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CRITICAL CARE

Predicting death and readmission after intensive care discharge

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Background. Despite initial recovery from critical illness, many patients deteriorate after discharge from the intensive care unit (ICU). We examined prospectively collected data in an attempt to identify patients at risk of readmission or death after intensive care discharge.

Methods. This was a secondary analysis of clinical audit data from patients discharged alive from a mixed medical and surgical (non-cardiac) ICU.

Results. Four hundred and seventy-five patients (11.2%) died in hospital after discharge from the ICU. Increasing age, time in hospital before intensive care admission, Acute Physiology and Chronic Health Evaluation II (APACHE II) score, and discharge Therapeutic Intervention Scoring System (TISS) score were independent risk factors for death after intensive care discharge. Three hundred and eighty-five patients (8.8%) were readmitted to intensive care during the same hospital admission. Increasing age, time in hospital before intensive care, APACHE II score, and discharge to a high dependency unit were independent risk factors for readmission. One hundred and forty-three patients (3.3%) were readmitted within 48 h of intensive care discharge. APACHE II scores and discharge to a high dependency or other ICU were independent risk factors for early readmission. The overall discriminant ability of our models was moderate with only marginal benefit over the APACHE II scores alone.

Conclusions. We identified risk factors associated with death and readmission to intensive care. It was not possible to produce a definitive model based on these risk factors for predicting death or readmission in an individual patient.

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Despite initial recovery from critical illness requiring intensive care unit (ICU) admission, many patients remain at risk of subsequent deterioration and death. This may result in readmission to ICU or death on another ward or during the ICU readmission. Early identification of patients at the highest risk would allow resources to be targeted appropriately and prevent avoidable morbidity and mortality. ICU readmission rates have been advocated as a marker of ICU quality on the basis that early readmissions (within 48 h) may indicate premature discharge or discharge to an inappropriate clinical area.[1 2] Although using readmission rates as a quality indicator remains controversial,[3] early readmissions are certainly a group who merit special attention. They have disproportionately high hospital mortality[4–7] and include patients in whom deterioration could probably have been avoided. Some may have been discharged prematurely from ICU due to either clinical resource limitations or poor discharge planning.[5 6] Similarly, some deaths after ICU may be preventable.[8] Interventions aimed at reducing readmission or death after ICU requires timely identification of patients at highest risk. At present, there is no validated scoring system to predict readmission or death after ICU discharge.

We aimed to determine whether we could utilize prospectively collected clinical data to identify which patients are at high risk of readmission or death after ICU discharge. Identification of these patients before they leave

the ICU might allow these patients to be kept in ICU for a further period, to triage the patient to an appropriate level of ongoing care, and to focus efforts in identifying early signs of deterioration.[9]

Methods

Local research ethics committee approval was not required as the study was a secondary analysis of routinely collected and anonymized clinical audit data. We analysed the existing Scottish Intensive Care Society Audit Group database of all admissions to a single mixed medical–surgical ICU over a 10 yr period from January 1995 to January 2005. The ICU in Aberdeen operates as a closed unit led by consultants in intensive care medicine. There are no strict protocols governing admission and discharge policies. Patients from all adult medical and surgical specialties are accommodated with the exception of cardiac surgery patients who are cared for in a separate unit. A small number of postoperative cardiac patients requiring a prolonged stay for non-cardiac complications are transferred from the cardiac ICU. Data are collected prospectively using Ward Watcher™ software (Critical Care Audit Ltd, Yorkshire, UK). Data recorded include patient age, sex, hospital and ICU admission diagnosis, severity of illness scoring [Acute Physiology and Chronic Health Evaluation (APACHE) II and Simplified Acute Physiology Score (SAPS) II], date and time of unit and hospital admission and discharge, and patient outcome up to hospital discharge. The study cohort comprised adult patients (>16 yr) admitted during this period. These patients were considered as a derivation cohort to attempt to identify factors associated with death and readmission to the ICU. In order to study the number of patients readmitted rather than the number of readmissions, only the first ICU admission during the same hospital admission was analysed. Patients who died during their first ICU admission were excluded from analysis because they were not at risk of readmission or death after ICU. Patients who were recorded as discharged for palliative care or expected to die (as assessed by their consultant in intensive care medicine) were also excluded from the main analysis (Fig. 1). These patients and those who died in ICU were included only in the presentation of baseline data.

Three different outcome groups were examined: patients who died after ICU discharge; patients who were readmitted within 48 h of ICU discharge (early readmissions); and patients who were readmitted at any time during the same hospital admission. Patients falling into more than one of these poor outcome groups were included in each category since their outcome could not be identified prospectively. Data relating to each outcome category should therefore be interpreted independently.

APACHE II[10] and SAPS II scores[11] were calculated using standard methods during the first 24 h of the first ICU admission. SAPS II has been found to have the best overall performance and APACHE II to have the best calibration when various severity of illness scoring systems were tested in a large Scottish ICU database to predict hospital mortality.[12] Daily Therapeutic Intervention Scoring System (TISS) scores[13] were recorded over each 24 h period during ICU admission.

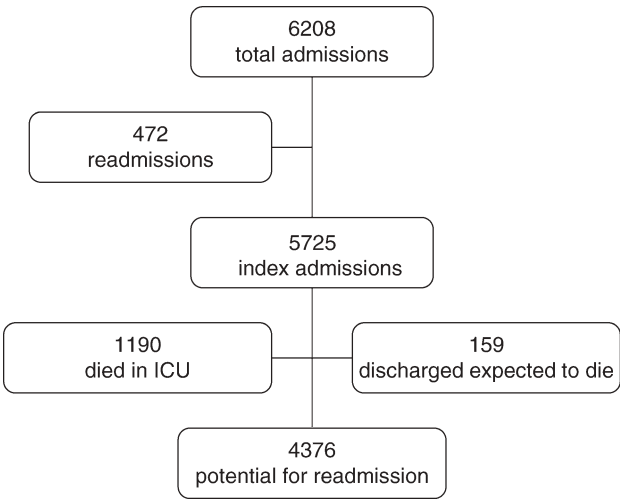

Fig 1 Flow diagram of patients included in study cohort.

Data are presented as median (inter-quartile range) or as the number of cases and the proportion as appropriate. The association of individual factors was assessed separately in a simple logistic regression model for each of the outcomes in turn. We then used a multivariable logistic regression to evaluate the relationship between potential variables and outcome.

Gender and age were included in the multivariable analyses. Other predictor variables were included in multivariable logistic regression model if they were associated with ICU readmission or death with $P \leq 0.2$ in the simple logistic regression analysis. An *a priori* decision was made that variables with more than 5% missing data or with obvious co-linearity were not entered into multivariable logistic regression model. SPSS version 14 was used for analysis. A base case analysis which included only the APACHE II score was also performed for each outcome. Calibration and discrimination of the prediction model were assessed using Hosmer and Lemeshow goodness of fit test and the area under the curve (AUC), respectively. Nagelkerke R^2 statistic was also calculated.

Results

Over a 10 yr period, there were 6208 adult (≥16 yr) admissions, of which 5725 were index admissions (first admission in a single episode of hospital admission). One thousand one hundred and ninety patients died during their first ICU admission. One hundred and fifty-nine were recorded as discharged for palliative care or were expected

not to survive. Four thousand three hundred and seventy-six adult patients were thus discharged alive from ICU without being recorded as expected to die or for palliative care (Fig. 1). Patient characteristics are shown in Table 1. An outline of patient characteristics is presented in 2 yr time slots to allow an assessment of potential changes over the 10 yr study period (Table 2). Both case mix and ICU management have evolved over the 10 yr period, but no specific changes in policy have been implemented.

Four hundred and seventy-five patients (11.2%) of the study cohort died after ICU discharge. Hospital length of stay in those who died after initial discharge from ICU was similar to those who survived to hospital discharge [14 (5–27) *vs* 13 (7–27) days]. Three hundred and eighty-five patients (8.8%) were readmitted to ICU during the same hospital admission. Hospital mortality in those who were readmitted at any time was 40.2% and hospital length of stay after initial discharge from ICU was 32 (18–51) days.

The subgroup of readmissions who were readmitted within 48 h was also examined. One hundred and forty-three patients (3.3%) were readmitted within 48 h of ICU discharge. Hospital mortality in these early readmissions was 27.7% and hospital length of stay after initial discharge from ICU was 31 (15–47) days.

Hospital mortality in those who were not readmitted was 8.4% and hospital length of stay after ICU discharge was 13 (7–24) days.

Factors associated with death, readmission, or readmission within 48 h are shown in Tables 3–5.

Table 1 Patient characteristics for all ICU admissions during study period. Data are presented as median (inter-quartile range) or as percentages. APACHE, Acute Physiological and Chronic Health Evaluation; SAPS, Simplified Acute Physiology Score; ICU, intensive care unit; LOS, length of stay

	All patients	Died in ICU	Survived ICU
n	5725	1190	4535
Males (*n*)	3324 (58.1%)	672 (56.5%)	2652 (58.5%)
Age (yr)	63 (46–73)	66 (54–74)	61 (44–72)
APACHE II	19 (14–25)	28 (23–33)	18 (13–23)
APACHE II mortality prediction	29 (12–53)	64 (42–80)	23 (10–42)
SAPS II	38 (27–52)	59 (47–72)	34 (24–45)
Surgery on or before admission	2903 (52.0%)	355 (30.6%)	2548 (57.6%)
ICU LOS (days)	2 (1–5)	2 (1–7)	2 (1–5)
Hospital LOS after ICU discharge (days)	10 (1–21)	—	13 (7–27)
ICU mortality	1190 (20.8%)	—	—
Hospital mortality	1775 (31.0%)	—	585 (13.3%)
Unit APACHE II standardized mortality rate for study period		0.87–0.96	

Reason for readmission

Admitting diagnoses were grouped according to whether it was the same pathology as original admission or a new diagnosis. Diagnoses were further grouped on the basis of organ system involved. Admitting diagnosis for both initial and readmission were available for 121/143 patients (85%). Forty-nine per cent were readmitted for the same or related diagnosis and 51% for a different diagnosis. Twenty-eight per cent of the total was readmitted with a new diagnosis of chest infection (initial admitting diagnosis not respiratory infection); 2.5% with new sepsis (not chest); 2.5% after in-hospital cardiac arrest; 3% with new acute respiratory distress or acute lung injury; 4% with fluid overload; and 2% with cardiac failure. Between them, these diagnoses account for 42% of the 49% of readmissions for new diagnoses. The remaining 7% were for miscellaneous reasons.

Multivariable logistic regression analysis

Admitting specialty was excluded from the multivariable analysis because of more than 5% missing data (28% missing). This was not recorded routinely until 1998. SAPS II scores and total TISS scores were excluded because of expected co-linearity with APACHE II scores and ICU length of stay, respectively. Factors associated with death or ICU readmission on multivariable analysis are shown in Tables 6–8.

Discrimination ability was moderate for the three models: AUC of 0.74, 0.67, and 0.62 for predicting death after ICU discharge, early readmissions, and readmissions, respectively. On the basis of the Hosmer and Lemeshow goodness of fit test, there was no evidence of poor calibration for any of the three logistic regression models. However, discrimination ability based only upon the APACHE score was: AUC of 0.69, 0.63, and 0.59,

Table 2 Patient characteristics presented in 2 yr time slots over the study period. Data are presented as median (inter-quartile range) and numbers (percentages). CPR, cardiopulmonary resuscitation; ICU, intensive care unit; N/A, information not available

Year	<1997	1997–8	1999–2000	2001–2	>2003
Number of patients	875	1023	1094	1226	1496
Age (yr)	63 (48–72)	61 (44–72)	63 (47–72)	63 (47–73)	63 (46–73)
Males, *n*	514 (58.7%)	578 (56.5%)	606 (55.4%)	724 (59.1%)	895 (59.8%)
CPR in 24 h before initial ICU admission	111 (12.8%)	95 (9.3%)	127 (11.6%)	132 (10.8%)	143 (9.6%)
Surgical admitting specialty	N/A	269 (64.5%)	678 (62.0%)	761 (62.1%)	885 (59.2%)
ICU mortality	151 (17.3%)	166 (16.2%)	246 (22.5%)	278 (22.7%)	347 (23.2%)
Hospital mortality	255 (29.1%)	266 (26.0%)	366 (33.5%)	416 (33.9%)	469 (34.2%)
APACHE II score	18 (13–23)	18 (13–24)	20 (14–26)	20 (15–27)	20 (14–27)

Table 3 Simple logistic regression of patients who died after ICU discharge with those who survived to hospital discharge. Data are presented as median (inter-quartile range) and numbers (percentages). OR, odds ratio; CPR, cardiopulmonary resuscitation; ICU, intensive care unit; HDU, high dependency unit; APACHE, Acute Physiological and Chronic Health Evaluation; SAPS, Simplified Acute Physiology Score; TISS, Therapeutic Intervention Scoring System. *Variable with <95% of data available

	Died (n=475)	Alive (n=3779)	Unadjusted OR (95% CI)	P-value
Age (yr)	70 (60–76)	59 (42–71)	1.04 (1.03–1.05)	<0.001
Males	290 (61.1%)	2211 (58.5%)	1.11 (0.91–1.35)	0.288
Days in hospital before ICU admission	2 (0–7)	1 (0–3)	1.03 (1.02–1.03)	<0.001
CPR in 24 h before initial ICU admission	51 (10.8%)	217 (5.8%)	1.98 (1.43–2.72)	<0.001
Surgical admitting specialty*	205 (61.2%)	1824 (67.2%)	0.77 (0.61–0.97)	0.028
Surgery on admission or before ICU	263 (56.3%)	2169 (58.9%)	0.90 (0.74–1.09)	0.290
APACHE II	22 (17–27)	17 (13–22)	1.09 (1.08–1.11)	<0.001
SAPS II	43 (33–54)	33 (23–43)	1.05 (1.04–1.05)	<0.001
Days of mechanical ventilation	2 (1–6)	2 (1–3)	1.04 (1.03–1.05)	<0.001
Highest TISS	42 (36–48)	37 (30–44)	1.05 (1.04–1.06)	<0.001
Total TISS	124 (65–314)	74 (45–172)	1.0011 (1.0008–1.0014)	<0.001
Mean TISS	35 (31–38)	32 (28–37)	1.05 (1.04–1.06)	<0.001
Discharge TISS	29 (24–35)	28 (23–34)	1.013 (1.003–1.023)	0.010
Unit stay (days)	3 (1–9)	2 (1–5)	1.03 (1.02–1.04)	<0.001
Night discharge	13 (2.7%)	105 (2.8%)	0.99 (0.55–1.77)	0.958
Discharge to HDU or other ICU	161 (33.9%)	1233 (33.6%)	0.99 (0.81–1.21)	0.897

Table 4 Simple logistic regression of patients who were readmitted to ICU at any time during index admission with patients who were not readmitted to ICU. Data are presented as median (inter-quartile range) and numbers (percentages) as appropriate. OR, odds ratio; CPR, cardiopulmonary resuscitation; ICU, intensive care unit; HDU, high dependency unit; APACHE, Acute Physiological and Chronic Health Evaluation; SAPS, Simplified Acute Physiology Score; TISS, Therapeutic Intervention Scoring System. *Variable with <95% of data available

	Readmitted to ICU (n=385)	Not readmitted to ICU (n=3981)	Unadjusted OR (95% CI)	P-value
Age (yr)	66 (54–73)	60 (43–71)	1.02 (1.01–1.02)	<0.001
Males	245 (63.6%)	2323 (58.4%)	1.25 (1.01–1.55)	0.045
Days in hospital before ICU admission	1 (0–6)	1 (0–3)	1.02 (1.01–1.02)	0.001
CPR in 24 h before initial ICU admission	30 (7.8%)	242 (6.1%)	1.30 (0.88–1.93)	0.190
Surgical admitting specialty*	213 (71.0%)	1889 (65.9%)	1.27 (0.97–1.64)	0.078
Surgery on admission or before ICU	233 (61.3%)	2252 (58.0%)	1.15 (0.92–1.42)	0.213
APACHE II	20 (16–24)	17 (13–22)	1.05 (1.03–1.06)	<0.001
SAPS II	37 (28–48)	33 (23–43)	1.02 (1.01–1.02)	<0.001
Days of mechanical ventilation	2 (1–5)	2 (1–3)	1.03 (1.01–1.04)	<0.001
Highest TISS	41 (35–47)	37 (31–44)	1.03 (1.02–1.04)	<0.001
Total TISS	111 (65–274)	75 (45–176)	1.001 (1.000–1.001)	<0.001
Mean TISS	34 (30–38)	32 (28–37)	1.04 (1.02–1.05)	<0.001
Discharge TISS	28 (24–35)	28 (23–34)	1.008 (0.997–1.019)	0.136
Unit stay (days)	2.9 (1–7.5)	2 (1–5)	1.02 (1.01–1.04)	<0.001
Night discharge	10 (2.6%)	109 (2.7%)	0.95 (0.49–1.83)	0.871
Discharged to HDU/ICU	161 (42.0%)	1293 (33.4%)	0.69 (0.56–0.86)	0.001

respectively, suggesting limited gain from using the full model. The highest Nagelkerke R^2 statistic was 0.162 for death after ICU discharge. Because of their limited usefulness, prospective validation of these models was not considered to be warranted.

Discussion

A significant minority of patients deteriorate after discharge from intensive care. In our study, 8.8% of initial survivors were readmitted to ICU and 11.2% died in hospital after ICU discharge. These are consistent with data from other units.[6] Not all of these deaths and readmissions will be preventable. A few patients discharged from ICU, although not expected to die, will have been assessed as unsuitable for readmission in the event of deterioration. Despite this, some will inevitably have been readmitted and subsequently died. These patients are not reliably detected by our data collection system and will contribute to the post-ICU and readmission mortality figures. However, identification of other high-risk patients before they leave ICU may allow extra resources to be targeted towards them. This may include delayed discharge; discharge to a high dependency unit (HDU) or other 'step-down' unit; or more aggressive follow-up on the wards.

Early readmissions may be particularly important. Within this group, there may be a number of problems which might be attributed to premature discharge from ICU and which could have been prevented.[2 6] Undoubtedly, other factors will also impinge on the early readmission rate, including local high dependency facilities, quality of care on the ward after ICU discharge, and the presence of ICU follow-up services. Whatever the reason for their

Table 5 Simple logistic regression of patients readmitted to ICU within 48 h with patients who were not readmitted within 48 h. Data are presented as median (inter-quartile range) and numbers (percentages) as appropriate. OR, odds ratio; CPR, cardiopulmonary resuscitation; ICU, intensive care unit; HDU, high dependency unit; APACHE, Acute Physiological and Chronic Health Evaluation; SAPS, Simplified Acute Physiology Score; TISS, Therapeutic Intervention Scoring System. *Variable with <95% of data available

	Readmitted within 48 h (n=143)	Not readmitted with 48 h (n=4223)	Unadjusted OR (95% CI)	P-value
Age (yr)	66 (51–73)	61 (44–72)	1.011 (1.001–1.020)	0.028
Males	96 (67.1%)	2472 (58.5%)	1.45 (1.02–2.06)	0.041
Days in hospital before ICU admission	1 (0–5)	1 (0–3)	1.00 (0.99–1.02)	0.603
CPR in 24 h before initial ICU admission	13 (9.1%)	259 (6.1%)	1.53 (0.85–2.74)	0.156
Surgical admitting specialty*	78 (67.8%)	2024 (66.3%)	1.07 (0.72–1.59)	0.744
Surgery on admission or before ICU	79 (56.4%)	2406 (58.4%)	0.92 (0.66–1.30)	0.647
APACHE II	20 (16–24)	17 (13–22)	1.04 (1.02–1.07)	<0.001
SAPS II	36 (28–48)	34 (24–44)	1.01 (1.00–1.03)	0.001
Days of mechanical ventilation	2 (1–5)	2 (1–4)	1.01 (0.99–1.04)	0.315
Highest TISS	40 (33–46)	38 (31–45)	1.015 (0.999–1.031)	0.072
Total TISS	109 (59–253)	76 (47–184)	1.0004 (0.9998–1.0010)	0.209
Mean TISS	33 (30–38)	32 (28–37)	1.01 (0.99–1.04)	0.242
Discharge TISS	28 (23–35)	28 (23–34)	1.00 (0.98–1.02)	0.931
Unit stay (days)	2 (1–7)	2 (1–5)	1.01 (0.99–1.03)	0.339
Night discharge	3 (2.1%)	116 (2.7%)	0.76 (0.24–2.42)	0.640
Discharged to HDU or other ICU	68 (48.2%)	1136 (33.7%)	0.55 (0.39–0.76)	<0.001

Table 6 Multivariable logistic regression of death after initial ICU discharge before hospital discharge. Data presented as adjusted odds ratios (95% confidence intervals). With continuous variables, odds ratio refers to odds associated with a unit increase in the predictor variable. Nagelkerke R^2 statistic was 0.162. Hosmer and Lemeshow goodness of fit test was not significant at 5%, P=0.103. AUC was 0.74. CPR, cardiopulmonary resuscitation; OR, odds ratio; APACHE, Acute Physiological and Chronic Health Evaluation; TISS, Therapeutic Intervention Scoring System

	Adjusted OR (95% CI)	P-value
Age (yr)	1.03 (1.02–1.04)	<0.001
Males	1.24 (1.01–1.53)	0.043
Days in hospital before ICU admission	1.02 (1.01–1.03)	<0.001
CPR in 24 h before initial ICU admission	1.21 (0.85–1.73)	0.295
APACHE II	1.06 (1.04–1.08)	<0.001
Days of mechanical ventilation	0.97 (0.92–1.03)	0.300
Mean TISS	1.03 (1.02–1.05)	<0.001
Discharge TISS	1.01 (1.00–1.02)	0.064
Unit stay	1.04 (1.00–1.09)	0.046

Table 7 Multivariable logistic regression of readmission at any time after initial ICU discharge and before hospital discharge. Data presented as odds ratios (95% confidence intervals). With continuous variables, odds ratio refers to odds associated with a unit increase in the predictor variable. Nagelkerke R^2 statistic was 0.046. Hosmer and Lemeshow goodness of fit test was not significant at 5%, P=0.216. AUC was 0.65. CPR, cardiopulmonary resuscitation; ICU, intensive care unit; HDU, high dependency unit; OR, odds ratio; APACHE, Acute Physiological and Chronic Health Evaluation; TISS, Therapeutic Intervention Scoring System

	Adjusted OR (95% CI)	P-value
Age (yr)	1.01 (1.00–1.02)	0.010
Males	1.23 (0.98–1.54)	0.070
Days to unit	1.01 (1.00–1.02)	0.011
CPR in 24 h before initial ICU admission	0.91 (0.59–1.39)	0.653
APACHE II	1.03 (1.01–1.05)	<0.001
Days of mechanical ventilation	0.96 (0.91–1.02)	0.232
Mean TISS	1.02 (1.01–1.04)	0.006
Discharge TISS	1.01 (1.00–1.02)	0.146
Unit stay	1.05 (1.00–1.10)	0.052
Discharged to HDU or other ICU	1.37 (1.10–1.72)	0.005

Table 8 Multivariable logistic regression of readmission within 48 h of initial ICU discharge. Data presented as odds ratios (95% confidence intervals). With continuous variables, odds ratio refers to odds associated with a unit increase in the predictor variable. Nagelkerke R^2 statistic was 0.02. Hosmer and Lemeshow goodness of fit test was not significant at 5%, P=0.269. Area under curve was 0.62. CPR, cardiopulmonary resuscitation; ICU, intensive care unit; HDU, high dependency unit; OR, odds ratio; APACHE, Acute Physiological and Chronic Health Evaluation; TISS, Therapeutic Intervention Scoring System

	Adjusted OR (95% CI)	P-value
Age (yr)	1.01 (0.99–1.02)	0.360
Males	1.38 (0.96–1.99)	0.083
CPR in 24 h before initial ICU admission	0.96 (0.49–1.88)	0.900
APACHE II	1.04 (1.01–1.07)	0.012
Highest TISS	1.00 (0.99–1.02)	0.737
Discharged to HDU or other ICU	1.66 (1.18–2.35)	0.004

deterioration and readmission, it is clear that patients readmitted to ICU are at much higher risk of subsequent death than those who are not readmitted.[4–6] It would be useful to be able to identify those at risk of readmission before initial ICU discharge.

Not surprisingly, our data show that death after ICU is independently associated with increasing illness severity, age, and time in hospital before ICU admission. Time in hospital before ICU may reflect a failure to respond to treatment on a general ward or late referral to ICU.[4] It is tempting to speculate that this might be amenable to earlier intervention, perhaps facilitated by early warning systems and hospital outreach teams. For readmissions overall, the risk factors are similar and also include discharge to an HDU. This last factor may reflect illness severity at discharge or an earlier recognition of deterioration because of higher levels of monitoring. Only surgical HDU facilities exist in our hospital and it is possible that surgical patients are discharged earlier in their recovery phase because a higher level of step-down care is

available. The only factors associated with early readmissions are severity of illness at ICU admission and discharge to an HDU. Our findings are consistent with previous studies.[5–7 14] Better predictive models might be produced by including more patient variables at the time of ICU discharge. Status at discharge would seem a more relevant factor and is also when we might have the opportunity to intervene. Higher TISS scores at discharge have been found in other studies to be associated with an increased risk of readmission and death, but we did not confirm this finding in our patients.[2 15 16] Although discharge TISS score was statistically associated with death in our study, the difference between scores in those who died and survived (29 *vs* 28) is not clinically useful. We do not currently collect other measures of illness severity at the time of patient discharge.

Other factors associated with death or readmission after ICU have been identified, but none has yet translated into a useful predictive model for individual patients.[6] A US study in a medical ICU found the acute physiology score component of APACHE II at ICU discharge to be the independent risk factor most associated with readmission to ICU.[4] These data are not collected routinely in our unit at present. Another study showed proximity of extubation to time of discharge and the need for organ support on the day of discharge to be independently associated with readmission.[2] These might indicate unresolved organ failure and premature discharge or substandard care after ICU discharge. Premorbid functional status and several severity of illness-related factors such as delirium and muscle weakness might also be relevant in determining outcome. None of these is currently recorded in our clinical audit system.

If discharges are indeed premature, would delaying discharge make any difference? A model developed in the UK suggested that about one-third of ICU patients are at increased risk of death after ICU and that delaying their discharge by 48 h might reduce their risk of death.[9] Decisions on discharge from ICU are currently based on clinical judgement rather than objective criteria. The effect on mortality and readmission of introducing a discharge policy based around a 'physiological discharge score' is unlikely to be straightforward but deserves further investigation. We do know that night-time discharge, used as an indicator for premature discharge, is associated with poorer outcome.[16 17] Our findings did not note any influence of night-time discharge, perhaps because the absolute number of night-time discharges in our unit was very small. Other potentially relevant organizational factors not considered in our study include ICU bed occupancy and the level of ward care. Increasing length of stay in ICU or increasing the provision of high dependency care has been suggested as strategies for improvement.[16] Each of these solutions has major resource implications so cost-effectiveness needs to be demonstrated by prospective study. Case-by-case analysis might be valuable in identifying avoidable readmissions and deaths. This has been studied elsewhere to assess quality of care before admission to intensive care and found several cases of suboptimal care but rather fewer cases of preventability.[18] A study of 97 early readmissions to a surgical ICU concluded that most (63%) initial discharges were appropriate, 22% of readmissions were preventable, 11% of readmissions may have been anticipated, and 5% might have been prematurely discharged.[5] Other studies report that up to 40% of readmissions may have been associated with premature discharge.[6] Such results are not easily extrapolated to different units because of differing patient and organizational factors, particularly between countries. One strategy for obtaining local information is the development of follow-up teams who monitor patients after ICU discharge, can provide early warning of deterioration, and perhaps suggest interventions to prevent further deterioration.[19] One study of a critical care outreach team found preliminary evidence of benefit in both survival and reduced readmission rates,[20] although this is not a universal finding.[21] Effective and aggressive follow-up may actually increase readmission rate. As the mortality of patients deteriorating after ICU discharge is so high, some clinicians may elect to readmit at an early stage to avert further deterioration. This may be clinically appropriate but will confound the use of readmission rate as a quality marker. Caution must therefore be exercised when interpreting comparative data on readmission rates.

The above studies and our results give some insight into the problem of unexpected deterioration after ICU discharge. Different hospitals, particularly in different countries have different case mixes, different step-down arrangements, and different organizational factors such as numbers of transfers between hospitals, each of which might affect readmission rates. This makes comparisons and identification of common predictors more difficult.[3 4 6] Nonetheless, readmission rates and unexpected deaths may be a relevant quality marker, particularly at a local level.

In conclusion, the risk of death after ICU is independently associated with increasing illness severity at time of ICU admission, age, and time in hospital before ICU admission. Risk factors for readmission to ICU are similar and also include discharge to an HDU. Risk factors for early readmissions are severity of illness at ICU admission and discharge to an HDU. Prognostic models based on these risk factors had moderate discrimination ability, but only performed slightly better than models based only upon APACHE score at ICU admission. We conclude that our routinely collected data cannot be used to produce models that are more clinically useful in predicting death or readmission than admission APACHE II scores alone. In future, the most logical area on which to focus efforts to predict outcome might be on physiological variables at discharge. This could be based around the same acute physiological score components included in the APACHE II score, not currently collected at the time of discharge from our unit. Follow-up of patients after discharge

provides the ideal opportunity to study reasons for deterioration and to assess the likely preventability of each readmission or unexpected death. Only when we have answered these questions, will we be able to target our resources best at those at highest risk of poor outcome, despite a good response to treatment of their initial illness.

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References

1 Society of Critical Care Medicine Quality Indicators Committee. *Candidate Critical Care Quality Indicators*. Anaheim, CA: Society of Critical Care Medicine, 1995

2 Metnitz PG, Fieux F, Jordan B, *et al*. Critically ill patients readmitted to intensive care units-lessons to learn? *Intensive Care Med* 2003; **29**: 241–8

3 Angus DC. Grappling with intensive care unit quality—does the readmission rate tell us anything? *Crit Care Med* 1998; **26**: 1779–80

4 Rosenberg AL, Hofer TP, Hayward RA, *et al*. Who bounces back? Physiologic and other predictors of intensive care unit readmission. *Crit Care Med* 2001; **29**: 511–8

5 Nishi GK, Suh RH, Wilson MT, *et al*. Analysis of causes and prevention of early readmission to surgical intensive care. *Am Surg* 2003; **69**: 913–7

6 Rosenberg AL, Watts C. Patients readmitted to ICUs: a systematic review of risk factors and outcomes. *Chest* 2000; **118**: 492–502

7 Chen LM, Martin CM, Keenan SP, *et al*. Patients readmitted to the intensive care unit during the same hospitalization: clinical features and outcomes. *Crit Care Med* 1998; **26**: 1834–41

8 Wallis CB, Davies HT, Shearer AJ. Why do patients die on general wards after discharge from intensive care units? *Anaesthesia* 1997; **52**: 9–14

9 Daly K, Beale R, Chang RW. Reduction in mortality after inappropriate early discharge from intensive care unit: logistic regression triage model. *Br Med J* 2001; **322**: 1274–6

10 Knaus WA, Draper EA, Wagner DP, *et al*. APACHE II: a severity of disease classification system. *Crit Care Med* 1985; **13**: 818–29

11 Le Gall JR, Lemeshow S, Saulnier F. A new simplified acute physiology score (SAPS II) based on a European/North American multicenter study. *JAMA* 1993; **270**: 2957–63

12 Livingston BM, MacKirdy FN, Howie JC, *et al*. Assessment of the performance of five intensive care scoring models within a large Scottish database. *Crit Care Med* 2000; **28**: 1820–7

13 Keene AR, Cullen DJ. Therapeutic intervention scoring system: update 1983. *Crit Care Med* 1983; **11**: 1–3

14 Azoulay E, Adrie C, De Lassence A, *et al*. Determinants of post-intensive care unit mortality: a prospective multicenter study. *Crit Care Med* 2003; **31**: 428–32

15 Fortis A, Mathas C, Laskou M, *et al*. Therapeutic intervention scoring system-28 as a tool of post ICU outcome prognosis and prevention. *Minerva Anestesiol* 2004; **70**: 71–81

16 Beck DH, McQuillan P, Smith GB. Waiting for the break of dawn? The effects of discharge time, discharge TISS scores and discharge facility on hospital mortality after intensive care. *Intensive Care Med* 2002; **28**: 1287–93

17 Goldfrad C, Rowan K. Consequences of discharges from intensive care at night. *Lancet* 2000; **355**: 1138–42

18 McQuillan P, Pilkington S, Allan A, *et al*. Confidential inquiry into quality of care before admission to intensive care. *Br Med J* 1998; **316**: 1853–8

19 Intensive Care Society. *Guidelines for the Introduction of Outreach Services*. London: Intensive Care Society, 2002

20 Ball C, Kirkby M, Williams S. Effect of the critical care outreach team on patient survival to discharge from hospital and readmission to critical care: non-randomised population based study. *Br Med J* 2003; **327**: 1014–7

21 Leary T, Ridley S. Impact of an outreach team on re-admissions to a critical care unit. *Anaesthesia* 2003; **58**: 328–32