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Hospital mortality rate and length of stay in patients admitted at night to the intensive care unit* 

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Objective: Although admission of patients to a medical ward after 5:00 pm has been associated with increased mortality rate and possibly shorter hospital stay, the association between timing of admission to the intensive care unit and outcome has not been studied. The objective of this study was to determine whether there are any associations between the timing of patient admission to a medical intensive care unit and hospital outcome.

Design: A retrospective cohort study that used an Acute Physiology and Chronic Health Evaluation III database containing prospectively collected demographic, clinical, and outcome information for patients. Patients were divided according to the time of admission into daytime (from 7:00 am to 5:00 pm) and nighttime admissions. We further subdivided nighttime admissions into two groups (regular and heavy workload) according to the number of patients who were admitted during the same shift.

Setting: Medical intensive care unit (a 15-bed unit in an academic referral hospital).

Patients: 6,034 patients consecutively admitted to our medical intensive care unit over a 5-yr period starting April 10, 1995.

Interventions: None.

Measurements and Main Results: The patients admitted at night had a lower mortality rate (13.9 vs. 17.2%, p < .0001), adjusted for admission source and severity of illness. Their hospital stay was shorter, 11.0 days ± 13.5 (median 7) vs. 12.7 ± 14.8 (median 8; p < .0001), as was their intensive care unit stay, 3.5 ± 4.4 days (median 2) vs. 3.9 ± 4.7 (median 2; p < .0001), compared with the daytime admission group. The nighttime shifts that admitted three or more patients (heavy workload) had the same mortality rate (13.2%) as those with fewer admissions (14.5%; p = .5961). Hospital and intensive care unit stays were also similar in both workload groups.

Conclusions: Nighttime admission to our intensive care unit is not associated with a higher mortality rate or a longer hospital or intensive care unit stay compared with daytime admission. (Crit Care Med 2003; 31:858–863)

Key Words: intensive care; night care; hospital mortality rate; length of stay; workload; Acute Physiology and Chronic Health Evaluation

Only a few studies have addressed the relationship of patient outcome to the time of day at hospital admission or resident and staff physician workload. Admission to a medical ward during the nighttime shift (after 5:00 pm) has been associated with increased mortality rate and shorter hospital length of stay (LOS) (1). Although no linear relationship has been found between the number of hospital admissions and LOS, a nonlinear initial increase followed by a decrease in LOS has been noted as interns receive more on-call admissions (1). The effect of the number and timing of admissions on outcome may be related to house staff workload (1). It may also be related to nursing and ancillary personnel issues (2).

Attention has been focused recently on the impact of sleep deprivation among healthcare providers on patient outcomes. Well-publicized cases (3) have resulted in laws restricting working hours of physicians in training (e.g., Code 405.4, New York State health-code regulations). Such policies have been adopted variably among training programs in other areas and among different specialties. On April 30, 2001, the American Medical Student Association and Public Citizen (a non-profit public interest organization) filed a petition with the Occupational Safety and Health Administration requesting the agency to limit resident physician work hours to 80 per week. It appears logical that overworked and sleep-deprived staff physicians and nursing personnel might provide substandard care. Research on sleep deprivation of physicians has involved limited assessment of functionality and has not focused on patient outcome. After overnight duty, for example, interns and residents show performance decrements in some physical tasks (4, 5), standardized tests of knowledge (6), identification of cardiac arrhythmias (7) and other simulated conditions (8), recognition of abnormal laboratory values (9), and short-term memory tasks (10, 11). Nevertheless, researchers have found small, if any, differences in results of standard tests of psychomotor performance between rested and sleep-deprived house officers (4, 9, 11–15).

The impact of timing and number of admissions of critically ill patients to the intensive care unit (ICU) has not been studied. The purpose of this study was to determine whether there were any associations between the timing of admission to our medical intensive care unit (MICU) and hospital mortality, hospital LOS, and duration of ICU support. We also assessed whether the number of admissions at night had any impact on these outcomes.
METHODS

In this retrospective, cohort study, we examined a prospectively collected Acute Physiology and Chronic Health Evaluation (APACHE) III database of 6,041 patients consecutively admitted to the MICU in Saint Mary’s Hospital, Rochester, MN, over a 5-yr period starting April 10, 1995.

We included all patients who were admitted to the MICU during the study period. Seven patients had not given consent for their medical records to be used for research purposes and were excluded from the study. The MICU was a 15-bed, closed unit in Saint Mary’s Hospital, one of the two Mayo Clinic Hospitals, located in Rochester, MN. There was no intermediate care unit in the hospital for medical patients. Trauma patients are generally not admitted to the MICU. A small percentage of patients requiring coronary care interventions are admitted to the MICU, and these are managed in direct collaboration with the cardiology service.

The critical care service team, consisting of attending intensivists, critical care fellows, internal medicine residents, medical students, critical care pharmacists, critical care nurses, and respiratory therapists, provided care to all patients. The call schedules and composition of teams were as follows. Three teams admitted patients. The call schedules and composition of teams were as follows. Three teams admitted patients. Team A had admitting responsibilities starting at 7:00 am of the following day. Team B had already started admitting patients at 7:00 am, and team C would generally stay in the hospital after the noontime conference. Team C had started admitting patients at 7:00 am, and team C would generally stay in the hospital after the noontime conference. The intensivist did not stay in house at night but would consult over the phone and come to the ICU as needed. Each resident trainee and fellow spends 1 month in the ICU rotation. Staff intensivists rotate usually for 2 wks at a time. The nurse/patient ratio in the ICU was 1:1–1:2 during the day and did not change at night. The ICU team would not follow patients after discharge from the ICU. At discharge from the ICU, patients were transferred to another coprimary medical service that had been following the patients’ progress while they were in the ICU.

We collected data including demographics, admission source, categories of primary ICU admission diagnosis, time of MICU admission and discharge, first MICU day predicted hospital mortality rate, LOS, and hospital mortality rate from the APACHE III database. The predicted hospital mortality rate was calculated as described by Knaus and colleagues (16), taking into account acute physiologic scores, patient age, and admission diagnosis. The patients’ admission source was categorized as direct admission if patients were admitted directly from the emergency room, outpatient clinic, or operating room. Patients from other sources (medical floors, outside hospitals) were categorized as transfers. Patients were divided according to the time of MICU admission. Admission time was defined as the time the patient arrived in the MICU. Daytime admissions were considered those from 7:00 am to 5:00 pm. We chose the morning cutoff (7:00 am), since after that hour, the entire MICU team and attending staff members were present and the new on-call team assumed admission responsibilities. We also collected the number of admissions per nighttime shift. We divided the night shifts based on the number of admissions into “regular workload” and “heavy workload” categories. The regular workload shifts were those at or below the mode of distribution of admissions per shift. The heavy workload shifts were those with a greater number of admissions. We also performed subgroup analysis of the patients admitted at night, dividing them into two categories, “early admission” between 5:00 pm and midnight, and “late admission,” from midnight to 7:00 am.

Means and standard deviations were used to summarize approximately normally distributed data, whereas medians were used for skewed data. We compared mean differences by using the Student’s t-test or the rank-sum test when data were skewed. Chi-square test was used to compare categorical variables. Because of differences in baseline severity of illness and admission source, outcome analyses regarding mortality rate were adjusted for APACHE III predicted mortality rates by using logistic regression analyses. Patients with missing variable values were excluded from analyses involving the missing variable. To assess the duration of ICU support, we determined “ ICU-support free days” at 28 days after ICU admission. Patients who died in the hospital or spent more than 28 days in the ICU were assigned zero ICU-support free days. All survivors accrued one ICU-support free day for each day after entry into the study that they were both alive and free from ICU support in the first 28 days after ICU admission (17). The 95% confidence interval (CI) was calculated for all odd ratios (ORs) determined by logistic regression analysis. In calculating the OR, daytime admission was coded as 1 and nighttime admission as 0. In calculating ORs for the nighttime admission categories, we ceded early nighttime admission as 1 and late nighttime as 0. APACHE III-predicted mortality rate, admission source, admission time, and primary admission diagnosis category were used to develop a logistic regression model for predicting hospital mortality rate. Hosmer-Lemeshow C statistic and receiver operating characteristic curve analysis were applied to determine the calibration and discrimination of this model. Hosmer-Lemeshow statistic measures the goodness of fit. A model with good fit should have a Hosmer-Lemeshow statistic close to 8 with a p value >.05. We considered p < .05 to be statistically significant.

RESULTS

Most of the patients were Caucasians. Nighttime admissions were younger, were less likely to be transfers, and had higher predicted mortality rate than daytime admissions (Table 1). Comparison of daytime admissions with nighttime admissions showed that there were significantly more daytime admissions in the cardiovascular and respiratory admission diagnosis categories and less daytime admissions in the neurologic admission diagnosis category (Table 2). Transfers to the MICU had an increased mortality rate, an OR of 2.4 (95% CI, 2.091–2.774) compared with direct admissions. The patients admitted during the day had a higher mortality rate (17.2 vs. 13.9%, p < .001), with OR for hospital death of 1.588 (95% CI, 1.352–1.864) adjusted for admission source and severity of illness. The Hosmer-Lemeshow C statistic of APACHE III predicted mortality was 110 with p < .001. After excluding primary admission diagnosis categories of transplant and trauma because of their small number, we performed logistic regression analysis by entering primary admission diagnosis category, APACHE III predicted mortality rate, admission time, and admission source. Age was not entered in this analysis since it is a component of the APACHE III prognostic system. The Hosmer-Lemeshow C statistic of this model was 39 with p < .001. In
Table 1. Demographic and Acute Physiology and Chronic Health Evaluation (APACHE) III data for patients by timing of admission

<table>
<thead>
<tr>
<th></th>
<th>Daytime (n = 2,946)</th>
<th>Nighttime (n = 3,088)</th>
<th>Total</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yrs</td>
<td>62.7 ± 18.4</td>
<td>60.2 ± 20.4</td>
<td>61 ± 19.5</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Sex, n (%)</td>
<td>Male</td>
<td>1,539 (52)</td>
<td>1,614 (52)</td>
<td>3,153 (52.3)</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1,407</td>
<td>1,474</td>
<td></td>
</tr>
<tr>
<td>Race, n (%)</td>
<td>White</td>
<td>2,789 (94.6)</td>
<td>2,878 (93.2)</td>
<td>5,667 (93.9)</td>
</tr>
<tr>
<td></td>
<td>African-American</td>
<td>32</td>
<td>48</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>Hispanic</td>
<td>30</td>
<td>35</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>Asian</td>
<td>27</td>
<td>34</td>
<td>61</td>
</tr>
<tr>
<td>Admission source, n (%)</td>
<td>Direct</td>
<td>1,820 (61.8)</td>
<td>2,091 (67.7)</td>
<td>3,911 (64.9)</td>
</tr>
<tr>
<td></td>
<td>Transfers</td>
<td>1,126</td>
<td>997</td>
<td>2,123</td>
</tr>
<tr>
<td>APACHE-predicted mortality, %</td>
<td>14.6 ± 19.0</td>
<td>16.5 ± 21.2</td>
<td>15.6 ± 20.2</td>
<td>.0002</td>
</tr>
</tbody>
</table>

Values are n (%).

Table 2. Admission diagnosis categories by timing of admission

<table>
<thead>
<tr>
<th>Admission Diagnosis Categories</th>
<th>Daytime (n = 2,946)</th>
<th>Nighttime (n = 3,088)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory</td>
<td>1,124 (52)</td>
<td>1,043 (48)</td>
<td>2,167</td>
</tr>
<tr>
<td>Gastrointestinal</td>
<td>704 (50)</td>
<td>703 (50)</td>
<td>1,407</td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>511 (52)</td>
<td>463 (48)</td>
<td>974</td>
</tr>
<tr>
<td>Neurologic</td>
<td>321 (36)</td>
<td>583 (64)</td>
<td>904</td>
</tr>
<tr>
<td>Metabolic/endocrine</td>
<td>114 (45)</td>
<td>142 (55)</td>
<td>256</td>
</tr>
<tr>
<td>Genitourinary</td>
<td>108 (55)</td>
<td>89 (45)</td>
<td>197</td>
</tr>
<tr>
<td>Hematologic</td>
<td>35 (47)</td>
<td>40 (53)</td>
<td>75</td>
</tr>
<tr>
<td>Musculoskeletal/skin</td>
<td>28 (56)</td>
<td>22 (44)</td>
<td>50</td>
</tr>
<tr>
<td>Trauma</td>
<td>1 (33)</td>
<td>2 (67)</td>
<td>3</td>
</tr>
<tr>
<td>Transplant</td>
<td>0</td>
<td>1 (100)</td>
<td>1</td>
</tr>
</tbody>
</table>

Values are n (%).

This model, cardiovascular admission diagnosis category (OR, 1.314; 95% CI, 1.039–1.661; p = .022) and neurologic admission diagnosis category (OR, 0.645; 95% CI, 0.468–0.889; p = .007), higher APACHE III predicted mortality rate (OR, 1.047; 95% CI, 1.043–1.051; p < .001), daytime admission (OR, 1.557; 95% CI, 1.325–1.830; p < .001), and transfer to ICU (OR, 1.535; 95% CI, 1.307–1.802; p < .001) were independently associated with hospital mortality rate. The area under the receiver characteristic curve for APACHE III was 0.807 (95% CI, 0.796–0.817) compared with 0.811 (95% CI, 0.801–0.821) for the new model (p = .336). The hospital LOS was also shorter for nighttime admissions (11.0 ± 13.5 days, median 7 vs. 12.7 ± 14.8 days, median 8, p < .001). Their length of ICU support was also shorter, with a median of 26 ICU-support free days vs. 25 ICU-support free days for the daytime admission group (p < .0001).

The percentage of patients admitted during the day who required mechanical ventilation was 35%, compared with 32.5% of those admitted during the night (p = .0233). Pulmonary artery catheterization was performed in 7.5% of daytime vs. 7.9% of nighttime patients (p = .6219).

Among the nighttime admissions, 1,814 (59%) were admitted early, between 5 pm and midnight, and 1,274 (41%) were admitted late, between midnight and 7 am. Thirty-four percent of the early nighttime admissions were transfers compared with 30% of the late nighttime admissions (p = .0177). The APACHE III-predicted hospital mortality rate of the early nighttime admission group was 18% compared with 15% of the late nighttime group (p = .0001). The hospital mortality rate of the early nighttime admission group was 15% compared with 13% of the late nighttime admission group (p = .1903). The median ICU-support free days was 25 for the early nighttime admission group compared with 26 for the late nighttime admission group (p < .0001). When we used a logistic regression analysis model with hospital mortality rate as the dependent variable and admission source, admission diagnosis category, APACHE III predicted hospital mortality rate, and group of nighttime admission as independent variables, we did not find significant difference in mortality rates between the early and late nighttime admissions (p = .6191; OR, 1.063; 95% CI, 0.835–1.354).

Most of the night admissions were limited to three patients or fewer each night (Table 3). There were no significant differences in baseline characteristics between the regular and heavy workload groups (Table 4). The nighttime shifts that admitted three or more patients (heavy workload group) had the same mortality rate (13.2%) as those with fewer admissions (regular workload group; 14.5%; p = .5961). Being admitted at night in a shift with heavy workload was not associated with an increased mortality rate, with an OR of 0.939 (95% CI, 0.743–1.186) compared with admission to a night shift with regular workload, adjusted for admission source and severity of illness. Hospital LOS was also similar in both heavy and regular workload groups (11.1 ± 13.0 days, median 7 vs. 10.9 ± 13.9 days, median 7, respectively, p = .7374). Their length of ICU support was also similar (a median of 26 ICU-support free days for the heavy workload group vs. 25 days for the regular group; p = .1926). Outcome data are summarized in Tables 5 and 6.

**DISCUSSION**

In this study, we did not find an increase in hospital mortality rate or LOS in patients admitted to the MICU at nighttime. We also did not find increased mortality rate or length of hospital stay associated with higher number of nighttime MICU admissions. We do not believe that these findings represent a type II error, based on the large sample size of the data analyzed and thus high statistical power. Our results suggest that nighttime admission to an intensive care unit need not be associated with poor outcome as long as adequate staffing and services are maintained. Provided that there are enough nurses, respiratory therapists, physicians, and other medical personnel as well as laboratory, radiology, and other services needed to provide optimal patient care, the timing of ICU admission is unlikely to be associated with mortality rate. In our MICU essential services are maintained, and nursing shortage at night is uncommon. One critical care fellow and two internal medicine residents are on call at night.
In the present study, we used logistic regression models to show that nighttime admission to the ICU is not associated with increased mortality rate. However, the calibrations of the models showed poor fit. In general, large sample sizes can lead to spuriously poor model fit. The large sample size in the present study may account for the poor calibration. Poor calibration can be associated with higher or lower than expected mortality rates.

We do not have a good explanation for the higher mortality rate of daytime admissions. Although the absence of an intermediate care unit may have led to the overall low hospital mortality rate, we do not think that it explains the differences in mortality and LOS between daytime and nighttime admissions. We believed that the inclusion of a severity of illness score (APACHE III) in the logistic regression analysis would neutralize the bias that may arise from differences in the number of “less ill” patients admitted to the ICU during each shift who in other institutions might have been admitted to an intermediate care unit.

In our study, the nighttime admissions included a relatively higher number of patients with neurologic admission diagnosis category who had lower associated mortality rates and a lower number of patients with cardiovascular admission diagnosis category who had higher associated mortality rate. This patient mix only partly explains the lower mortality rate of nighttime ICU admissions. During the day, more invasive procedures and surgeries are performed throughout the hospital. It is possible that complications from these procedures or more aggressive interventional diagnostic and therapeutic approaches might produce this observed increase in mortality rate. However, we have compared the number of patients who required mechanical ventilation and pulmonary artery catheterization in both daytime and nighttime groups, and only small differences were seen.

Since the same resident teams that admitted at night would admit patients during the day 48 hrs later, it is unlikely that individual physician practices would account for differences. Also, if most deaths had occurred very shortly after admission, it would have been very difficult to prove differences in mortality rates between groups based on time of admission, or these differences may have been due to chance or bias. The mean ICU LOS for patients in our study who died was 5.1 days, so we believe that timing of admission by itself might affect mortality rate.

It is difficult to assess the impact of admitting critically ill patients to the hospital at a time when personnel might not be working at their best capacity. Because of concerns regarding the effects of sleep deprivation on medical house staff and additional staffing difficulties at night, authors have hypothesized that patients admitted at night might have worse outcomes than their daytime counterparts (1, 18, 19). Changes made at hospitals in attempts to improve resource utilization and to reduce sleep deprivation of medical house staff have resulted in a reduction in LOS and a decrease in the number of laboratory tests ordered (18). However,
Compared with admission during the day, nighttime admission and the number of admissions per night shift to our medical intensive care unit are not associated with a higher mortality rate or a longer hospital stay.

Others have reported more medical complications and more diagnostic test delays with no change in mortality rate or LOS (20). Many hospitals have difficulties with lower nurse/patient ratios at night. A low nurse/patient ratio at night in the ICU in the United States has been associated with an increased risk for postoperative complications in patients undergoing esophageal resection (19). In the United Kingdom, it has been reported that high nursing workload in the ICU is related to an increased mortality rate (21). However, in Switzerland, it has been reported that despite an increase in nursing workload in the ICU over 15 yrs, ICU mortality rate and LOS actually decreased (22). A recent article by Bell et al. (23) described an increased mortality rate in patients admitted to the hospital on weekends, perhaps related to staffing issues. Similar to another previous study (20), Bell et al. used the Charlson (24) comorbidity score to assess severity of illness at hospital admission. However, the Charlson comorbidity score has been validated for predicting 1-yr mortality rate but not for in-hospital mortality rate. The authors recognized this limitation and acknowledged that severity of illness may have contributed to the increased mortality rate of patients admitted during the weekend in their study. In the present study, we used the APACHE III prognostic system to adjust for the severity of illness. The APACHE III system incorporates age, admission diagnosis, and physiologic assessments of severity of illness and provides predictions for hospital LOS and risk of death (25, 26). It has been widely used and validated (27, 28). There also may be other confounding factors related to the timing of admission and in-hospital mortality rate. It is well established, for example, that mortality rate due to various diseases has a diurnal variation (29, 30).

There are several weaknesses in this study. It was performed retrospectively by using prospectively collected data. Since our analyses were limited to data available in the APACHE III database, we may not have included confounding variables that influence outcome. The division of admissions between regular and heavy workload groups may not represent the actual work conditions for each shift, since many factors besides the number of admissions influence the workload imposed on ICU staff. We have no data available as to the percentage of patients at night who required direct staff intensivist intervention (either by phone or direct presence). We also do not have data regarding the variations in the MICU patient census at various times of day and night.

It has been pointed out that it may not be meaningful to compare performance of acutely sleep-deprived residents admitting patients during the night to chronically sleep-deprived residents working during the day (31). We do not have data available on the sleep patterns of the residents, fellows, and attendings during their MICU rotations. Also, our definition of nighttime admissions as those after 5:00 pm may not have fully measured the potential impact of sleep deprivation. Because the study was limited to a single academic medical center and one model of MICU staffing with 24-hr physician coverage and adequate support services, these findings may not apply to other institutions.

CONCLUSIONS

Compared with admission during the day, nighttime admission and the number of admissions per night shift to our medical intensive care unit are not associated with a higher mortality rate or a longer hospital stay.

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REFERENCES


