High occupancy increases the risk of early death or readmission after transfer from intensive care*

Carla A. Chrusch, MD, MSc, FRCPC; Kendiss P. Olafson, MD, MPH, FRCPC;
Patricia M. Mcmillan, MD, FRCPC; Daniel E. Roberts, MD, FRCPC; Perry R. Gray, MD, FRCSC

Objective: **To determine whether a lack of intensive care unit beds was leading to premature patient discharge from the intensive care unit and subsequent early readmission or death.**

Design: **Prospective cohort study.**

Setting: **A single Canadian tertiary care teaching hospital.**

Patients: **All intensive care unit admissions between January 1, 1989 and December 31, 1996 were collected prospectively for inclusion in a registry database.**

Interventions: **None.**

Measurements and Main Results: **There was a positive correlation between early readmission or death and average quarterly intensive care unit percent occupancy ($p = 0.001$). During the study period, 8693 patients experienced 10,185 admissions to intensive care. Of the 8222 patients remaining under active treatment (patients under palliative care were excluded), there were 455 (5.5%) adverse events (431 intensive care unit readmissions and 24 deaths) in the first 7 days post intensive care unit discharge. Patients requiring a new surgical intervention with postoperative intensive care unit admission were not considered readmissions. In a multivariate analysis, significant risk factors for an adverse event included age >35 yrs, particular diagnoses (respiratory diagnoses, sepsis, neurosurgery, thoracic surgery, and gastrointestinal diagnoses), Acute Physiology and Chronic Health Evaluation II score, and intensive care unit length of stay. Discharge from the intensive care unit at a time of no vacancy was also a significant risk factor for intensive care unit readmission or unexpected death with an adjusted relative risk of 1.56 (95% confidence interval = 1.05, 2.31).**

Conclusions: **Increased patient occupancy within an intensive care unit is associated with an increased risk of early death or intensive care unit readmission post intensive care unit discharge. Overloading the capacity of an intensive care unit to care for critically ill patients may affect physician decision-making, resulting in premature discharge from the intensive care unit. (Crit Care Med 2009; 37:000–000)**

Key Words: intensive care; readmission; mortality; transfer; vacancy; quality of health care

Caring for critically ill patients requires a substantial commitment of expensive physical and human resources. As a jurisdiction's ability to provide critical care to its population is finite (1), some degree of patient prioritization and selection is needed. This has led to the development of statements regarding the allocation of intensive care unit (ICU) resources and guidelines for admission, discharge, and triage of patients (2–4). Optimal benefit from intensive care depends on appropriate admission and discharge decisions based on a combination of need and potential benefit. Intensive care is most beneficial to severely ill, unstable patients who are likely to improve with treatment. Patients at the two extremes of illness—either at low risk of death, such as patients admitted for monitoring (5), or those patients with a high mortality despite aggressive interventions—have limited benefit from an ICU admission (6). In addition to need and benefit, the availability of resources can influence both admission and discharge decisions (7, 8). Resources vary from one institution to another as well as within the same institution over time (9). Bed availability can be influenced by system problems leading to inefficient use of ICU beds (8, 10).

When ICU care is no longer appropriate or required, patients are transitioned to a lower intensity and less expensive level of care. Premature transfer places the patient at risk of an adverse event, such as death or a readmission to ICU that may have been prevented if the patient had remained in the ICU (11–13). Patients who require readmission to the ICU usually return with greater severity of illness (14) and have a poorer prognosis with higher mortality rate and longer hospital lengths of stay compared with similar patients who do not require ICU readmission (11, 13–19). Readmission rates have therefore been proposed to be important quality indicators for ICU care (14, 20). Unnecessarily delaying transfer from the ICU, however, decreases the overall availability of ICU resources. ICU physicians are challenged with the responsibility of both caring for patients already under their care and patients in their jurisdiction who require admission. In practice, this means that patients already admitted to the ICU are in competition with the next patient who requires ICU care.

Our hypothesis was that an inadequate number of ICU beds was leading to premature patient discharge and subsequent ICU readmission or unexpected death. We sought to answer this question by exam-

***See also p. XXX.**

From the Department of Critical Care Medicine, University of Calgary, Calgary, AB, Canada; Departments of Medicine and Surgery, University of Manitoba, Winnipeg, MB, Canada; Department of Anaesthesia, McGill University, Montreal, QC, Canada.

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For information regarding this article, E-mail: carla.chrusch@calgaryhealthregion.ca

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ining the association between ICU bed occupancy and other markers of unit activity with the rate of early death or readmission after transfer from intensive care in patients eligible for readmission to the ICU. In addition, we attempted to identify risk factors for and the consequences of ICU readmission.

MATERIALS AND METHODS

The Health Sciences Centre is the primary tertiary care teaching hospital in the Province of Manitoba serving a population of 1.5 million. The Centre treats trauma, neurosurgery, and lung and bone marrow transplant patients as well as general medical and surgical patients. There are separate medical and surgical ICUs. The units are staffed by residents, fellows, and intensivists with all admission, discharge, and transfer decisions being made by the attending intensivist. The medical ICU is a closed unit. The surgical ICU is semiclosed, meaning that the physician of record is the attending surgeon, but medical care within the unit is directed by the attending intensivist. Patients in the ICU are cared for by nurses who have completed additional training in critical care. The nurse/patient ratio in the ICU is 1:1 or 1:2 in the case of stable lower acuity patients, at the discretion of the nurse-in-charge. Care on the wards is organized into medical and surgical services composed of medical students and resident physicians and led by specialist medical staff. The Centre has surgical step-down units where patients are cared for by ward medical and nursing staff with a nurse/patient ratio of 1:4. Patients are transferred between the general ward and the step-down unit at the direction of the ward medical staff and housestaff. A rapid response or formal follow-up team was not in place during the study period. All patients admitted to the medical or surgical ICU of the Health Sciences Centre between January 1, 1989 and December 31, 1996 were included in the study. Cardiology patients not requiring mechanical ventilation are cared for in a separate unit and were not included in this study population.

For all patients admitted to the ICU, demographic information, admission diagnoses, Acute Physiology and Chronic Health Evaluation (APACHE) II score, and admission and discharge times were collected prospectively at the time of admission by trained data collectors and entered into a database (Critical Care Manager, Chelmsford, ON, Canada). Patient-related data were collected and maintained in a manner approved by the Research Ethics Board of the University of Manitoba. Medical admissions were grouped by primary system involved and surgical admissions by procedure, resulting in 13 diagnostic categories.

Patients who were readmitted to the ICU within 7 days of their transfer from the ICU were identified in the database retrospectively. Patients requiring a new surgical intervention with postoperative ICU admission, those designated as palliative at the time of ICU discharge, and those discharged from the hospital and readmitted were excluded. The hospital medical records of patients who left the ICU under active treatment and died within 7 days of transfer were reviewed by one of the investigators. Patients were classified as under active treatment if cardiac resuscitation was attempted. Patients who died within 7 days of transfer to the ward without resuscitative efforts were designated as palliative and excluded from further analysis. The decision not to resuscitate the patient had to be documented in the chart before the cardiac arrest. Readmission or death occurring within 7 days of discharge from the ICU, while still under active treatment, was considered an adverse outcome.

A number of markers of unit activity were derived *a priori*. Unit occupancy at the time of each patient's admission and discharge from the ICU was derived from discharge dates and times and the number of operational beds. The terms vacancy and no vacancy at the time of discharge refer to the status of the unit after that patient is discharged. That is, no vacancy means that a patient is discharged from an overcensus ICU. Vacancy means that there are one or more beds available after that patient's discharge. The number of admissions in the 4 hrs preceding an admission, the time to the next admission, and the time of day that a discharge occurred (9 AM to 2 PM; 2 PM to 9 PM; 9 PM to 9 AM) were determined. It was hypothesized that these variables may be markers for premature discharge precipitated by the need to admit another patient. Patients were also retrospectively given a discharge rank for each day based on their discharge time, specifically either the first discharge of the day shift, the second, the third, and so forth. It was assumed that patients discharged earlier in the day were judged to be more appropriate discharges by the attending physician than patients discharged later in the day. Interaction terms for no vacancy and unit of discharge as well as vacancy and unit activity markers were derived *post hoc*.

The average adverse event rate was calculated as the total number of premature deaths and ICU readmissions occurring within 7 days of ICU discharge divided by the number of discharges at risk for readmission. In addition, the average percent ICU bed occupancy was the average midnight ICU bed census divided by the number of funded ICU beds within the hospital. The average readmission and premature death rates and average percent ICU occupancy are calculated on a quarterly annual basis.

Statistical Analysis

The relationship between average readmission rates and percent occupancy by calendar quarter was examined, using a linear regression model.

Categorical variables were compared by chi-square analysis, and continuous variables were expressed as the mean and SD and were compared using paired and unpaired Student's *t* tests as appropriate. Univariate and multivariate logistic regression, using generalized estimating equations, were employed to model the outcome of an adverse event (death or readmission) within 7 days of discharge from the ICU. Regression with generalized estimating equations adjusts the variance for correlated observations, in this case, multiple admissions of the same patient.

A $p < .05$ was considered statistically significant, as was a relative risk where the 95% confidence intervals (CIs) did not cross zero. Statistical analysis was performed, using SAS version 9.1 (SAS Institute, Cary, NC).

RESULTS

During the study period, the number of staffed ICU beds within the hospital was ten in the surgical ICU whereas it increased from eight to ten beds in the medical ICU in 1992. The ICU bed occupancy and adverse event rates by calendar quarter for each unit are shown in Figure 1. The average midnight percent occupancy was 71.2% (range = 22%–115%). A histogram of the midnight census is shown in Figure 2. The relationship between average ICU bed occupancy and readmission rates by calendar quarter was statistically significant (r = .55; p = .001 by linear regression) and is shown in Figure 3.

A total of 8693 patients experienced 10,185 admissions to the ICUs. Patient demographics, APACHE II scores, ICU length of stay, and survival are shown in Table 1. Overall ICU survival was 83.5% with 8222 discharges to the ward still receiving active treatment. Of the 8222 discharges remaining under active treatment on the ward, there were 24 deaths (0.3%) and 431 ICU readmissions (5.2%) in the first 7 days post ICU discharge. In the first 3 days, 74.7% of these events occurred.

Patients who required readmission had an APACHE II score of 22.0 ± 8.6 compared with an APACHE II score of 19.1 ± 6.6 on their prior admission ($p < .01$ by paired Student's *t* test). The ICU mortality of readmitted patients was 21.3%, which is substantially higher than

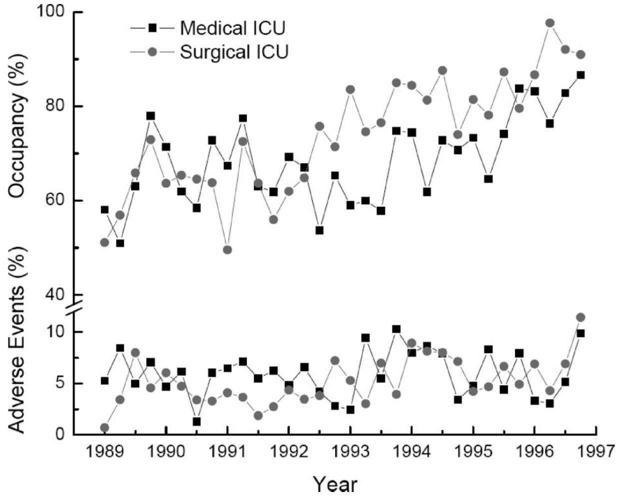

Figure 1. Intensive care unit (*ICU*) bed occupancy and adverse event rates by calendar quarter.

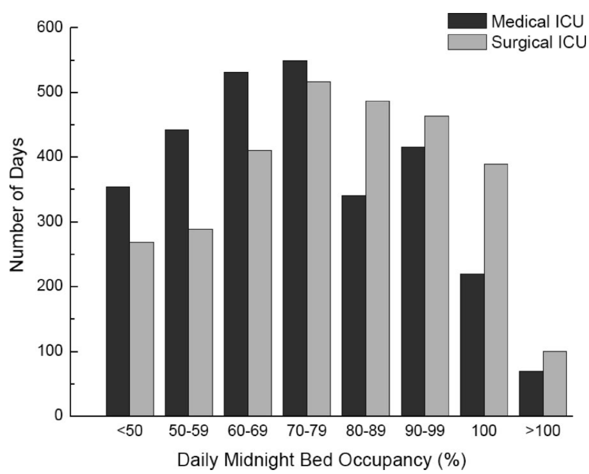

Figure 2. Histogram of daily midnight bed occupancy. *ICU*, intensive care unit.

those who did not require readmission who had a ward mortality of 0.3% ($p <$ .01 by chi-square test). However, it is no different from patients who had only a single ICU admission (n = 7538 patients) with an ICU mortality of 19.0% ($p = .27$ by chi-square test). The most common reasons for readmission were respiratory conditions (21.7%), cardiovascular problems (17.5%), and infections (16.8%). The diagnosis on readmission was the same as for the initial admission in 49% of cases. The population at risk experienced 71 cardiac arrests in 66 patients within 7 days of discharge from the ICU. Twenty-four of those patients died on the ward. An additional 20 patients died subsequently in the ICU.

Patient characteristics, admission characteristics, and markers of unit activity were examined regarding their relationship to readmission or death after transfer from the ICU. The results of the univariate analysis are shown in Table 2 as the relative risk and 95% CIs. Age >35 yrs and certain diagnoses (respiratory conditions, sepsis, neurosurgical condition, thoracic surgery, and gastroenterological disorders) were associated with an increased risk on an adverse outcome. Other important admission characteristics included high APACHE II scores and an ICU length of stay of >3 days.

Markers of unit activity that were significant in the univariate analysis included discharge from an overcensus ICU (relative risk = 1.62; 95% CI = 1.10, 2.39) and the rank of discharge. Specifically, the second or later patient discharged from the ICU on a given day was at increased risk (relative risk = 1.21; 95% CI = 1.00, 1.46). There were 402 discharges from the ICU under conditions of no vacancy. The number of admissions that preceded or followed a patient's discharge from the ICU, the time to the next admission, and time of discharge were not significant risk factors and, therefore, they were not included in further analyses. The interactions between no vacancy and other unit activity factors were not significant.

The adjusted relative risks of an adverse event were derived, using a multivariable model and generalized estimating equations. Results are shown in Table 2. Age >35 yrs remained significant (adjusted relative risk = 1.46; 95% CI = 1.02, 2.07) as did particular diagnoses (respiratory diagnoses, sepsis, neurosurgery, thoracic surgery, and gastrointestinal diagnoses), APACHE II score and ICU length of stay. Being discharged from the ICU when there was no vacancy was the only unit activity variable that remained significant with an adjusted relative risk for an adverse outcome of 1.56 (95% CI = 1.05, 2.31). The risk of an adverse event when discharged from an overcensus surgical ICU was not statistically different from an overcensus medical ICU (relative risk = 1.71; 95% CI = 0.75, 3.88). Of the 402 patients discharged from an overcensus ICU, 34 patients (8.5%) required ICU readmission within 7 days compared with 397 readmissions (5.1%) in the 7398 patients discharged when the ICU was not over census.

DISCUSSION

We have presented the early death and readmission rates from >10,000 ICU admissions in a single institution over an 8-yr period. In this study, we have made a number of refinements in the definition of readmission as far as timing, active care, and emergency surgery are concerned. Previous studies considered any subsequent ICU admission during the same hospitalization a readmission (14, 15, 17, 21). The earlier a readmission occurs post ICU discharge, the more likely that readmission can be attributable to the discharge decision. Our study identified adverse outcomes that occurred within 7 days of ICU discharge on the assumption that, after this period, the decision to transfer the patient could not realistically be considered premature. Care was taken to ensure that only patients still eligible for ICU readmission were included in the at-risk population by excluding those who were under palliative care on the ward. Patients may require readmission to the ICU because of recurrence of their initial problem, appearance of a new problem, and elective or emergency surgical procedure. We excluded operative interventions necessitat-

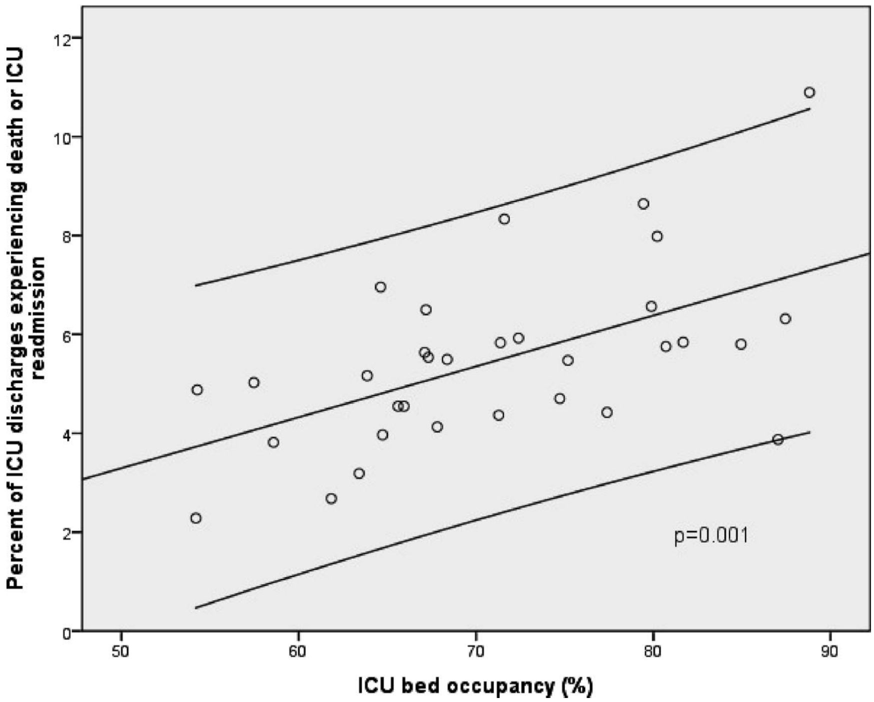

Figure 3. Average intensive care unit (*ICU*) bed occupancy and adverse event rates per calendar quarter.

Table 1. Characteristics of patients admitted to the ICU between January 1, 1989 and December 31, 1996

	Both Units	Medical	Surgical	Medical Versus Surgical, *p*
Number of admissions	10185	4052	6133	
Age, yrs	59.3 ± 18.1	57.8 ± 18.9	60.3 ± 17.5	<.001
Males	6261 (61.5%)	2266 (55.9%)	3995 (65.1%)	<.001
APACHE II	18.6 ± 8.6	21.5 ± 9.7	16.7 ± 7.1	<.001
ICU length of stay, days	3.9 ± 6.5	4.6 ± 7.4	3.5 ± 5.8	<.001
ICU survivors	8501 (83.5%)	3012 (74.3%)	5489 (89.5%)	<.001
Active treatment on ward	8222	2839	5383	
Readmitted within 7 days[a]	431 (5.2%)	157 (5.5%)	274 (5.0%)	.40
Died within 7 days[a]	24 (0.3%)	13 (0.5%)	11 (0.2%)	.04

ICU, intensive care unit; APACHE, Acute Physiology and Chronic Health Evaluation.

[a]The denominator is the number of discharges from the ICU and under active treatment on the ward.

ing postoperative ICU care, as transfer from the ICU to a ward does not create indications for surgery.

Our study supports the previous findings of increased age, ICU length of stay, admission APACHE II score, and gastrointestinal bleeding as significant risk factors for early readmission or death (17, 21).. When compared with patients who had a single ICU admission, the readmitted patients did not experience an increased ICU mortality. The reason for readmission was the same as the reason for initial ICU admission in half of the patients, a finding similar to that of Chen et al (17).

In our examination of 8222 ICU patients eligible for readmission, we found an effect of vacancy even after adjustment for patient and admission characteristics (adjusted relative risk 1.56; 95% CI = 1.05, 2.31). Previous studies aimed at examining the effect of a lack of ICU beds on patient outcomes were negative. The study by Singer and colleagues included a large proportion of coronary care unit and monitoring admissions (9). As most of these patients are at the low risk of death, it is not surprising that rationing had little impact. Strauss et al examined 1150 ICU admissions with an overall ICU mortality of 12.7% (7). Patients discharged when there was a lack of ICU bed availability had higher severity of illness scores at discharge, suggesting that bed resources affected physician decision-making. Although their readmission rate was very high (14%), there was no association observed between bed availability and adverse outcomes after ICU discharge. Their ICU mortality, however, was lower than our 16.5% ICU mortality and perhaps a lack of effect was again from selecting patients at a lower risk of death.

In our institution, being discharged from the ICU at night did not increase the risk of an adverse outcome. This is different from a previous study that described an increased mortality for patients discharged between 8 PM and 7:59 AM (22). Another marker of unit activity, discharge rank, was significant in the univariate analysis, but not after adjustment in the multivariable model. Our assumption was that, in an overcensus situation, discharge order reflects how suitable a patient was for discharge, with the "best" patients being discharged first. However, in the case of multiple discharges leaving to different wards, the ICU discharge rank may be more dependent on the exact time that a ward bed is ready than a reflection of the patient's clinical status.

Our hypothesis was that premature discharge from the ICU was leading to an increased rate of readmissions. It is challenging to account and adjust adequately for all of the patient and hospital factors that may affect the risk of readmission. In this study, we assumed that patients discharged from a nonoverfull ICU were appropriate for discharge based on the judgment of the attending intensivist. This decision is based on the clinical status of the patient as well as the attending physician's intimate knowledge of capabilities and limitations of the healthcare system in which they work. Consideration could be given to using a score to further adjust for patient acuity at the time of discharge, such as acute physiology scores, nursing workload measures, or organ dysfunction scores.

Acute physiology scores have been designed to predict hospital mortality and work very well for that purpose. However, they award points for severe physiologic abnormalities, such as hypotension, infections, and metabolic derangements that are generally resolved before ICU discharge. Physiology scores, therefore, may not add much to patient discrimination at the time of discharge.

An important component of the risk of ICU readmission is the care received outside of the ICU. In reality, this care is dependent on the available medical and

Table 2. Unadjusted and adjusted relative risk of early death or readmission to the intensive care unit

Covariate	Relative Risk (95% CI)	Adjusted Relative Risk (95% CI)
Patient factors		
Male	0.80 (0.63, 1.00)	1.01 (0.82, 1.24)
Age ≥35 yrs	1.59 (1.12, 2.25)	1.46 (1.02, 2.07)
Admission factors		
MICU (vs. SICU)	1.14 (0.93, 1.39)	0.85 (0.62, 1.16)
Diagnostic group (vs. cardiac diagnoses)		
Overdose/poisoning	0.19 (0.07, 0.53)	0.31 (0.11, 0.88)
Cardiac surgery	0.35 (0.21, 0.55)	0.40 (0.23, 0.70)
Vascular surgery	0.83 (0.53, 1.30)	0.91 (0.53, 1.56)
Medical miscellaneous	0.92 (0.50, 1.70)	0.96 (0.52, 1.78)
Trauma	0.95 (0.62, 1.47)	0.99 (0.58, 1.68)
Cardiac	1.00	1.00
General surgery	1.49 (1.00, 2.21)	1.53 (0.96, 2.42)
Neurological	1.50 (0.68, 3.39)	1.54 (0.68, 3.48)
Respiratory	1.64 (1.08, 2.51)	1.73 (1.11, 2.68)
Sepsis	2.15 (1.42, 3.25)	1.66 (1.08, 2.55)
Neurosurgery	2.29 (1.44, 3.62)	1.95 (1.14, 3.33)
Thoracic surgery	2.77 (1.75, 4.38)	2.79 (1.64, 4.73)
Gastroenterology	2.86 (1.76, 4.64)	2.55 (1.54, 4.25)
APACHE II score vs. APACHE II <10		
APACHE II 10–19	1.84 (1.24, 2.75)	1.50 (1.00, 2.24)
APACHE II 20–29	3.55 (2.35, 5.35)	2.16 (1.40, 3.33)
APACHE II 30–39	4.67 (2.72, 8.02)	2.75 (1.52, 4.97)
APACHE II ≥40	8.05 (2.19, 29.6)	4.57 (1.17, 17.8)
LOS in ICU vs. LOS <3 days		
LOS 3–10 days	2.40 (1.94, 2.96)	1.72 (1.35, 2.18)
LOS >10 days	3.42 (2.65, 4.42)	2.22 (1.65, 2.98)
Unit activity factors		
Admission in previous 4 hrs vs. no admission		
1 admission	0.96 (0.76, 1.22)	
≥2 admissions	1.02 (0.60, 1.74)	
Time to next admission vs. no admission within 8 hrs of a discharge		
4–8 hrs	0.91 (0.69, 1.21)	
<4 hrs	1.06 (0.86, 1.30)	
Time of Discharge vs. 9 AM–4 PM		
4 PM–9 PM	1.01 (0.80, 1.26)	
9 PM–9 AM	0.69 (0.43, 1.11)	
No vacancy at discharge	1.62 (1.10, 2.39)	1.56 (1.05, 2.31)
Second or later discharge of the day	1.21 (1.00, 1.46)	1.16 (0.94, 1.42)

CI, confidence interval; MICU, medical intensive care unit; SICU, surgical intensive care unit; APACHE, Acute Physiology and Chronic Health Evaluation; LOS, length of stay; ICU, intensive care unit.

nursing staff and the patient workload on a given service or ward. For nursing, there is a well-validated measure of workload. Therapeutic Intervention Scoring System scores have been used to assess ICU workload and resource allocation (23, 24). Discharge Therapeutic Intervention Scoring System scores may have been helpful to adjust for patient acuity at the time of discharge from the ICU. A downside of the Therapeutic Intervention Scoring System score is that, although it describes what interventions a patient received, the score does not indicate whether the intervention was necessary. For example, a patient ready for the regular ward may continue to undergo hourly vital signs and continuous electrocardiographic monitoring during his/her ICU stay even though the patient no longer requires this type of monitoring and will not be receiving it after transfer. Medical staff workload is a combination of the number of patients and their complexity. An organ dysfunction score, such as the Multiple Organ Dysfunction Score (25), may be a way to adjust for patient acuity on ICU discharge as well as be a reflection of patient complexity.

In this study, we did not examine the specific ward location from which patients were readmitted. In our institution, patients in step-down units and general ward beds are cared for by the same medical and nursing staff. Step-down units provide a higher nursing ratio and degree of vigilance than the general wards. Without examining specific ward locations and having detailed ward staffing information, we cannot exclude that the readmission rate was significantly influenced by a small number of hospital wards.

This study is limited by the fact that it represents a single institution. In addition, with a study of this duration, changes to the general functioning of the unit or institution could impact patient outcomes. During the study period, both ICUs continued to function as closed units. All care was directed by trained intensivists and provided by nurses with specialty training in critical care. There were no significant changes in staffing ratios or protocols within the ICU beds. Although we have attempted to account for all factors in the ICU known to influence patient outcomes, we do not have a measure for changes in medical or nursing practices or workloads on the hospital wards, which may have influenced the rate of ICU readmission. In addition, the presence of a rapid response team may mitigate the risk of readmission. Future studies would benefit from including a measure of patient complexity and workload at the time of ICU discharge.

Iapichino and colleagues have previously shown that an ICU occupancy of >80% was associated with increased ICU mortality (26). In our study, we observed a positive association between occupancy and readmission rates over a large range of occupancy rates in contrast to a critical percent occupancy above which adverse events are increased.

Rationing of intensive care therapy occurs based on patient needs combined with the perceived potential benefit in addition to resource availability. Increased ICU bed occupancy with limited vacancy may adversely affect patient outcome through either premature ICU discharge or the late admission of appropriate ICU patients. This study focuses only on the outcomes of patients discharged from the ICU with respect to unit occupancy and therefore may underestimate the effect of bed resources on patient outcomes. In this study, discharge from an ICU with no vacancy is significantly associated with an increased risk of ICU readmission. This finding raises the hypothesis that bed resources influence physician decision-making, resulting in premature ICU discharge and adverse patient outcomes.

CONCLUSIONS

Over the 8 yrs of the study period, an average of 5.2% patients experienced either early ICU readmission or death post ICU discharge. Independent patient risk factors for death or ICU readmission included increased age, length of stay, APACHE II score, and certain diagnoses (respiratory, sepsis, neurosurgery, thoracic surgery, and gastrointestinal bleeding). Lack of ICU vacancy at the time of ICU discharge was also independently associated with an increased risk of early death or ICU readmission. Overloading the capacity of an ICU to care for critically ill patients may affect physician decision-making, resulting in premature discharge from the ICU.

REFERENCES

1. Lyons RA, Wareham K, Hutchings HA, et al: Population requirement for adult critical-care beds: A prospective quantitative and qualitative study. *Lancet* 2000; 355:595–598
2. Bone RC, McElwee NE, Eubanks DH, et al: Analysis of indications for early discharge from the intensive care unit. Clinical efficacy assessment project: American College of Physicians. *Chest* 1993; 104:1812–1817
3. Bone RC, McElwee NE, Eubanks DH, et al: Analysis of indications for intensive care unit admission. Clinical efficacy assessment project: American College of Physicians. *Chest* 1993; 104:1806–1811
4. Fair allocation of intensive care unit resources. American Thoracic Society. *Am J Respir Crit Care Med* 1997; 156:1282–1301
5. Griner PF: Treatment of acute pulmonary edema: Conventional or intensive care? *Ann Intern Med* 1972; 77:501–506
6. Paz HL, Crilley P, Weinar M, et al: Outcome of patients requiring medical ICU admission following bone marrow transplantation. *Chest* 1993; 104:527–531
7. Strauss MJ, LoGerfo JP, Yeltatzie JA, et al: Rationing of intensive care unit services. An everyday occurrence. *JAMA* 1986; 255: 1143–1146
8. Metcalfe MA, Sloggett A, McPherson K: Mortality among appropriately referred patients refused admission to intensive-care units. *Lancet* 1997; 350:7–11
9. Singer DE, Carr PL, Mulley AG, et al: Rationing intensive care—Physician responses to a resource shortage. *N Engl J Med* 1983; 309: 1155–1160
10. Levin PD, Worner TM, Sviri S, et al: Intensive care outflow limitation–frequency, etiology, and impact. *J Crit Care* 2003; 18:206–211
11. Snow N, Bergin KT, Horrigan TP: Readmission of patients to the surgical intensive care unit: Patient profiles and possibilities for prevention. *Crit Care Med* 1985; 13:961–964
12. Baigelman W, Katz R, Geary G: Patient readmission to critical care units during the same hospitalization at a community teaching hospital. *Intensive Care Med* 1983; 9:253–256
13. Franklin C, Jackson D: Discharge decision-making in a medical ICU: Characteristics of unexpected readmissions. *Crit Care Med* 1983; 11:61–66
14. Cooper GS, Sirio CA, Rotondi AJ, et al: Are readmissions to the intensive care unit a useful measure of hospital performance? *Med Care* 1999; 37:399–408
15. Durbin CG Jr, Kopel RF: A case-control study of patients readmitted to the intensive care unit. *Crit Care Med* 1993; 21:1547–1553
16. Rosenberg AL, Hofer TP, Hayward RA, et al: Who bounces back? Physiologic and other predictors of intensive care unit readmission. *Crit Care Med* 2001; 29:511–518
17. 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; 26:1834–1841
18. Rosenberg AL, Watts C: Patients readmitted to ICUs*: A systematic review of risk factors and outcomes. *Chest* 2000; 118:492–502
19. Metnitz PG, Fieux F, Jordan B, et al: Critically ill patients readmitted to intensive care units—Lessons to learn? *Intensive Care Med* 2003; 29:241–248
20. Angus DC: Grappling with intensive care unit quality—Does the readmission rate tell us anything? *Crit Care Med* 1998; 26: 1779–1780
21. Rubins HB, Moskowitz MA: Discharge decision-making in a medical intensive care unit. Identifying patients at high risk of unexpected death or unit readmission. *Am J Med* 1988; 84:863–869
22. 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: 1287–1293
23. Cullen DJ, Civetta JM, Briggs BA, et al: Therapeutic intervention scoring system: a method for quantitative comparison of patient care. *Crit Care Med* 1974; 2:57–60
24. Cullen DJ, Keene R, Waternaux C, et al: Results, charges, and benefits of intensive care for critically ill patients: Update 1983. *Crit Care Med* 1984; 12:102–106
25. Marshall JC, Cook DJ, Christou NV, et al: Multiple Organ Dysfunction Score: A reliable descriptor of a complex clinical outcome. *Crit Care Med* 1995; 23:1638–1652
26. Iapichino G, Gattinoni L, Radrizzani D, et al: Volume of activity and occupancy rate in intensive care units. Association with mortality. *Intensive Care Med* 2004; 30:290–297