Unplanned admission to the intensive care unit in the very elderly and risk of in-hospital mortality

Steven A Frost, Patricia M Davidson, Evan Alexandrou, Leanne Hunt, Yenna Salamonson, Victor Tam, Michael J A Parr, Anders Aneman and Ken M Hillman

ABSTRACT

Background: Unplanned admission to the intensive care unit has been shown to significantly increase the risk of in-hospital mortality. Medical advances and increased expectations have resulted in a greater number of very elderly patients (80 years and over) being admitted to the ICU. The risk of in-hospital death associated with unplanned admission to the ICU in very elderly patients has not been clearly defined.
Objective: To estimate the risk of in-hospital mortality associated with unplanned admission to the ICU in patients aged 80 years and over.
Design, setting and participants: Retrospective review of an adult intensive care database. The setting was Liverpool Hospital, a large teaching hospital in Sydney, Australia, with a 28-bed ICU that has about 2000 admissions per year. We analysed data on very elderly patients ($n = 1680$), aged 80 years or more, admitted to the ICU between 1 January 1997 and 31 December 2007.
Main outcome measures: Baseline risk factors for in-hospital mortality.
Results: Mortality among patients with unplanned ICU admissions was 47%, compared with 25% in patients with planned admissions (adjusted rate ratio [RR], 1.92 [95% CI, 1.59–2.32]). An estimated 50% of the overall risk of in-hospital death among very elderly patients was attributable to a combination of unplanned admission to the ICU, the presence of at least one comorbid condition, acute renal failure and respiratory failure requiring intubation.
Conclusion: Unplanned admission to the ICU increases the risk of in-hospital mortality in very elderly patients. At least 50% of the risk of in-hospital death in this age group is attributable to a combination of unplanned ICU admission, comorbidity ($\geqslant$ 1 comorbid condition), acute renal failure and respiratory failure.

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Unplanned admission to the intensive care unit has been shown to significantly increase the risk of in-hospital mortality.[1-4] Improved treatment and outcomes in intensive care medicine within the context of an ageing population have resulted in an increasing number of the very elderly (aged 80 years or more) being admitted to the ICU.[5,6] The increased need for intensive care management in the very elderly may be in conflict with a competitive level of service availability, with increasing economic pressure to control mounting health costs.[7] Although many admissions are planned, such as for increased monitoring after elective surgery, a significant increased risk of in-hospital mortality has been recognised in patients admitted unexpectedly to the ICU from general wards areas of the hospital.[2,8] Outcomes for very elderly patients requiring intensive care therapy have been shown to be strongly determined by the elective nature of the admission. Age alone has not been found to be a strong predictor of poor outcomes.[6,9,10]

Importantly, the absolute risk associated with unplanned admission to the ICU and in-hospital mortality has not been extensively described. Assessment of absolute risk of in-hospital death in the very elderly is needed to reduce the risk of futile treatments and unnecessary suffering and uncertainty for patients. Many unplanned admissions to the ICU are related to the lack of advance care planning, and it is important that both clinicians and patients have accurate information to weigh the risks of admission to the ICU. Death may occur in an environment that is potentially not conducive to optimal end-of-life care.

The aim of our study was to estimate the relative and absolute risks of in-hospital mortality associated with unplanned versus planned admissions to the ICU in very elderly patients.

Methods

We conducted a retrospective review of the adult intensive care database of Liverpool Hospital, a large teaching hospital in south-western Sydney, Australia. The hospital has a 28-bed ICU with about 2000 admissions per year. All patients aged $\geqslant$80 years who were admitted to the ICU between 1 January 1997 and 31 December 2007 were included in our analysis. Our study was approved by the Institutional Ethics Committee of the study hospital.

The outcome of interest was in-hospital mortality. Overall hospital mortality was chosen over ICU mortality because most deaths in patients aged $\geqslant$80 years admitted to the study hospital's ICU are transferred from the ICU before death. Risk factors for in-hospital mortality were derived from routinely collected intensive care data and extracted from hospital-wide inpatient data for all patients aged 80 years or more at the time of admission to the ICU. The main risk factor of interest was unplanned admission to the ICU, which was defined as non-elective admission to the ICU from general wards of the hospital. "Unplanned" admissions did not include patients admitted directly to the ICU from the emergency department, operating theatre, or other hospitals or ICUs. APACHE II (Acute Physiology and Chronic Health Evaluation II) scores and SAPS II (Simplified Acute Physiology Score II) values were calculated on admission to the ICU.[11,12] Acute renal failure was defined as a 24-hour urine output < 410 mL, serum creatinine level > 133 µmol/L and absence of dialysis therapy before ICU. Patients were defined as "intubated" if they had an artificial airway at the time of the first blood gas sampling in the ICU.

Comorbid conditions at the time of hospital admission were identified using diagnostic codes from previous hospital admissions. A cumulative Charlson comorbidity index was calculated using hospital emergency department and inpatient data from July 1996. (For a list of International classification of diseases, 10th revision [ICD-10] codes and the method used to calculate the Charlson index, see Appendix.) Data were analysed using SAS version 9.1 (SAS Institute, Carey, NC, USA).

Statistical analysis

Relative risk (and 95% CIs) for in-hospital death associated with characteristics of patients at admission to the ICU were estimated using log-binomial regression.[13,14] As ICU admission type (planned or unplanned) was the main risk factor of interest, it was forced into all regression models along with sex and age. Other important factors present at admission to the ICU that were associated with in-hospital mortality, and therefore potential confounders, were identified using bootstrap methods.[15] Each bootstrap incorporated a backward-deletion method to identify potential confounders of the relationship between unplanned ICU admission and in-hospital mortality. A generous *P* value (0.2) was used to retain factors, using small bootstrap samples from the entire dataset (*n* = 50). This procedure was repeated 200 times to assess the frequency with which potential confounders were selected. Factors retained in at least 70% of the bootstrap samples were included in the final model.[15] All analysis was undertaken using the R statistical language. Potential effect modification of the relationship between admission type and in-hospital mortality by other important factors associated with in-hospital mortality (including year of admission) was assessed using interaction terms. Using a 5% level of significance for interaction terms, no effect modification was observed.

Table 1. Characteristics of very elderly patients (aged ⩾ 80 years) at the time of admission to the ICU, by admission status

Characteristics	Unplanned ICU admission (*n* = 349)	Planned ICU admission (*n* = 1331)	*P*
Mean age in years (SD)	84 (3)	84 (4)	1.000
Male, *n* (%)	196 (56%)	671 (50%)	0.050
Charlson index, *n* (%)			0.007
0	243 (70%)	1016 (76%)	
1–2	42 (12%)	153 (11%)	
3–4	44 (13%)	95 (7%)	
⩾ 5	20 (6%)	67 (5%)	
Median days in hospital prior to ICU (IQR)	3 (1.2–6.8)	0.4 (0.2–1.3)	< 0.001
Prior hospital admission status, *n* (%)			0.021
No admission in previous12 months	205 (59%)	900 (68%)	
Within previous 28 days	49 (14%)	139 (10%)	
Within previous 1–6 months	59 (17%)	197 (15%)	
Within previous 6–12 months	36 (10%)	95 (7%)	
Mean APACHE II score (SD)	20.9 (7.9)	17.9 (8.9)	< 0.001
Median SAPS II score (IQR)	45 (35–59)	36 (29–48)	< 0.001
Acute renal failure, *n* (%)	10 (3%)	23 (2%)	0.170
Intubated, *n* (%)	117 (34%)	540 (41%)	< 0.001
Median days in ICU (IQR)	2.0 (0.7–3.8)	1.9 (1.0–3.9)	0.026
In-hospital mortality, *n* (%)	163 (47%)	329 (25%)	< 0.001

APACHE = Acute Physiology and Chronic Health Evaluation. ICU = intensive care unit. IQR = interquartile range. SAPS = Simplified Acute Physiology Score.

In an attempt to estimate the proportion of the total risk of in-hospital mortality that could be ascribed to unplanned admission to the ICU alone (adjusted for confounders), and in combination with other important risk factors, partial attributable risks were calculated using the pARccs R-package.[16] Confidence intervals for all partial attributable risks were estimated using bootstrap methods. Kaplan–Meier survival curves[17] were developed to assess the difference in survival of patients based on ICU admission status. The difference between planned and unplanned ICU admissions in probability of survival after ICU was tested using a log-rank test.[18]

Results

During the study period, 1680 patients (813 women, 867 men) aged ⩾ 80 years were admitted to the study hospital's ICU. Characteristics of patients at the time of admission to the ICU, based on ICU admission status, are presented in Table 1. The mean age of patients with unplanned and planned admissions was 80 years in both groups. Male patients made up a greater proportion of unplanned admissions (56%) than planned admissions (50%) ($P = 0.05$). Thirty per cent of patients with unplanned ICU admissions had at least one Charlson comorbidity compared with 24% in planned admissions ($P = 0.007$). Median time in hospital before ICU admission was greater in the unplanned admission group (3 days) than in the planned admission group (0.4 days) ($P < 0.001$). A greater proportion of patients in the unplanned ICU admission group had been previously admitted to the study hospital in the 12-month period before the index admission that included an ICU stay ($P = 0.021$).

Patients with unplanned admissions had higher severity-of-illness indices at the time of admission to the ICU (mean APACHE II score, 20.9 v 17.9 [$P < 0.001$]; median SAPS II score, 45 v 362 [$P < 0.001$]). The prevalence of acute renal failure at ICU admission was similar in both groups ($P = 0.17$). Patients with unplanned ICU admission were less likely to be intubated at the time admission (34% v 41% [$P < 0.001$]). Overall in-hospital mortality was greater in the unplanned admission group (47% v 25% [$P < 0.001$]).

Table 2. Estimates of risk (rate ratios and 95% CI) for in-hospital mortality associated with unplanned admission to the ICU

	Died : survived (% died)	Unadjusted RR (95% CI)	Adjusted RR (95% CI)	*P*
Admitted to ICU from ward, *n*	163 : 186 (47%)	1.89 (1.57–2.28)	1.92 (1.59–2.32)	< 0.001
Age*		1.13 (0.91–1.40)	1.24 (1.00–1.54)	0.061
Sex, *n*				0.926
Male	260 : 607 (30%)	1.00†	1.00†	
Female	232 : 581 (29%)	0.95 (0.80–1.14)	1.01 (0.88–1.20)	
Charlson index, *n*				
0	348 : 905 (28%)	1.00†	1.00†	
1–2	57 : 141 (29%)	1.04 (0.78–1.37)	1.03 (0.78–1.36)	
3–4	52 : 84 (38%)	1.38 (1.03–1.84)	1.42 (1.06–1.90)	
⩾ 5	35 : 58 (38%)	1.36 (0.96–1.92)	1.43 (1.01–2.03)	
P (trend)				0.024
Intubated at admission to ICU, *n*	257 : 400 (39%)	1.70 (1.43–2.03)	1.88 (1.21–2.92)	< 0.001
ARF, *n*	21 : 12 (64%)	2.23 (1.44–3.45)	1.82 (1.52–2.17)	0.010

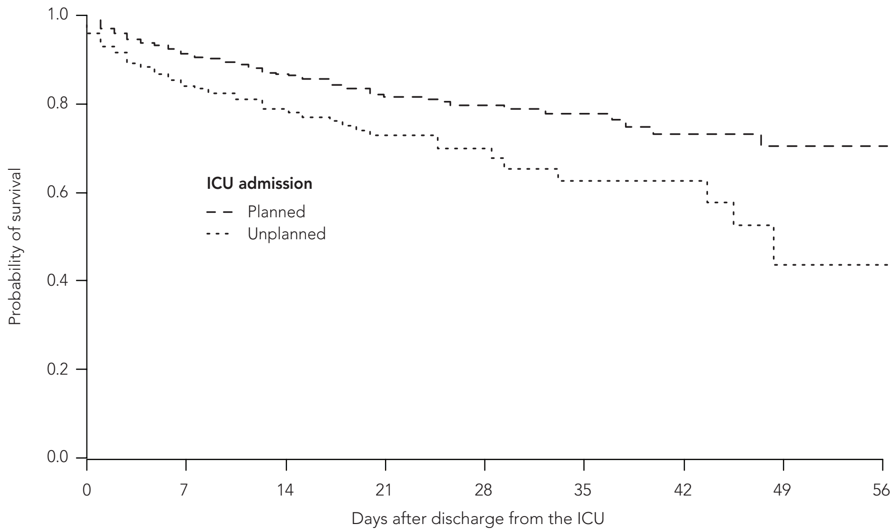
ARF = acute renal failure. ICU = intensive care unit. RR = rate ratio.
* For each 10-year increase. † Reference value.

Table 3. Absolute and partial attributable risks of in-hospital mortality in very elderly patients admitted to the ICU, by admission status, Charlson comorbidity index, presence/absence of acute renal failure, and intubation status at time of admission

Unplanned ICU admission	Charlson index ⩾ 1	ARF	Intubated at admission	Absolute risk of death (%) (95% CI)	pAR (%)
N	N	N	N	17% (14%–21%)	0
N	N	N	Y	33% (28%–38%)	30%
N	N	Y	N	45% (26%, 64%)	3%
N	N	Y	Y	66% (49%, 83%)	32%
N	Y	N	N	19% (15%, 23%)	4%
N	Y	N	Y	36% (30%, 42%)	33%
N	Y	Y	N	48% (28%, 67%)	7%
N	Y	Y	Y	68% (51%, 85%)	35%
Y	N	N	N	38% (32%, 45%)	22%
Y	N	N	Y	59% (52%, 67%)	47%
Y	N	Y	N	70% (54%, 87%)	24%
Y	N	Y	Y	85% (75%, 95%)	48%
Y	Y	N	N	41% (34%, 48%)	24%
Y	Y	N	Y	62% (54%, 40%)	48%
Y	Y	Y	N	73% (57%, 89%)	27%
Y	Y	Y	Y	86% (77%, 96%)	50%

ARF = acute renal failure. ICU = intensive care unit. N = no. pAR = partial attributable risk. Y = yes.

Figure 1. Probability of survival after discharge from the intensive care unit based on ICU admission status*



* Log-rank test for difference in survival between unplanned and planned admissions, $P < 0.001$.

patients surviving the ICU is presented as Kaplan–Meier curves in Figure 1. The risk of death was higher in the unplanned admission group ($P < 0.001$ for log-rank test), and appeared to remain constant throughout the period after discharge from the ICU.

Crude and adjusted relative risks (as rate ratios [RRs]) of in-hospital mortality due to unplanned admission to the ICU are presented in Table 2. After adjustment for age, sex and comorbid conditions, the risk of in-hospital death in unplanned admissions was two times higher than in planned admissions (RR, 1.92 [95% CI, 1.59–2.32]). Other important factors present at the time of admission to the ICU are also presented in Table 2. For example, the risk of death increased by 1.2 times for each 10-year increase in age (adjusted RR, 1.24 [95% CI, 1.00–1.54]). A higher Charlson index increased the risk of in-hospital mortality (adjusted RR [for Charlson index ⩾ 5 v 0], 1.43 [95% CI, 1.01–2.03]; P for trend = 0.024). Being intubated at the time of ICU admission increased the risk of in-hospital mortality by 1.9 times (adjusted RR, 1.88 [95% CI, 1.21–2.92]), and the presence of acute renal failure increased the risk by 1.8 times (adjusted RR, 1.82 [95% CI, 1.52–2.17]).

Absolute and partial attributable risks of in-hospital mortality as a function of Charlson index category, the presence of acute renal failure and intubation status at the time of unplanned ICU admission are presented in Table 3. After adjustment for potential confounders, the partial attributable risk (pAR) of unplanned admission to the ICU and in-hospital mortality was estimated to be 22% (95% CI, 15%–24%). The highest absolute risk (86% [95% CI, 77%–96%]) and pAR (50% [95% CI, 41%–57%]) were estimated to be among very elderly patients with unplanned admission to the ICU, with a Charlson index of ⩾ 1, with acute renal failure, who were intubated at the time if ICU admission. The risk of in-hospital mortality in

Discussion

Although well described in adult critical care settings,[1,2] the risk associated with unplanned admission to the ICU and in-hospital mortality has not been extensively described in very elderly patients. Our study found the risk of in-hospital death to be about two times greater in the very elderly with unplanned admission to the ICU from general wards areas compared with planned admissions to the ICU among patients of a similar age. An estimated 50% of the risk of in-hospital mortality is attributable to unplanned ICU admission in combination with comorbid conditions and organ failure (such as acute renal failure and respiratory failure) prior to ICU admission.

Even though mortality risk prediction in very elderly patients admitted to the ICU has been explored,[19,20] there is little in the literature about the risk associated specifically with unplanned admission from general ward areas, particularly within the context of the chronic illness trajectory. Our results, in common with previous studies,[6] showed that increasing age alone was not a strong predictor of in-hospital mortality. But in contrast with previous studies, we were able to estimate the independent risks associated with unplanned admission to the ICU and in-hospital mortality. With increased longevity among women and men throughout the world, the use of ICUs to care for the very elderly is increasingly of concern. This underscores the importance of advance care planning for patients with chronic illnesses and of ensuring that patients and their families have an accurate picture of the prognosis.

Our results should be considered in the context of several potential limitations. Firstly, we sought to confirm the relationship between unplanned admission to the ICU and risk of in-hospital mortality. To achieve this, all confounders of this relationship needed to be identified. As functional status plays an important role in determining the outcomes of elderly patients admitted to the ICU,[9] some residual confounding may have been present in our estimation of effect. However, the area under the receiver operating characteristic curve in our final model (0.76) was fairly high, and the correlation between predicted and observed frequencies of in-hospital death was high (Spearman rank correlation coefficient, 0.52). These results suggest that any factor omitted from our analysis would have played a small role in confounding the relationship between unplanned ICU admission and in-hospital death. Another important limitation may have been underestimation of comorbid status, which would have led to residual confounding. However, the discriminatory ability and calibration of the final model suggest that there was little, if any, residual effect of underestimation of comorbid status on the relationship between unplanned ICU admission and in-hospital mortality. Another potential weakness of our study was the possible underestimation or misclassification of acute renal failure. The definition we used differed from more recent thorough and robust descriptions of acute renal failure such as that used by Bellomo et al.[21]

An important strength of our study was the large number of consecutive admissions to the ICU over a 10-year period ($n = 1680$). We also had access to extensive data routinely collected at both the ICU and hospital level, allowing the identification of potential factors related to increased mortality in very elderly patients admitted to the ICU.

An important implication of our findings is that a significant proportion of the risk of in-hospital mortality in very elderly patients requiring ICU treatment may be attributed to unplanned admission, in-hospital organ failure and the presence of comorbid conditions. Obviously, the risk needs to be decided on an individual basis. However, it is of significant interest that patients with pre-existing comorbid conditions and acute failure in other systems represent a very high-risk group when coupled with being very elderly. Further studies exploring these associations, including economic analyses and patient perceptions, are warranted.

Anecdotally, the decision to admit patients to the ICU is often based on pressure from families and/or referring clinicians. The decision can leave clinicians and family members distressed, particularly if there is a perception of futility and unnecessary suffering. Identifying patients at risk and communicating effectively are important strategies for avoiding crisis admissions.

Conclusion

Our study showed a significant independent risk of in-hospital mortality associated with an unplanned admission to the ICU in very elderly patients. At least 50% of the risk may be attributable to the unplanned admission, the presence of comorbidities, and acute organ failure. These data may help clinicians to communicate likely outcomes and to assess the benefit of admission of very elderly patients to the ICU.

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Author details

Steven A Frost, Lecturer[1,2]
Patricia M Davidson, Professor[3]
Evan Alexandrou, Clinical Nurse Specialist,[1] and Lecturer[3]
Leanne Hunt, Registered Nurse[1,3]
Yenna Salamonson, Associate Professor[2]
Victor Tam, Staff Specialist in Intensive Care[1]
Michael J A Parr, Director of Intensive Care[1,4]
Anders Aneman, Staff Specialist in Intensive Care,[1] and Associate Professor[2]
Ken M Hillman, Professor of Intensive Care,[1] and Director, Simpson Centre for Health Services Research[4]

1 Department of Intensive Care, Liverpool Hospital, Sydney, NSW.
2 University of Western Sydney, Sydney, NSW.
3 Centre for Cardiovascular and Chronic Care, Curtin University of Technology, Sydney, NSW.
4 University of New South Wales, Sydney, NSW.

Correspondence: s.frost@uws.edu.au

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Appendix. Charlson index and diagnostic codes

Charlson index

Charlson index was estimated as a function of concomitant diseases, with each being weighted by a coefficient as follows:

AMI + CHF + PVD + DEM + CVD + CPD + RHE + PU + DM + HEP1 + (HP × 2) + (REN × 2) + (DMCC × 2) + (MAL × 2) + (HEP2 × 3) + (MST × 6) + (HIV × 6),

where AMI = acute myocardial infarction, CHF = congestive heart failure, PVD = peripheral vascular disease, DEM = dementia, CVD = cerebrovascular disease, CPD = chronic pulmonary disease, RHE = rheumatological disease, PU = peptic ulcer, DM = diabetes, HEP1 = mild liver disease, HP = hemiplegia/paraplegia, REN = renal disease, DMCC = diabetes with chronic complications, MAL = malignancy, HEP2 = moderate or severe liver disease, MST = metastatic solid tumour, and HIV = human immunodeficiency virus disease or AIDS.

Comorbid conditions (ICD-10 diagnosis codes)

Myocardial infarction	I21, I22, I23, I25.2
Congestive heart failure	I50, I11.0, I13.0, I13.2
Peripheral vascular disease	I70, I71, I72, I73, I74, I77
Cerebrovascular disease	I60–I69, G45, G46
Dementia	F00–F03, F05.1, G30
Pulmonary disease	J40–J47, J60–J67, J68.4, J70.1, J70.3, J84.1, J92.0, J96.1, J98.2, J98.3
Connective tissue disease	M05, M06, M08, M09, M30–36, D86
Peptic ulcer	K22.1, K25–K28
Liver disease	B15.0, B16.0, B16.2, B18, B19.0, K70–K74, K76.0, K76.6, I85
Diabetes	E10-E11
Hemiplegia/paraplegia	G81, G82
Renal disease	I12, I13, N00–N05, N07, N11, N14, N17–N19, Q61
Malignant conditions	C00–C96
Obesity	E65, E66
Pancreatitis	K85, K86.0, K86.1
Alcoholism and alcoholism-related conditions	F10, G31.2, G62.1, G72.1, I 42.6, K29.2, R78.0, T51, Z72.1

ICD-10 = International classification of diseases (10th revision).