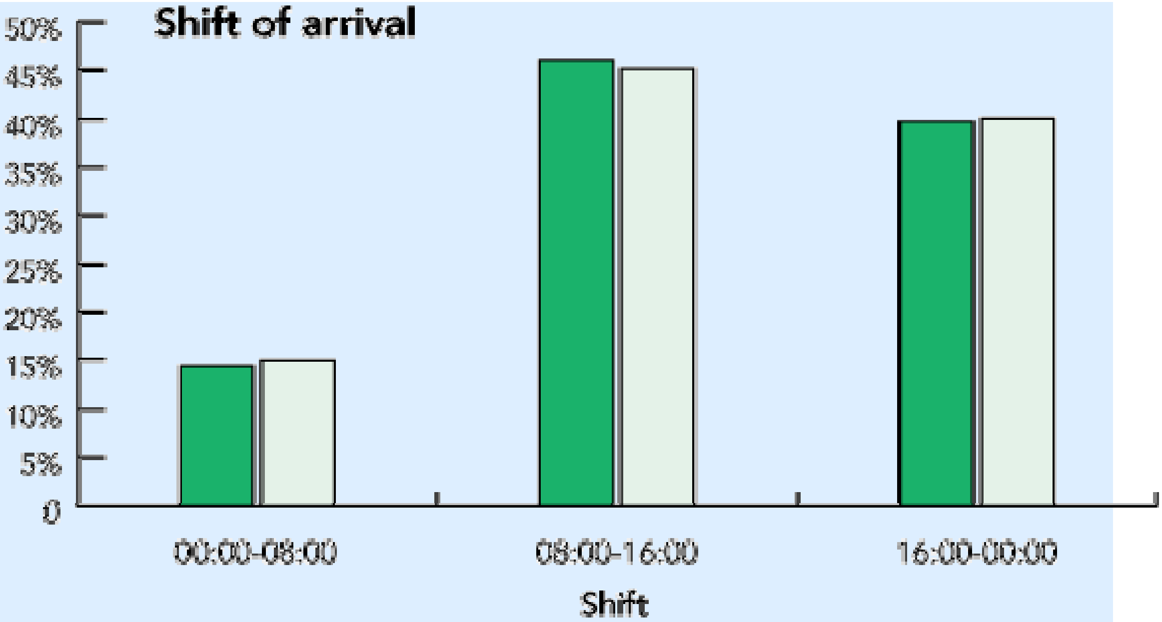
	Overcrowded shifts	Not overcrowded shifts
Year*		
2002	248	248
2003	244	244

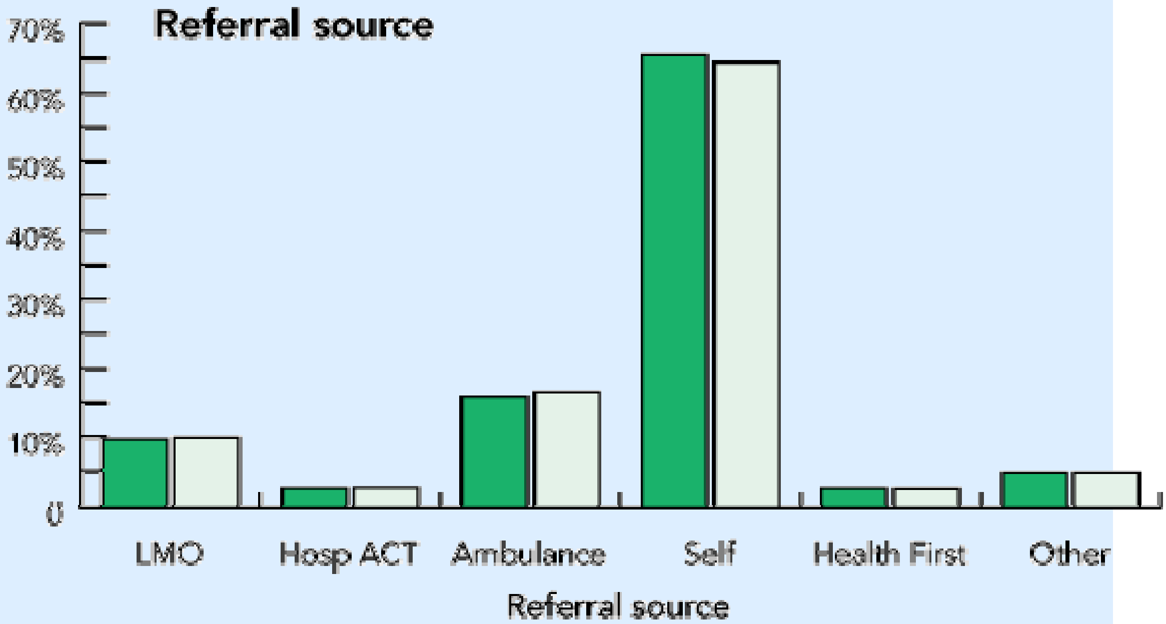
2004	244	244
Shifts		
Day	240	240
Evening	246	246
Night	250	250
Day		
Monday	139	139
Tuesday	115	115
Wednesday	88	88
Thursday	96	96
Friday	104	104
Saturday	90	90
Sunday	104	104
Patients		
Total	34 377	32 231
Male	18 579 (54.0%)†	17 214 (53.4%)†
Age > 60 years	5682 (16.5%)‡	5467 (17.0%)‡

* Of the possible 756 shifts in each cohort, 20 were excluded because there were insufficient matching shifts available. † P = 0.10. ‡ P = 0.13.

2 Characteristics of the patient cohorts presenting in overcrowded and not overcrowded shifts

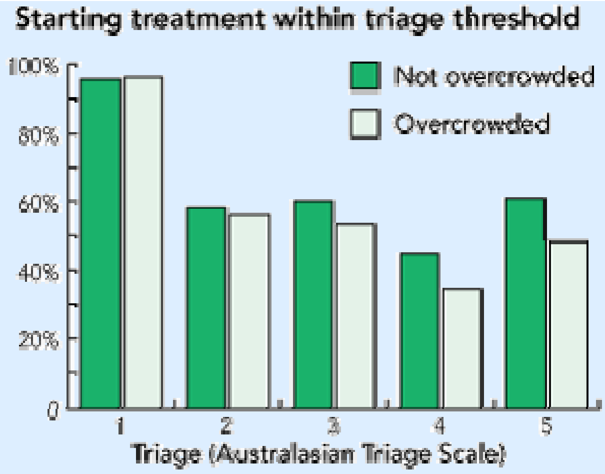

Age
Not overcrowded
Overcrowded
14%
12%
10%
8%
6%
4%
2%
0
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
Age (5-year age groups)
Triage
35%
30%
25%
20%
15%
10%
5%
0
1
2
3
4
5
Triage (Australasian Triage Scale)



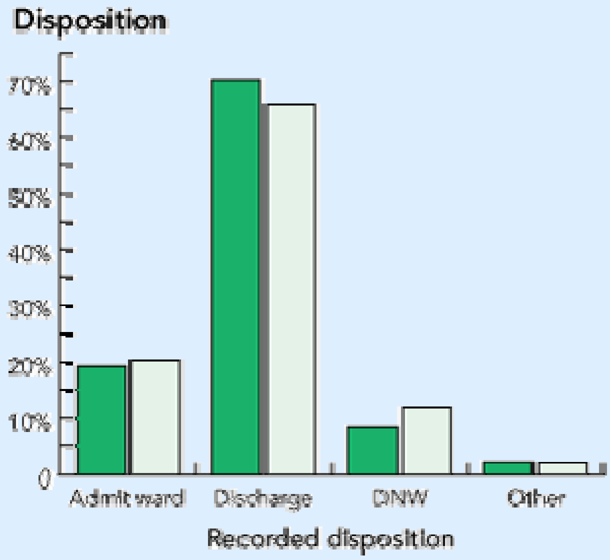


LMO = local medical officer; Hosp ACT = referred from a local hospital; Health First is a telephone and Internet health information service.

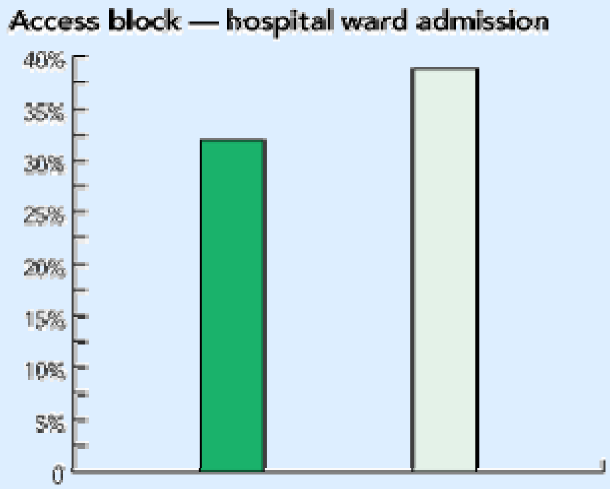
3 Standard performance indicators



Proportion of patients presenting to the emergency department (ED) whose medical assessment and treatment began within the triage thresholds defined by the Australasian College for Emergency Medicine[9] and the Australian Council on Healthcare Standards.[10]

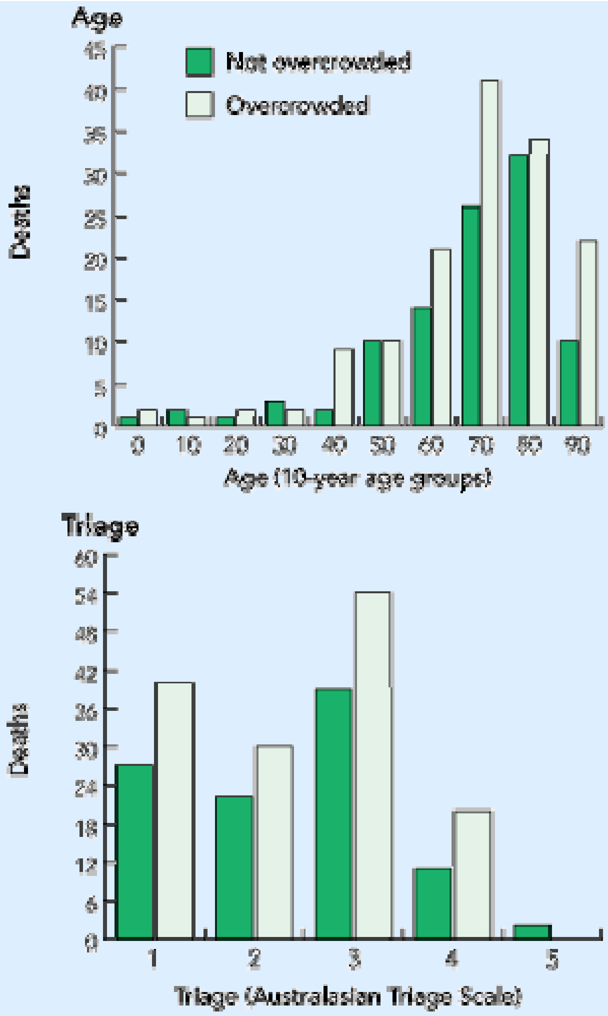


"Other" includes statistical admissions to the ED (admission paperwork completed without location change), as well as transfers and deaths. DNW = did not wait to be seen.



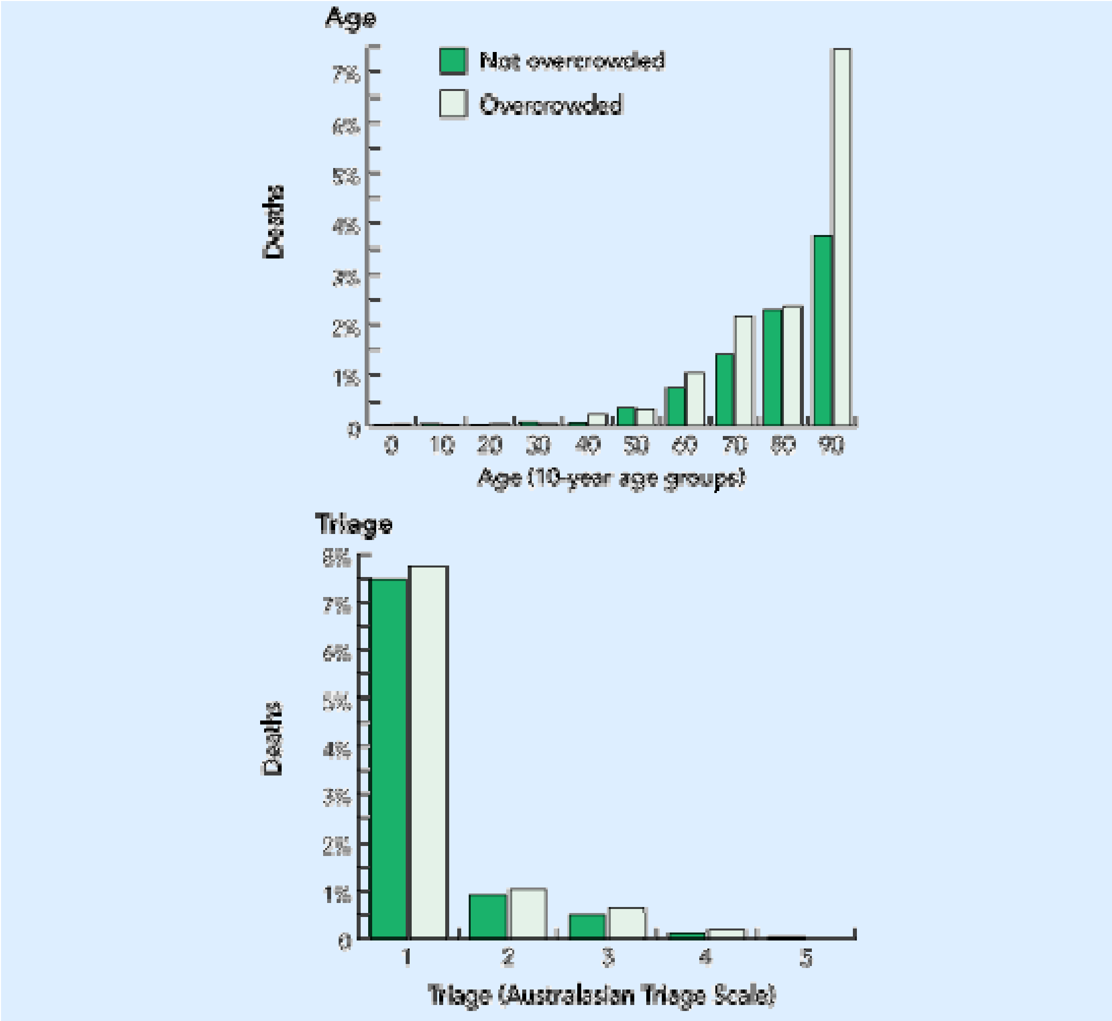
Access block (proportion of patients admitted after > 8 hours total time in ED), calculated here for admissions to the hospital wards only. The standard definition[11] would have included some of the “Other” patients but these data were not available in this statistical study.

4 Distribution of 10-day mortality by subgroup. The *y* axis represents the actual number of deaths in each subgroup in overcrowded (OC) and not overcrowded (NOC) cohorts

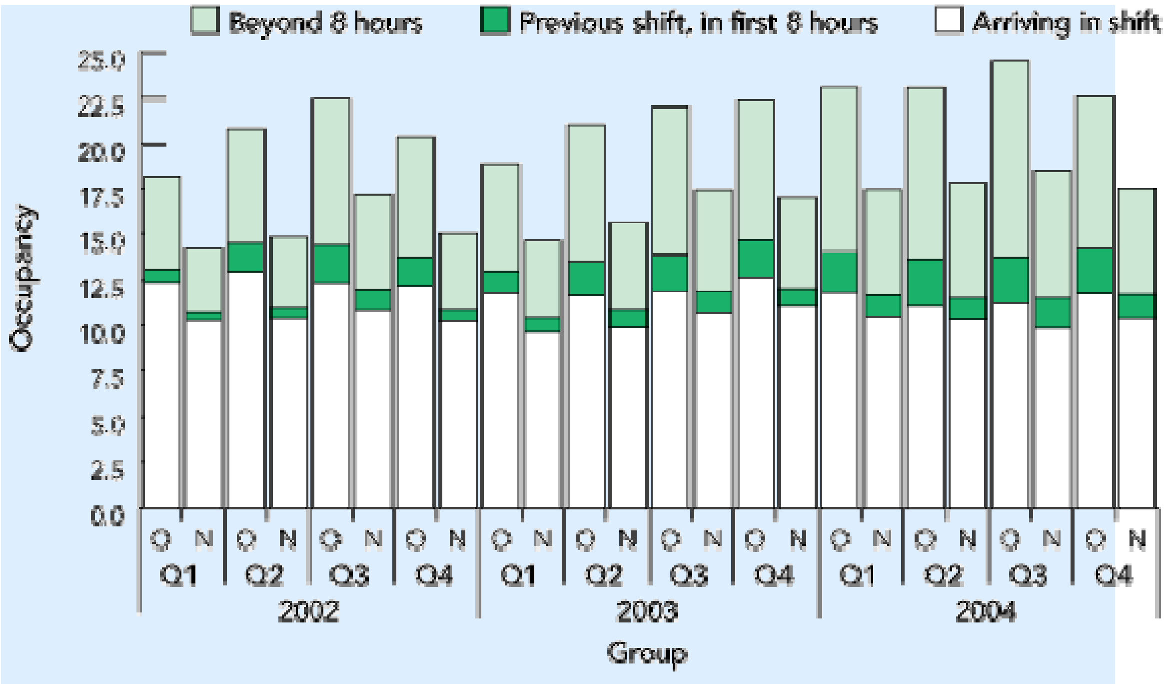


There were 7% more presentations and 43% more deaths in the OC cohort compared with the NOC cohort.

5 Absolute mortality rate by subgroup. The *y* axis represents the percentage mortality rate in that group. There was excess mortality even within triage category groups



6 Mean daily occupancy by quarter (Q) in overcrowded (O) and not overcrowded (N) shifts, categorised by patient time in the emergency department



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I would like to thank Dr Bruce Shadbolt for statistical input and advice.

Competing interests

None identified.

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Attachment 2

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Papers

Dynamics of bed use in accommodating emergency admissions: stochastic simulation model

Paper p *158*

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Abstract

Objective: To examine the daily bed requirements arising from the flow of emergency admissions to an acute hospital, to identify the implications of fluctuating and unpredictable demands for emergency admission for the management of hospital bed capacity, and to quantify the daily risk of insufficient capacity for patients requiring immediate admission.
Design: Modelling of the dynamics of the hospital system, using a discrete-event stochastic simulation model, which reflects the relation between demand and available bed capacity.
Setting: Hypothetical acute hospital in England.
Subjects: Simulated emergency admissions of all types except mental disorder.
Main outcome measures: The risk of having no bed available for any patient requiring immediate admission; the daily risk that there is no bed available for at least one patient requiring immediate admission; the mean bed occupancy rate.
Results: Risks are discernible when average bed occupancy rates exceed about 85%, and an acute hospital can expect regular bed shortages and periodic bed crises if average bed occupancy rises to 90% or more.
Conclusions: There are limits to the occupancy rates that can be achieved safely without considerable risk to patients and to the efficient delivery of emergency care. Spare bed capacity is therefore essential for the effective management of emergency admissions, and its cost should be borne by purchasers as an essential element of an acute hospital service.

Key messages

- Acute hospitals which operate at bed occupancy levels of 90% or more face regular bed crises, with the associated risks to patients
- Management interventions should focus on measures with long term benefits to counteract the growth trend in demand for admission
- Many initiatives have only a short term effect; they briefly delay the worst effects but do not address the growing mismatch between supply and demand
- Evaluating management interventions year on year at a single hospital is futile—any effects are swamped by random variation

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Introduction

Hospital provision for accommodating increasing numbers of emergency admissions is a matter of considerable public and political concern and has been the subject of widespread debate. [1 2] For several years hospital managers have been under pressure to reduce bed capacity and increase occupancy rates in the name of operational efficiency. More recently, public disquiet has arisen in cases where patients could not gain ready access to a local hospital or were subjected to extended delays while vacant beds were identified. An appreciation of the dynamics of the hospital system in its ability to respond to fluctuating demand is important in framing policy, determining appropriate levels of service provision, and establishing realistic performance monitoring criteria.

Systematic analysis of long term trends in emergency admissions has been most fully developed in Scotland by Kendrick et al, [3 4] but no comparable series has been published for England. A detailed analysis of hospital episode statistics for all diagnoses (excluding mental health) in England for the period 1989-90 to 1995-6, undertaken as part of the project reported here, showed a trend line for emergency admissions rising at 1.9% a year, of which only a quarter was attributable to changes in the size and composition of the population.[5] Elective admissions over the same period declined at a rate of 1.9% a year, while day cases rose by 16.3% a year. Occupied bed days declined by 4.6% a year for emergencies and by 5.4% a year for elective admissions.

Thus the balance between emergency and elective admissions has shifted in six years from 56%:44% to 61%:39%, with emergency patients now occupying 65% of the staffed beds available. Hospitals are thus faced with an increasing proportion of their inpatient work coming from the fluctuating and unpredictable demands of emergency admissions, and less coming from planned elective patients.

Analysis of hospital episode statistics shows that emergency admissions will continue to rise, probably at a similar rate in the future to that experienced in the past. Equally, the proportion of emergency admissions is also likely to increase, so that the proportion of bed capacity required for emergency work will continue to grow.

Lane et al have examined the impact of hour by hour demand on an accident and emergency department, with particular emphasis on long waiting times for admission,[6] but there is also a need to study the implications of the random nature of demand for emergency admission on a daily basis as it affects use of the bed stock. We are not aware of any recent published research with this emphasis.

Day to day fluctuations in emergency demand affect the quality of care and hospital efficiency, and an understanding of these effects is required to help in planning services and choosing operational interventions to alleviate problems and avoid crises.

Methods

Discrete-event stochastic simulation modelling is a well established management technique for investigating the behaviour of complex systems subject to random effects.[7] Such a model was developed, using a Microsoft Excel 5 spreadsheet, to explore the relation between randomly fluctuating demand for patient admission and available inpatient bed capacity. The model generates new arrivals for each day of a 1000 day period as random variations around a long term trend line, using an empirically derived normal distribution adjusted for seasonal and day of week variations. These patients are then accommodated as long as the hospital has a vacant bed. The model is designed to allow complex interactions to be explored (for example, random shocks such as flu epidemics, or feedback between discharge and admission rates), but these features are not reported in this paper.

The model has been further extended to encompass elective admissions sharing a common bed pool (including some designated elective beds), and an additional performance measure has been introduced to indicate the proportion of elective admissions cancelled each day. However, the effect of this change proved limited—some emergencies are admitted at the expense of cancelled electives but with no increase in the occupancy rates for the emergency bed pool. The simplicity of the emergencies-only model is preferred here as it serves to focus attention on the primary problem of rising emergency admissions for acute hospitals.

View this table: [in this window] [in a new window]	**Table 1.** Baseline values in model of randomly fluctuating demand for patient admission and available inpatient bed capacity

The model was calibrated to a notional baseline position by using data obtained from detailed analysis of admissions records and length of stay distributions at two NHS trusts (one city centre teaching hospital and one non-teaching hospital in a semirural post-industrial town) and was adjusted to represent a situation where the hospital is just beginning to experience significant operational risks in relation to accommodating emergency arrivals. The baseline values are shown in table 1.

A wide range of statistics can be derived from the model; the key output measures of system performance are the proportion of new arrivals for emergency admission who cannot be accommodated owing to lack of available beds; the proportion of days in a year when at least one patient requiring immediate admission cannot be accommodated (termed a crisis day); and the bed occupancy rates achieved. The level of risk to both patients and hospital is a function of the rate at which new emergency patients arrive at the hospital, the rate at which emergency patients are subsequently discharged, and the daily available bed capacity.

It was determined by experiment that a stable result was achieved when 100 repetitions of the model were carried out with different random numbers and the results aggregated. Eleven separate experiments were undertaken, in each of which a different factor was varied within a range of realistic values (table 2).

View this table: [in this window] [in a new window]	**Table 2.** Factors varied in experiments using model of randomly fluctuating demand for patient admission and available inpatient bed capacity

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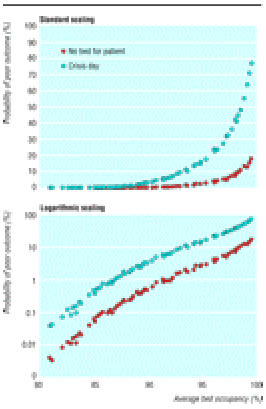
Results

Experiments 1-5 and experiment 10 were equivalent in terms of system dynamics; the figure shows the combined results. The level of risk for a hospital bed shortage is about four times that for an individual patient. Risks are minimal so long as the mean bed occupancy remains below about 85%. Above this level the risks become substantial (at 85%, a hospital can expect to be short of beds for admissions on four days in a year), and above a mean bed occupancy of 90% the system is regularly subject to bed crises.



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Relation of performance risks to average bed occupancy

Experiment 6 indicated that from very different initial bed occupancy positions all simulations converge to a relatively stable band within 14-16 days. Thus a hospital that experiences a day on which no further admissions can be accommodated can expect to recover its long term demand-capacity balance in a period approximately equal to twice the mean length of stay. This implies that even a relatively low risk of failure can disrupt the operation of the hospital for a considerable time: at 85% mean occupancy, a hospital that runs out of beds for four days in a year may be disrupted for up to eight weeks in total.

The results of experiments 7-9 show that risk increases as variability rises, seasonality being the most influential factor. Varying the size of the bed pool over a wide range (experiment 11) affects risk only for capacities below about 150 beds, and even then produces only modest increases in risk.

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Discussion

Management scientists have long been aware of the implications of queuing theory in systems with fixed or limited capacity. Thus our principal finding of a rapid increase in risk to patients and to the system at high occupancy levels is not unexpected.

Any model can capture only a limited range of the many contributory factors in real life, and models include various simplifying assumptions (such as the admission and discharge rate functions). Moreover we have intentionally reported only univariate experiments to show the relative importance of individual factors in the performance of the system. In reality these would all be operating together interactively, and additional complex organisational and psychological behaviours are likely to come into play as a hospital approaches maximum capacity. None the less, the results show how such responses may affect the system: if consultants seek to protect beds against mounting demand by delaying discharges, this will probably hasten the onset of a crisis, whereas action to discharge patients early may allow a crisis to be temporarily delayed.

Demand and capacity
The relation between demand, capacity, and the risk of failure is reflected in the average occupancy rate. At rates above 85% risks become discernible, and above 90% the hospital system is subject to regular bed crises. The average occupancy rate in acute hospitals in England was 78.9% in 1996-7,[8] and this is probably typical of the whole NHS. At a projected rate of growth in emergency bed days of 2.5% a year, this suggests that the NHS as a whole may be operating at 85% occupancy currently, and could exceed 90% by 2002-3.

However, little is known about the causes of the exogenous upward trend in the demand for emergency admission. Most suggested interventions have not been evaluated, and evidence on their relative effectiveness is scant. Indeed, some forms of intervention (educational programmes, telephone advice, admissions wards, etc) may actually increase admissions.[9-11]

Effect of interventions
It is important to distinguish between one-off interventions with only a short term impact and interventions that alter underlying trends. For example, the introduction of a rapid response team will not have a long term effect unless the capacity of the team is increased annually in line with the increase in demand.

Possible interventions to avoid or alleviate the effects of rising emergency admissions can be grouped into four categories: avoiding admissions (fewer patients presenting to the hospital), alternatives to admission (more non-hospital options available when patients present), better management of existing resources, and facilitating early discharge. The potential benefits of each can be assessed in the light of our findings from the model.

Policies designed to reduce the rate of growth in the demand for emergency admissions and those designed to provide alternatives to admission in the acute sector offer greatest long term benefit. Reducing the rate of growth of admissions (experiment 2) has the same effect as an equivalent annual increase in capacity (experiments 1 and 11). By combining the modelling results with future projections based on our analysis of hospital episode statistics,[5] we estimate that a reduction in the annual rate of growth of admissions of 1% has the effect of postponing by one year the time at which average occupancy in the acute sector reaches 85% and by three years the time at which average occupancy reaches 90%.

Management interventions designed to improve the efficiency with which current resources are used have the effect of increasing capacity (experiment 1). Such policies should be part of good management practice in all trusts, but most if not all of these interventions can be expected to lead to a one-off impact with little effect on the long term trend.

Facilitating earlier discharge has the effect of increasing capacity by reducing the average length of stay (experiment 5). However, the potential for further sustained reductions in average length of stay is likely to be finite and the long term potential of this type of policy is therefore limited.

It might be expected that where local hospitals cooperate in pooling capacity the situation could be eased. This may be true if different hospitals in the same area experience different pressures on the same day. However, if two units draw from the same catchment area, there may be little net benefit as they will only be reorganising the same capacity within a combined bed pool (experiment 11). It should also be recognised that where several hospitals are all operating close to maximum capacity, a crisis in one hospital can quickly be transmitted through the whole of the local system—the domino effect.

Difficulties in evaluation
The stochastic nature of emergency admissions has an important implication for attempts to evaluate management interventions. The performance of an acute hospital can vary considerably from one year to another solely as a result of the large fluctuations in demand, swamping the effects of policy or operational initiatives. Hence the meaningful evaluation of any measures taken to improve the performance of a single acute hospital in

relation to emergency admissions is not possible unless effects are monitored over a long period (typically 5-10 years) or across a very large sample of hospitals; year on year comparisons for one hospital are meaningless. The difficulty of carrying out such evaluations is an important justification for a modelling approach.

Emergency admissions are, by their nature, stochastic and difficult to predict. Our model shows that spare capacity is essential if an emergency admissions service is to operate efficiently and at a level of risk acceptable to patients. Emergency admission crises are not generally created by poor management. With insufficient spare bed capacity even the best run hospital is at risk. It must be recognised by the NHS that maintaining some unoccupied staffed beds is not wasteful, but is a cost which must be incurred if a quality service is to be sustained.

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Contributors: AB directed the design of the model, carried out the experiments, synthesised the results, and drafted and edited the paper; MP developed and tested the model structure, carried out data analysis and model calibration, and participated in writing and editing the paper; JWP initiated the project, contributed to conceptual discussions, analysed the policy implications, and participated in writing and editing the paper. All authors are guarantors for the paper.

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