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

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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.

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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

FOR EDITORIAL COMMENT, SEE PAGE 203. SEE ALSO PAGE 208.

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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.

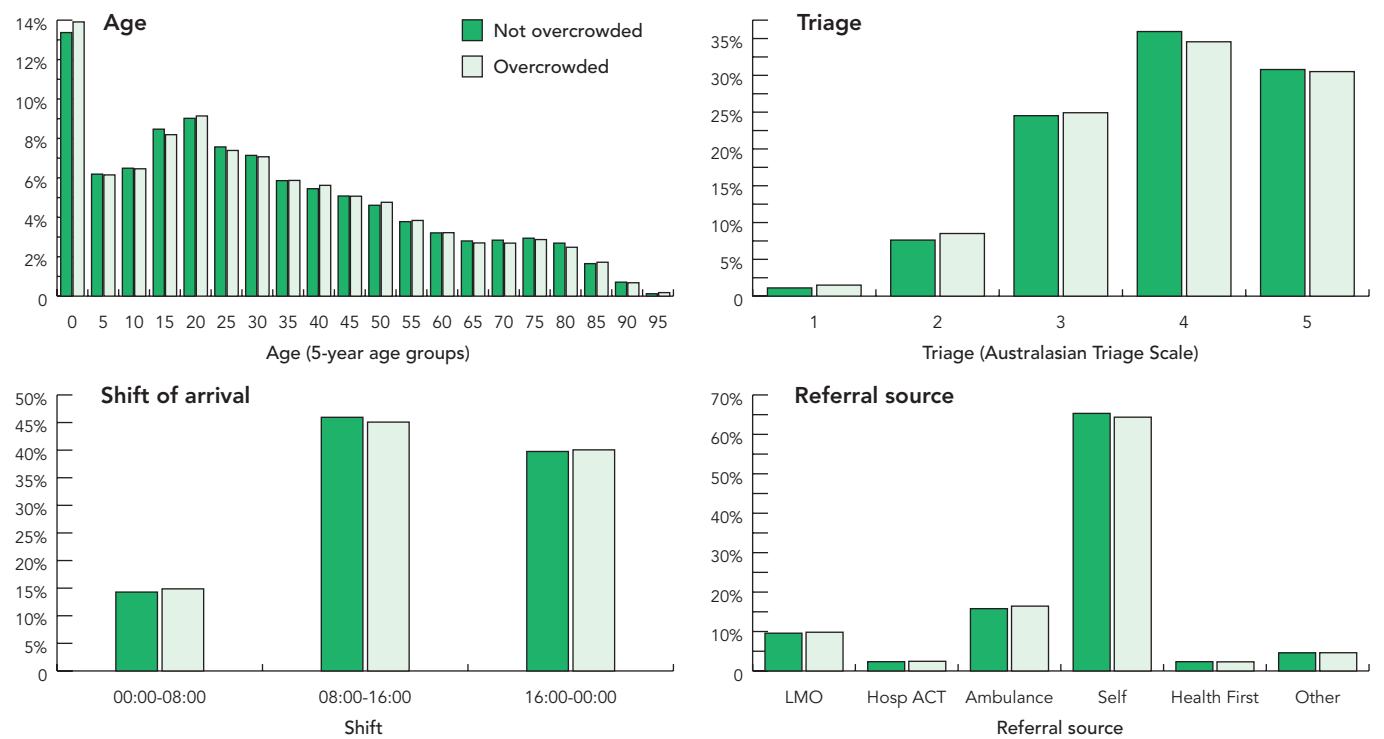
The primary outcome was in-hospital death within 10 days of presentation, defined as an ED disposition code of "died in ED" or an admission separation code of "died". Patients arriving in the ED with no signs of life, or with cardiopulmonary resuscitation in progress, were excluded from the primary outcome.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

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. † $P = 0.10$. ‡ $P = 0.13$. ◆

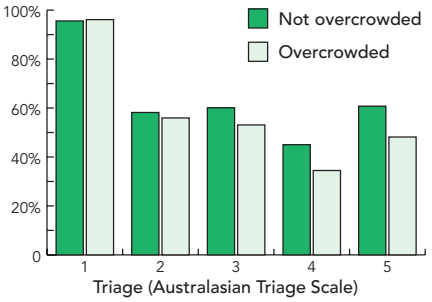
2 Characteristics of the patient cohorts presenting in overcrowded and not overcrowded shifts



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

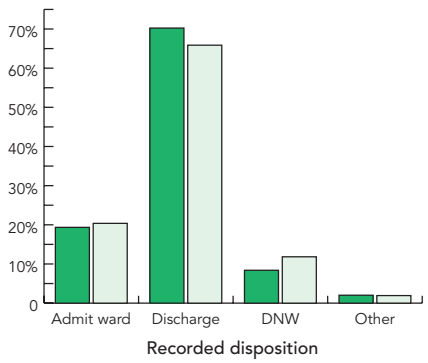
3 Standard performance indicators

Starting treatment within triage threshold



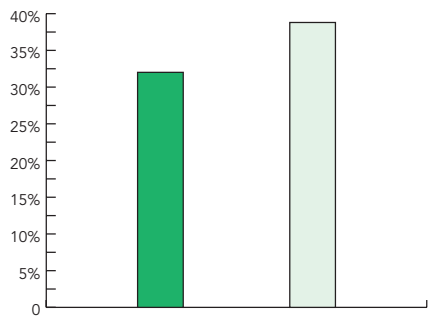
Proportion of patients presenting to the emergency department (ED) whose medical assessment and treatment began within the triage thresholds defined by the Australasian College for Emergency Medicine[9] and the Australian Council on Healthcare Standards.[10]

Disposition



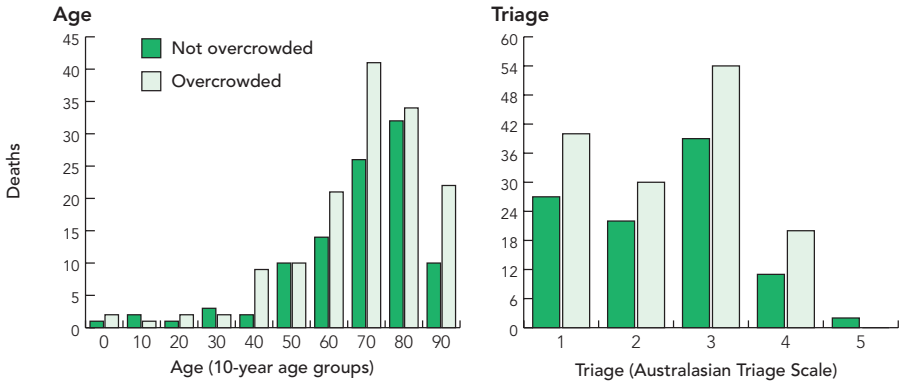
"Other" includes statistical admissions to the ED (admission paperwork completed without location change), as well as transfers and deaths. DNW = did not wait to be seen.

Access block — hospital ward admission



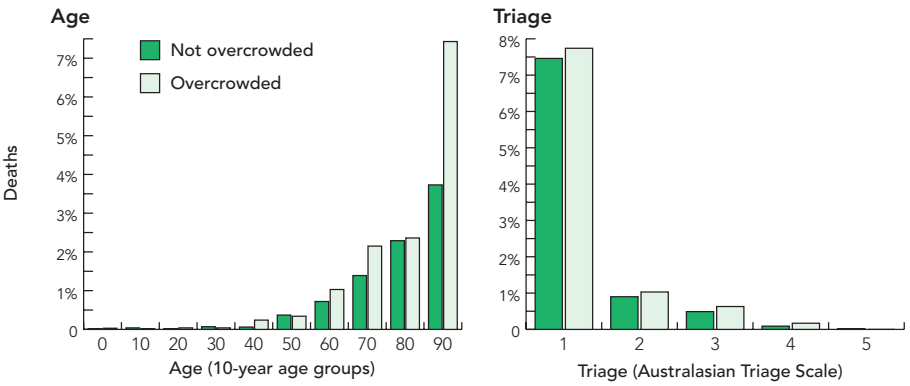
Access block (proportion of patients admitted after > 8 hours total time in ED), calculated here for admissions to the hospital wards only. The standard definition[11] would have included some of the "Other" patients but these data were not available in this statistical study. ◆

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



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).

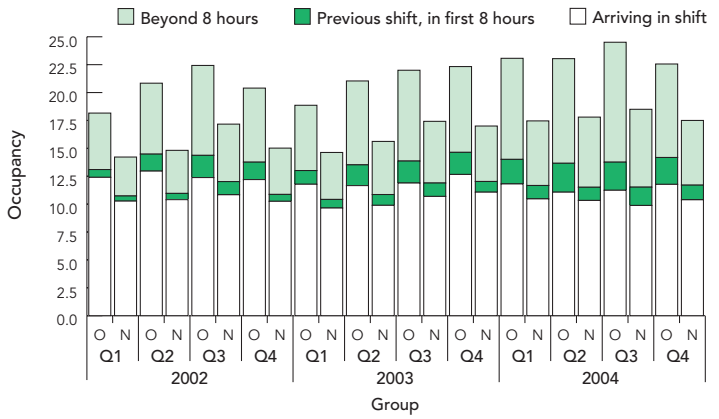
DISCUSSION

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).

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



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.

ACKNOWLEDGEMENTS

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COMPETING INTERESTS

None identified.

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