Journal of Critical Care (2008) **23**, 317–324

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Journal of Critical Care

Hospital mortality among adults admitted to and discharged from intensive care on weekends and evenings☆

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Keywords:
Mortality;
Weekends;
Evenings

Abstract

Purpose: Patient care may be inconsistent during off hours. We sought to determine whether adults admitted to or discharged from intensive care units (ICUs) on evenings and weekends have increased mortality rates.

Materials and Methods: All adults admitted to ICUs in the Calgary Health Region, Alberta, Canada, during 2000 to 2006 were included. The in-hospital mortality risk was assessed with admissions or discharges on weekdays (Monday to Friday) and daytime (8:00 AM to 5:59 PM) as compared with weekends (Saturday and Sunday) and nights (6:00 PM to 7:59 AM).

Results: Intensive care unit admissions (n = 20 466) occurred during weekends in 18%, nights in 41%, and nights and/or weekends in 49%. Among the 17 864 survivors to ICU discharge, 26% were discharged on weekends, 21% at night, and 41% on nights and/or weekends. Increased crude mortality rates were associated with both admission (24% vs 14%, $P < .0001$) and discharge (12% vs 5%, $P < .0001$) during nights as compared with days. Admission to (26% vs 16%, $P < .0001$) but not discharge from (6% vs 7%, $P = .42$) ICU during weekends as compared with weekdays was associated with increased mortality. After controlling for confounding variables using logistic regression analyses, neither weekend admission nor discharge was associated with death. However, both night admission and discharge were independently associated with mortality.

Conclusions: Our observations of excess risk associated with admission to or discharge from ICU at night merits further exploration as to whether it may reflect inconsistencies in care after hours.

1. Introduction

Several studies conducted in a number of different populations indicate that patients admitted to hospitals on weekends and evenings have a higher mortality rate [1-7]. Many factors have been proposed to explain these observations including lower levels of staffing and restricted

☆ No external funding was received for this study. None of the authors have financial or professional conflicts of interest that would influence the conduct or reporting of this study.

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doi:10.1016/j.jcrc.2007.09.001

availability of tests and procedures during these times. In addition, patients admitted "after hours" may be intrinsically at higher risk for death by virtue of a different case mix or increased severity of illness as compared with patients admitted during usual business hours. As a result of their acuity and severity of illness, patients admitted to intensive care units (ICU) represent a distinct in-hospital population. Although the body of literature is limited, studies conducted in critically ill populations have largely demonstrated higher crude mortality rates associated with admission during weekends and evenings [8-14]. However, in many cases, no increased risk associated with off-hours admission was present after controlling for confounding factors [8,10,12,13]. Similarly to off-hours admissions, weekend and evening discharge from ICU has also been associated with increased mortality risk [15-17].

If admission to or discharge from ICU after hours and/or on weekends truly increases the risk for an adverse outcome, then a major safety and process of care issue is present that requires attention. A relatively small number of studies have specifically looked at the effect of admission timing and outcome in adult ICUs, and even fewer have assessed the effect of timing of discharge. We undertook the present study to explore the effect that timing of admission to and discharge from ICU may have on mortality outcome.

2. Methods

2.1. Study population

The Calgary Health Region (CHR) provides virtually all acute hospital care to the residents of the cities of Calgary and Airdrie and a large surrounding area (population, 1.2 million) in the Province of Alberta, Canada. Critically ill adult patients in the CHR are managed in closed ICUs under the care of the Department of Critical Care Medicine, University of Calgary and CHR. These currently include a 14-bed cardiovascular surgery ICU (CVICU) and 3 multisystem ICUs: one 24-bed multisystem ICU that serves as the regional trauma and neurosurgical referral center, one 14-bed multisystem ICU that is also the vascular surgery referral center, and a 10-bed multisystem ICU. Patients are all admitted under the care of certified intensivists. In-house 24-hour per day coverage is provided by resident trainees or licensed physician associates. The base study population consisted of all adults (≥18 years) admitted to any multisystem or the CVICU in the CHR between January 1, 2000, and December 31, 2006. The Conjoint Health Research Ethics Board at the University of Calgary and CHR approved this study.

2.2. Study protocol

This study used an inception cohort design. Data were obtained using the ICU Tracer database, a regional patient care, research, and administrative database that systematically and uniformly records detailed demographic, clinical, laboratory, and hospital outcome data on all patients admitted to CHR ICU's [18]. A weekend was a priori defined by the period from Saturday midnight to Sunday at 11:59 PM, days as 8:00 AM to 5:59 PM and nights as 6:00 PM to 07:59 AM.

Severity of illness at inception was assessed using the Acute Physiology and Chronic Health Evaluation (APACHE) II score and intensity of care using the Therapeutic Intervention Scoring System (TISS) scores [19,20]. Shock was deemed to be present at presentation if a vasopressor infusion was required at any dose to maintain a clinically adequate blood pressure. Surgical patients included all patients admitted to the CVICU, victims of major trauma, patients admitted directly from the operating room, or those who were classified as having a surgical diagnosis as defined for the APACHE II score. Calgary Health Region residents were defined using postal code and/or town of residence according to the December 2003 boundaries of the CHR [21]; in homeless individuals or in cases where this information was not available, patients were considered to be CHR residents as long as they were not transferred from an extraregional site.

2.3. Statistical analysis

Analysis was performed using Stata version 9.0 (Stata Corp, College Station, Tex). To avoid the assessment of multiple outcomes for a single patient, we analyzed only the first ICU presentations from patients with multiple ICU admissions. Normally or near-normally distributed variables were reported as means ± SDs and nonnormally distributed variables as medians with interquartile ranges (IQRs). Means were compared using the Student t test and medians using the Mann-Whitney U test. Differences in proportions among categorical data were assessed using Fisher exact test for pairwise comparisons and the χ^2 test for multiple group trend analysis. Where missing data occurred, they were not replaced and are reported with reduced n.

Logistic regression models were developed to assess the independent effects of day and time of admission to and discharge from ICU on in-hospital mortality. Factors found to be significant to the $P < .1$ level in univariate analyses and weekend/weekday and day/evening admission time were included in the initial models. Backward stepwise variable elimination was then performed to develop the most parsimonious models. Discrimination was assessed using the area under the receiver operator characteristic (ROC) curve and calibration using the Hosmer-Lemeshow goodness-of-fit test.

3. Results

During the 7-year study period, a total of 24 204 ICU admissions occurred among 20 466 adult patients. Sixty-four

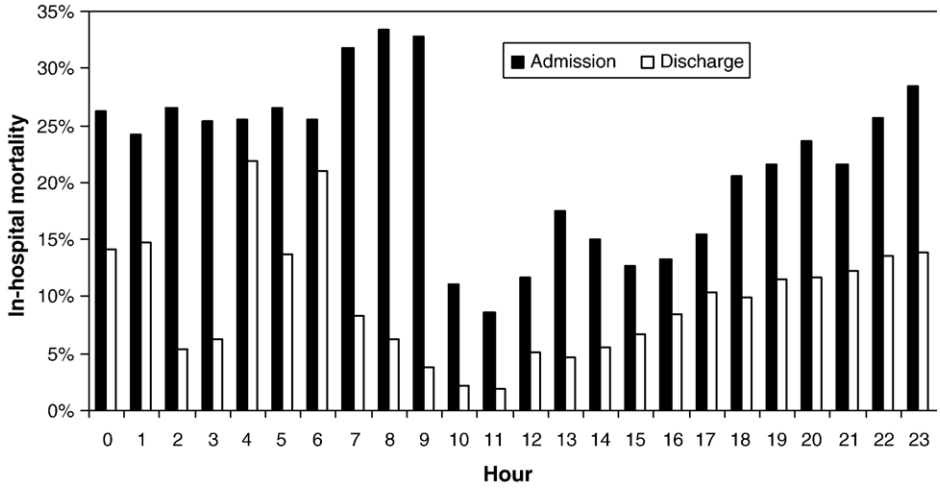

Fig. 1 Crude in-hospital mortality rates associated with time of admission to and discharge from adult ICU's, CHR, 2000 to 2006.

percent (13 119) of patients were male, the median age was 63.7 years (IQR, 49.9-73.8 years), and the mean ± SD APACHE II score was 25.1 ± 8.48 (n = 20 338). Intensive care unit admissions occurred during weekends (Saturday and Sunday) in 3715 (18%) cases, during the night (6:00 PM - 7:59) in 8450 (41%), and on nights and/or weekends in 9987 (49%) cases. Among 17 864 survivors to ICU discharge, 4661 (26%) were discharged on weekends, 3713 (21%) at night, and 7386 (41%) on nights and/or weekends.

The overall ICU and in-hospital mortality rates were 2506 (12%) of 20 466 and 3711 (18%) of 20 370, respectively. The crude risk for in-hospital death associated with time of ICU admission or discharge was generally lowest in late morning and early afternoon and then increased gradually until midnight at which point a relatively stable high rate was observed as shown in Fig. 1. Increased crude mortality rates were associated with both admission (2062/8418 [24%] vs 1649/11 952 [14%], $P < .0001$) and discharge (428/3713 [12%] vs 777/14 151 [5%], $P < .0001$) during night (6:00 PM to 7:59 AM) as compared with day (8:00 AM to 5:59 PM) hours.

The in-hospital mortality rates significantly differed ($P < .001$) according to the day of the week of ICU admission as shown in Fig. 2. The mortality rate associated with admission on Wednesdays and Thursdays was 1080 (15%) of 7170, on Monday, Tuesday, and Friday was 1663 (17%) of 9502, on Saturday was 459 (25%) of 1859, and on Sundays was 509 (28%) of 1839 ($P < .0001$ for each group comparison). In-hospital mortality rates were significantly higher with admission to ICU during weekends as compared with weekdays (968/3698 [26%] vs 2743/16 672 [16%], $P < .0001$). The day of discharge of survivors from ICU was also associated ($P = .06$) with a different risk for in-hospital death with a gradually increasing risk starting on Fridays and

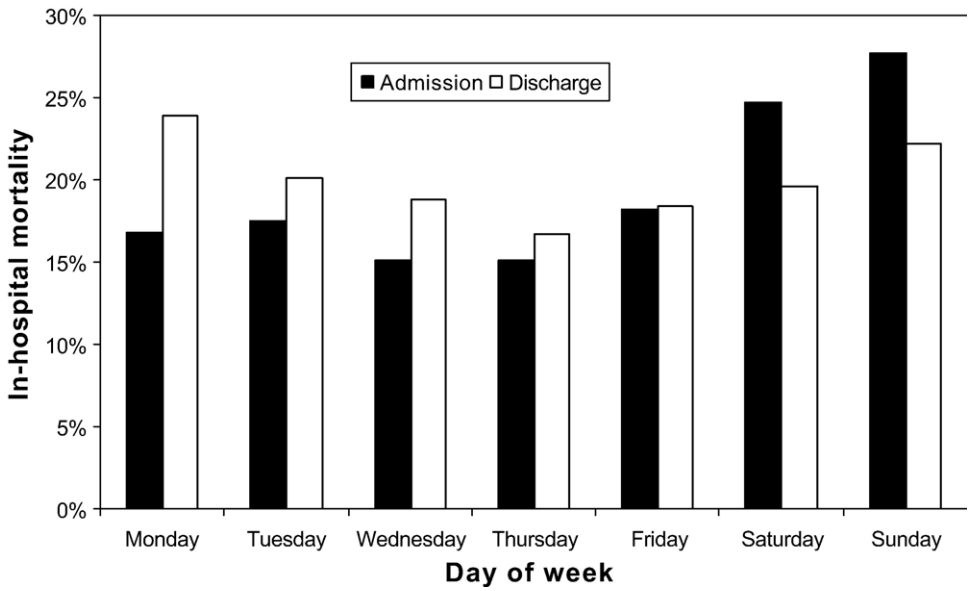

Fig. 2 Crude in-hospital mortality rates associated with day of admission to and discharge from adult ICUs, CHR, 2000 to 2006.

peaking on Mondays with a subsequent nadir on Thursday as shown in Fig. 2. However, unlike with ICU admission on weekends, no difference in in-hospital mortality was observed in relation to ICU discharge on weekends as compared with weekdays (302/4661 [6%] vs 903/13 203 [7%], $P = .42$).

Patients admitted during weekdays were intrinsically different based on a number of characteristics from those admitted during nights and/or weekends as shown in Table 1. Overall ICU length of stay among those admitted on weekends and/or nights was longer at a median of 2.6 days (IQR, 1.24-5.81 days) as compared with 1.8 (1.24-5.81 days, $P < .0001$) for those admitted during weekdays. Patients discharged during daytime hours during weekdays were also significantly different from those discharged on weekends and/or nights as shown in Table 2.

Table 1 Characteristics of adults admitted to ICU during weekday/daytime as compared with nights/weekends, CHR, 2000 to 2006

Factor	8:00 AM to 5:59 PM, Monday to Friday (n = 10 479)	6:00 PM to 7:59 AM, daily and anytime, Saturday or Sunday (n = 9987)	*P*
Median (IQR) age (y)	65.7 (54.5-74.0)	60.9 (44.7-73.4)	<.0001
Male sex	7165 (68%)	5953 (60%)	<.0001
Mean ± SD APACHE II	26.8 ± 7.42 (n = 10 375)	23.4 ± 9.1 (n = 9963)	<.0001
Mean ± SD TISS	50.8 16.5 (n = 10 099)	37.9 15.7 (n = 9626)	<.0001
Admitting ICU			<.001
CVICU	6708 (64%)	958 (10%)	
ICU A	1718 (16%)	4701 (47%)	
ICU B	1158 (11%)	2452 (25%)	
ICU C	895 (9%)	1876 (19%)	
Median (IQR) Pre-ICU hospital LOS	0.88 (0.25-3.93; n = 10 419)	0.05 (0.0-1.37; n = 9936)	<.0001
Medical-surgery category			<.001
Medical	2265 (22%)	5014 (50%)	
Elective noncardiac surgery	884 (8%)	1839 (18%)	
Emergent noncardiac surgery	622 (6%)	2176 (22%)	
Elective cardiac surgery	5786 (55%)	539 (5%)	
Emergent cardiac surgery	922 (9%)	419 (4%)	
Study year			<.001
2000	1565 (52%)	1461 (48%)	
2001	1583 (54%)	1348 (46%)	
2002	1601 (55%)	1327 (45%)	
2003	1519 (53%)	1359 (47%)	
2004	1415 (50%)	1398 (50%)	
2005	1413 (48%)	1513 (52%)	
2006	1383 (47%)	1581 (53%)	
Regional resident	7065 (67%)	7611 (76%)	<.0001
Admitting location			<.001
Operating room	7681 (73%)	3396 (34%)	
Emergency room	1234 (12%)	3640 (36%)	
Hospital ward	980 (9%)	1836 (18%)	
Hospital transfer	245 (2%)	444 (4%)	
Other hospital dept	28 (<1%)	41 (<1%)	
Other	311 (3%)	630 (6%)	
Main diagnostic category			<.001
Cardiovascular	7647 (73%)	2774 (28%)	
Respiratory	1168 (11%)	2471 (25%)	
Neurologic	461 (4%)	1190 (12%)	
Trauma	284 (3%)	1120 (11%)	
Gastrointestinal	308 (3%)	936 (9%)	
Poisoning	137 (1%)	446 (4%)	
Shock	119 (1%)	240 (2%)	
Genitourinary	89 (1%)	194 (2%)	
Endocrine/metabolic	84 (1%)	196 (2%)	
Other	182 (2%)	420 (4%)	

Table 2 Characteristics of live adults discharged from ICU during weekday/daytime as compared with nights/weekends, CHR, 2000 to 2006

Factor	8:00 AM to 5:59 PM, Monday to Friday (n = 10476)	6:00 PM to 7:59 AM, daily and anytime, Saturday or Sunday (n = 7386)	*P*
Median (IQR) age (y)	63.4 (51.0-73.2)	62.7 (47.1-73.3)	<.0001
Male sex	6998 (67%)	4632 (63%%)	<.0001
Mean ± SD APACHE II	24.6 ± 7.7 (n = 10399)	23.5 ± 8.1 (n = 7341)	<.0001
Mean ± SD TISS	46.3 ± 17.5 (n = 10197)	40.9 ± 16.7 (n = 7171	<.0001
Discharging ICU			<.001
CVICU	5339 (51%)	2089 (28%)	
ICU A	2502 (24%)	2662 (36%)	
ICU B	1351 (13%)	1670 (23%)	
ICU C	1287 (12%)	965 (13%)	
Median (IQR) ICU LOS	1.9 (0.99-3.95)	2.1 (1.24-4.67)	<.0001
Medical-surgery category			<.001
Medical	2724 (26%)	2956 (40%)	
Elective noncardiac surgery	1247 (12%)	1134 (15%)	
Emergent noncardiac surgery	1169 (11%)	1207 (16%)	
Elective cardiac surgery	4489 (43%)	1.682 (23%)	
Emergent cardiac surgery	849 (8%)	407 (6%)	
Study year			<.001
2000	1641 (62%)	1021 (38%)	
2001	1584 (61%)	1001 (39%)	
2002	1519 (59%)	1051 (41%)	
2003	1453 (58%)	1042 (42%)	
2004	1356 (56%)	1060 (44%)	
2005	1480 (58%)	1094 (43%)	
2006	1445 (56%)	1117 (44%)	
Regional resident	7222 (69%)	5421 (73%)	<.0001
Level of care			<.001
1 (all measures)	10071 (96%)	6905 (93%)	
2 (no cardiopulmonary resuscitation)	344 (3%)	407 (6%)	
3 (comfort only)	63 (1%)	74 (1%)	
Main diagnostic category			<.001
Cardiovascular	6299 (60%)	3153 (43%)	
Respiratory	1629 (16%)	1497 (20%)	
Neurologic	583 (6%)	649 (9%)	
Trauma	587 (6%)	594 (8%)	
Gastrointestinal	474 (5%)	570 (8%)	
Poisoning	262 (3%)	303 (4%)	
Shock	127 (1%)	108 (1%)	
Genitourinary	134 (1%)	120 (2%)	
Endocrine/metabolic	126 (1%)	133 (2%)	
Other	257 (2%)	259 (4%)	

A multivariable logistic regression model was developed to assess factors associated with in-hospital death (n = 19659; area under ROC curve, 0.855; goodness-of-fit P = 1.0). As shown in Table 3, although admission on weekends did not increase the risk for mortality, admission in the evening was an independent risk factor for death. A second logistic regression model was developed limited to patients surviving to ICU discharge (n = 17740; area under ROC curve, 0.846; goodness-of-fit P = 1.0) to assess the potential effect of the time of ICU discharge on mortality. As shown in Table 4, discharge from ICU during the evening was independently associated with mortality. Fig. 3 shows the in-hospital mortality associated with hour of admission to and live discharge from ICU after adjustment for confounding variables using the regression models.

4. Discussion

After controlling for a number of covariates, we found that, although there is no evidence of a "weekend effect," patients admitted after hours are at increased risk for death.

Table 3 Logistic modeling of factors associated with in-hospital death among adult patients admitted to ICU, CHR, 2000 to 2006

Factor	Odds ratio	95% CI	*P*
Noncardiac surgery [a]	0.60	0.54-0.66	<.001
Cardiac surgery [a]	0.04	0.03-0.04	<.001
Age (per year)	1.02	1.02-1.03	<.001
APACHE II (per point)	1.10	1.10-1.11	<.001
Weekend admission	1.05	0.95-1.17	.328
Night admission	1.37	1.24-1.50	<.001
Shock	1.17	1.05-1.31	<.001
Regional resident	1.29	1.16-1.44	<.001
2002/2004 [b]	1.24	1.13-1.35	<.001
TISS score (per point)	1.02	1.02-1.03	<.001

[a] As compared with reference category of medical patients.
[b] As compared with reference category of admission 2000/2001 or 2005/2006.

A number of investigators have observed increased risk for mortality associated with ICU admission on weekends, but this excess mortality has largely been explained by increased rates of admission of sicker patients or those with a different case mix [8-13]. Although we adjusted for a number of covariates in our logistic regression model (Table 3), it is notable that simply adjusting for medical-surgical class explains this excess risk (not shown). On the other hand, few studies have investigated the effect of time of admission to ICU and its effect on mortality outcome [9,11,13,14]. In contrast to our study that showed excess mortality associated with evening admission to ICU, these previous investigations have found no excess mortality risk associated with after-hours admission. Of note, we found no evidence for a statistical interaction between night and weekend admission times and mortality ($P = .17$ not shown). On the other hand, a significant interaction between night and weekend ICU discharge times was present in the model development ($P = .046$ not shown), and therefore, the odds ratios for each combination of night/day and weekday/weekend discharge times are shown in Table 4. Although an unrecognized confounding variable may explain the excess mortality risk associated with night admissions to our ICUs, the possibility that this is related to inconsistencies in provision of care within or outside of the ICU is compelling and merits further investigation [15].

Previous studies conducted in hospitalized populations have identified reduced staffing or decreased access to tests and procedures as potential means to explain excess mortality risk associated with off-hours admissions [3,11,22]. In our region, radiologic investigations, consultations, and procedures including coronary angiography are all available upon request 24/7. However, it is not uncommon to defer testing to weekdays or daytime hours in elective cases or in those where they are felt not to likely influence a patient's course. In our ICUs, weekend days staffing is similar to weekdays with the notable exception of resident house staff and allied health professionals. Although nurse and respiratory therapist staffing is similar 24/7, allied health professionals such as nutritionists, and social workers routinely staff the ICUs only during daytime on weekdays. During the daytime on weekdays, there are approximately 3 residents for each 10 ICU beds, but at night and weekends, this is reduced to one resident. In addition to a reduction in resident house staff at night, attending physician coverage is reduced. Although most patients are assessed by the attending intensivist or critical care medicine subspecialty resident/fellow within hours of admission [23], attending intensivists are not mandated to remain in-house. Of interest, Arabi et al [11] studied more than 2093 admissions to a Saudi Arabian tertiary care and found no excess mortality risk associated with evening or weekend admission. The authors attributed this to staffing 24/7 with board-certified intensivists However, no control group was included, and therefore, it is difficult to determine whether this was related to the in-house attending schedule or to other factors. Although it may be theorized that higher mortality rates observed in association with night admission or discharge may be related to reduced physician staffing, our observation that discharge during weekend days was associated with the lowest risk for death (Table 4) argues against this.

As compared with the day and time of admission to ICU, the role of the day and time of discharge from ICU on mortality has been less well investigated. Goldfrad and Rowan [16] reported on a large study from the Intensive Care National Audit and Research Centre's Case Mix Programme Database

Table 4 Logistic modeling of factors associated with in-hospital death after discharge from ICU, CHR, 2000 to 2006

Factor	Odds ratio	95% CI	*P*
Noncardiac surgery [a]	0.79	0.68-0.92	.002
Cardiac surgery [a]	0.14	0.11-0.17	<.001
Age (per year)	1.03	1.03-1.04	<.001
APACHE II (per point)	1.06	1.05-1.07	<.001
Weekend admission	0.99	0.84-1.16	.880
Night admission	1.15	1.00-1.33	.051
Regional resident	1.80	1.50-2.15	<.001
Level 2 [b]	3.69	3.07-4.42	<.001
Level 3 [b]	78.45	45.71-134.66	<.001
Weekday night discharge [c]	1.20	1.01-1.41	.035
Weekend day discharge [c]	0.81	0.67-0.98	.027
Weekend night discharge [c]	1.35	1.05-1.73	.018
2002/2004 [d]	1.40	1.23-1.60	<.001

[a] As compared with reference category of medical patients.
[b] Level 2, all care except no cardiopulmonary resuscitation; level 3, comfort measures only; as compared with level 1, no care restrictions at time of ICU discharge as reference category.
[c] As compared with reference category weekday daytime discharge.
[d] As compared with reference category of admission 2000/2001 or 2005/2006.

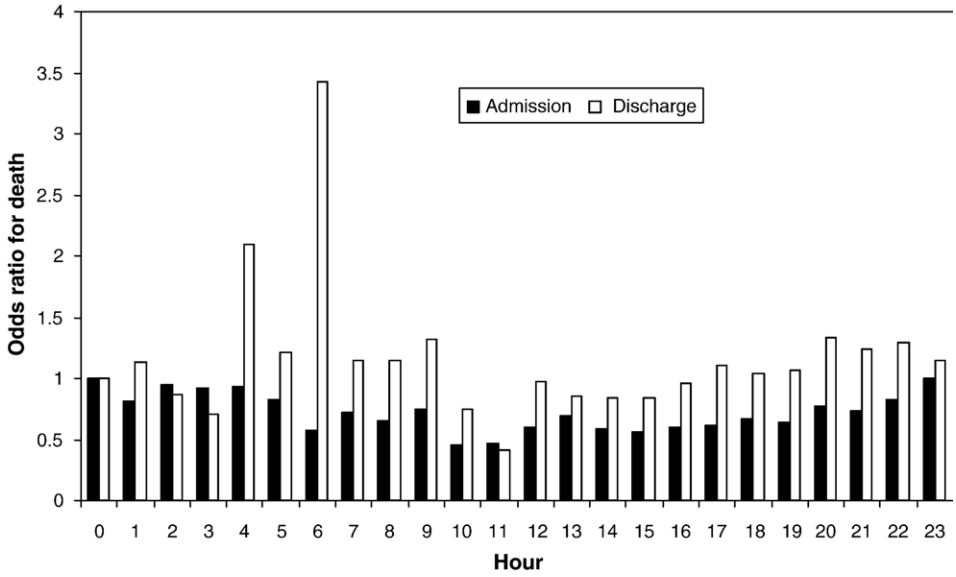

Fig. 3 Adjusted risk for in-hospital death associated with hour of admission to and live discharge from adult ICUs, CHR, 2000 to 2006.

in the UK and found an increased risk (odds ratio, 1.33; 95% confidence interval [CI], 10.6-1.65) associated with night discharge after adjusting using APACHE II score. These findings were echoed in a second study by Priestap and Martin [17] using information from the Critical Care Research Network's Minimum Dataset from 31 Canadian ICUs. In contrast, Uusaro et al [9] reported on a large study from 18 ICUs in Finland and found that, among 20636 survivors to ICU discharge, no excess risk was associated with night or weekend discharge after controlling for confounding factors including severity of illness and limitations on future care. In our study, despite controlling for a large number of covariates including severity of illness, limitations on care, and major diagnostic category, we found that evening discharge was associated with excess risk for death.

There are a number of important strengths and limitations of our study that merit discussion. By inclusion of all adults admitted to ICU in a large well-defined region, we minimized the risk of selection bias associated with conduct in a single or nonrandomly selected group of ICUs [21]. Furthermore, external generalization of our results should be facilitated by inclusion of a broad range of medical and surgical patients. Although we systematically collected detailed demographic, severity of illness, and intensity of care data and had few missing data, it is a limitation that we did not have further specific underlying comorbid illness information to allow adjustment for a range of underlying chronic illnesses. In addition, it would have been valuable to have specific staffing measures such as daily nurse/patient ratios as well as times to attendance by the staff intensivist and completion of investigations and consults to better explain our observations. Finally, it must be recognized that the care patients receive after ICU discharge has an important effect on outcome, and it is a limitation that we did not collect data specifically to investigate this aspect.

In conclusion, after controlling for confounding factors, admission to adult ICUs on the weekend in our region is not associated with an increased risk for mortality. On the other hand, both admission to and discharge from ICU at night is associated with an excess risk for in-hospital death. Further investigation is warranted to examine whether changes in process of care may reduce the excess risk associated with after-hours admission to and discharge from the ICU.

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