

## Outcome of Severe Head Injured Patients Admitted to Intensive Care During Weekday Shifts Compared to Nights and Weekends

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### Abstract

**Introduction:** Some studies have demonstrated an increased risk of death for patients admitted at nights or during weekends. This study was undertaken to investigate the demographic profile, medical interventions and outcome of severe head injury patients stratified according to day and time of admission to a specialised neurosciences intensive care unit (NICU). **Materials and Methods:** A retrospective study using a prospectively maintained severe head injury database in a tertiary hospital. Admissions to the NICU were grouped into weekdays, weeknights and weekends. A comparison of patients admitted during the day and night hours were also made. **Results:** A total of 838 severe head injury patients admitted to NICU were included in the study, of which 263 were admitted on weekdays, 327 on weeknights and 248 on weekends. More patients were admitted during the night (496) compared to during the day (342). There were no significant differences in the demographic profile, mechanism of injury, severity of injury, need for neurosurgical intervention, and duration of mechanical ventilation, intensive care unit (ICU) stay and mortality associated with day and time of admission. In multivariate analyses controlling for confounding factors, no statistically significant difference in ICU mortality was found with the day and time of admission. **Conclusions:** There were more severe head injury patients admitted to ICU at night and on weekends, with no significant difference in demographic profile, types of injuries, need for neurosurgical interventions and duration of ICU stay and mortality in a specialised NICU with adequate staffing and requisite diagnostic and therapeutic modalities available.

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**Key words:** Admission, Intensive care, Nights, Severe head injury, Weekend

### Introduction

Recognising that severe head injury is a major health problem with significant mortality and morbidity, numerous epidemiological and outcome studies have been conducted in order to devise effective preventive measures and, allocation of resources, and for the prognostication for healthcare planning.<sup>1-3</sup> Patients presenting with severe head injury [defined as Glasgow coma scale (GCS)  $\leq 8$ ] are at the highest risk for the development of intracranial hypertension and thus require admission to the intensive care unit (ICU) for close monitoring.

In recent years, several studies have demonstrated an increased risk of death and longer duration of stay for patients admitted at night or during weekends.<sup>4-8</sup> However, similar studies demonstrate no such relationship.<sup>9-13</sup> Many factors, including availability of staffing and resources, severity of disease, patient characteristics at time of admission, and organisational pattern of the particular ICU

may contribute to the contradictory findings. Although severe head injury is a diagnosis frequently encountered in critical care units, no studies have been conducted on the association of day and time of admission to ICU with the characteristics and outcome of patients. This has a potential impact on the organisation of ICU services and logistic planning.

The current study was undertaken to investigate the demographic characteristics and outcomes of severe head injury patients in relation to the day and time of admission to a specialised neurosciences intensive care unit (NICU) in a tertiary hospital with uniform staffing and ready access to diagnostic and therapeutic options.

### Materials and Methods

This is a retrospective study using a prospectively maintained severe head injury database in a tertiary hospital from April 1999 to June 2006. All patients were managed

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according to the severe head injury protocol instituted in 1996, based on the guidelines on the management of severe head injury.<sup>14</sup> The protocol emphasises the early detection, prevention and aggressive management of secondary insults using a cerebral perfusion pressure centred protocol in an incremental algorithm.<sup>15</sup> The 18-bedded NICU has in attendance dedicated intensive care specialists, available round the clock. The intensivist is a fully trained anaesthetist who leads a team of doctors and nurses, the latter trained in critical care and neuroscience nursing. The nurse/patient ratio is approximately 1:1.5 throughout the day and night, including weekends. There is an in-house neurosurgery registrar on call at all times. The neurosurgery consultant is not in house, but is consulted over the phone and returns as necessary. There is an ICU clinical information system (Carevue, Philips Medical Systems, Netherlands) that integrates and manages the clinical information from patient monitors, and charts this information electronically. At the same time, it links up with the hospital's laboratory and demographic databases, allowing access to patient information at the computer at each patient cubicle. The unit is also supported by a dedicated neuroradiology department providing 24-hour computed tomography (CT), magnetic resonance imaging (MRI) and angiographic services.

Admission time was defined as the time the patient arrived in the NICU. For the purpose of this study, admissions were grouped into weekday (Monday to Friday, 0800 to 1729 hours), weeknight (Monday to Friday, 1730 to 0759 hours) and weekend (Saturday to Sunday, 0800 to 0759 hours) admission categories. We also grouped the patients into day (0800 to 1729 hours) and night (1730 to 0759 hours) admission categories. We arbitrarily chose 8 am and 5.30 pm as the cut-off timings as these are the normal working hours for staff in our hospital.

All statistical analyses were carried out using SPSS software version 12.0. Continuous variables were expressed as mean ± SD. Chi-square test was used to compare categorical variables. Statistical significance was set at *P* < 0.05. Logistic regression analysis was used to identify risk factors associated with ICU mortality at various day and times of admission.

**Results**

Of the 858 severe head injury patients admitted to the NICU during the study period, 20 (2.33%) were not analysed because of missing data on time of admission to ICU. Among the remaining 838 patients, 263 (31.4%) were admitted on weekdays, 327 (39.0%) on weeknights, and 248 (29.6%) on weekends. Figures 1 and 2 show the distribution of NICU admissions by hour and day of week. Admission numbers were fairly consistent throughout the day of the week. The number of admissions varied

considerably by the time of the day, with peaks around midnight and troughs around 0500 to 0700. More patients were admitted at night (496 or 59.19%) compared to in the day (342 or 40.81%). We examined demographic characteristics and outcome of patients by day of week admission, but found no significant differences. Tables 1 and 2 show the characteristics and outcomes of patients according to their day and time of admission to NICU. There was no significant difference in the demographic profile, mechanism of injury, types of injuries or severity, duration of ICU stay and mechanical ventilation, although a significantly larger number of patients under the influence of alcohol were admitted at nights and during weekends. Further analysis did not demonstrate alcohol use to have a statistically significant effect with respect to NICU mortality. Similarly, no significance differences were found in the likelihood of the need for tracheostomy, barbiturate coma or neurosurgical interventions such as intracranial pressure

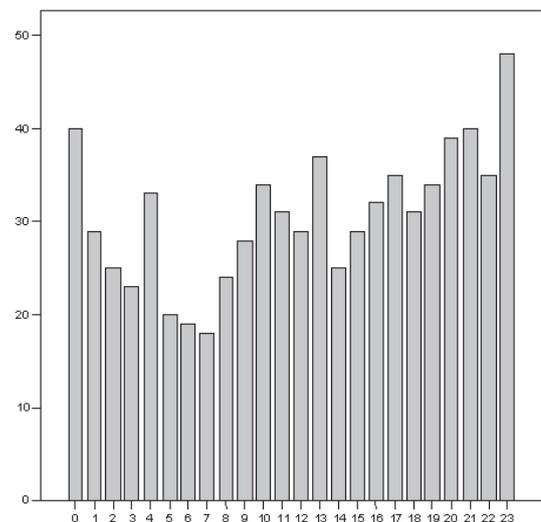


Fig. 1. Distribution of severely head injured patient NICU admission by hour of the day.

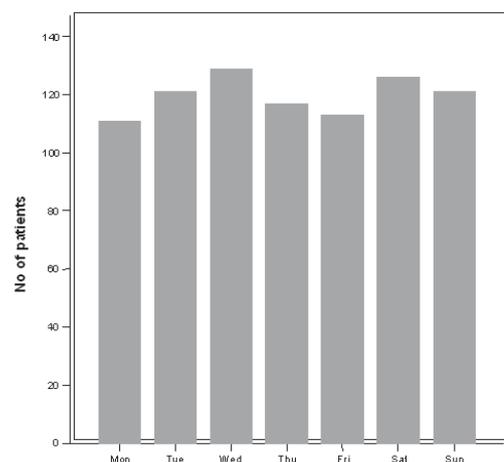


Fig. 2. Distribution of severely head injured patient NICU admission by day of the week.

Table 1. Characteristics and Outcomes by ICU Admission on Weekdays, Weeknights and Weekends

	Weekdays n = 263 (31.4%)	Weeknights n = 327 (39.0%)	Weekends n = 248 (29.6%)	P value
Age (y)	48.87 ± 20.04	47.13 ± 20.90	45.19 ± 20.64	0.130
Gender				0.926
Male	198 (75.3%)	250 (76.5%)	190 (76.6%)	
Female	65 (24.7%)	77 (23.5%)	58 (23.4%)	
Ethnic group				0.348
Chinese	193 (73.4%)	230 (70.3%)	169 (68.1%)	
Malay	25 (9.5%)	34 (10.4%)	38 (15.3%)	
Indian	21 (8.0%)	33 (10.1%)	24 (9.7%)	
Other	24 (9.1%)	30 (9.2%)	17 (6.9%)	
Mechanism of injury				0.159
MVA	109 (41.4%)	136 (41.6%)	119 (48.0%)	
Fall from height	48 (18.3%)	49 (15.0%)	25 (10.1%)	
Fall	81 (30.8%)	109 (33.3%)	81 (32.7%)	
Assault or violent	5 (1.9%)	15 (4.6%)	7 (2.8%)	
Others	20 (7.6%)	18 (5.5%)	16 (6.4%)	
Admission source				0.983
Direct	219 (83.3%)	271 (82.9%)	205 (82.7%)	
Transfer	44 (16.7%)	56 (17.1%)	43 (17.3%)	
Alcohol influence	17 (6.5%)	50 (15.3%)	36 (14.5%)	<b>0.02</b>
Multiple injuries	64 (24.3%)	71 (21.7%)	55 (22.2%)	0.733
Hypoxia	24 (9.1%)	34 (10.4%)	30 (12.1%)	0.547
Hypotension	31 (11.8%)	32 (9.8%)	32 (12.9%)	0.487
GCS-PR (median)	7	7	7	0.103
Pupil abnormality-PR	94 (36.4%)	125 (38.7%)	94 (38.5%)	0.834
ISS	25.12 ± 9.36	24.58 ± 9.79	23.45 ± 10.68	0.468
Apache II	23.55 ± 6.47	22.85 ± 6.97	22.24 ± 5.30	0.466
Need for				
Tracheostomy	50 (19.0%)	57 (17.4%)	29 (11.7%)	0.061
Barbiturate coma	25 (9.5%)	35 (10.7%)	19 (7.7%)	0.465
Neurosurgical intervention	149 (56.7%)	186 (56.9%)	128 (51.6%)	0.389
ICU mortality	84 (31.9%)	111 (33.9%)	85 (34.3%)	0.827
Hospital mortality	95 (36.1%)	129 (39.4%)	95 (38.3%)	0.707
ICU length of stay (days)	5.19 ± 6.27	4.70 ± 4.91	4.49 ± 4.82	0.318
Duration of mechanical ventilation (days)	3.89 ± 5.38	3.34 ± 3.82	3.48 ± 4.47	0.332

ICU: intensive care unit; ISS: injury severity score; MVA: PR: post resuscitation

monitor insertion, evacuation of intracranial haematoma or decompressive craniectomy. Of the 463 severe head injury patients who underwent neurosurgical intervention, 125 (27.0%) of the initial neurosurgical procedure were performed during weekdays, 152 (32.83%) on weeknights and 132 (28.51%) on weekends [Note: Fifty-four patients without exact time of surgery recorded were excluded from analysis as it was then not possible to precisely ascertain if ICU admissions occurred in the day or night shifts]. Two

hundred and thirty-four (50.54%) of these procedures were performed at night compared to 175 (37.80%) performed in the day.

There was no significant difference in ICU and hospital mortality for day and time of NICU admission. The ICU mortality for patients admitted during weekday was 31.9%, weeknight 33.9% and weekend was 34.3% ( $P = 0.827$ ), while day-time admission ICU mortality was 34.2%, compared to 32.9% during night-time admission

Table 2. Characteristics and Outcomes of ICU Admission by Days and Nights

	Day-time admission	Night-time admission	P value
	n = 342 (40.81%)	n = 496 (59.19%)	
Age (y)	48.04 ± 20.36	46.45 ± 20.72	0.273
Gender			0.918
Male	261 (76.3%)	377 (76.0%)	
Female	81 (23.7%)	119 (24.0%)	
Ethnic group			0.275
Chinese	254 (74.3%)	338 (68.1%)	
Malay	34 (9.9%)	63 (12.7%)	
Indian	27 (7.9%)	51 (10.3%)	
Other	27 (7.9%)	44 (8.9%)	
Mechanism of injury			0.223
MVA	146 (42.7%)	218 (44.0%)	
Fall from height	54 (15.8%)	68 (13.7%)	
Fall	112 (32.7%)	159 (32.1%)	
Assault or violent	5 (1.5%)	22 (4.4%)	
Others	25 (7.3%)	29 (5.8%)	
Admission source			0.799
Direct	285 (83.3%)	410 (82.7%)	
Transfer	57 (16.7%)	86 (17.3%)	
Alcohol influence	25 (7.3%)	78 (15.7%)	<0.001
Multiple injuries	85 (24.9%)	105 (21.2%)	0.211
Hypoxia	35 (10.2%)	53 (10.7%)	0.834
Hypotension	44 (12.9%)	51 (10.3%)	0.246
GCS-PR (median)	7	7	0.113
Pupil abnormality-PR	120 (35.9%)	193 (39.3%)	0.326
ISS	25.58 ± 10.16	23.61 ± 9.78	0.071
Apache II	23.47 ± 5.997	22.46 ± 6.53	0.228
Need for			
Tracheostomy	58 (17.0%)	78 (15.7%)	0.634
Barbiturate coma	32 (9.4%)	47 (9.5%)	0.954
Neurosurgical Intervention	195 (57.0%)	268 (54.0%)	0.393
ICU mortality	117 (34.2%)	163 (32.9%)	0.684
Hospital mortality	132 (38.6%)	187 (37.7%)	0.793
ICU length of stay (days)	5.13 ± 6.09	4.55 ± 4.76	0.128
Duration of mechanical ventilation (days)	3.86 ± 5.26	3.34 ± 4.09	0.108

ICU: intensive care unit; ISS: injury severity score; PR: post resuscitation

( $P = 0.684$ ). In univariate and multivariate analyses controlling for factors associated with mortality, such as age, gender, alcohol use, multiple injuries, hypoxia, hypotension, post-resuscitation GCS and pupil abnormality, no statistically significant difference in ICU mortality was found with the day and time of admission (Tables 3 and 4).

Both crude and adjusted odd ratios revealed that lower post-resuscitation GCS, presence of post-resuscitation pupil abnormality, hypotension and increasing age were significant predictors for ICU mortality (Tables 3 and 4).

## Discussion

To our knowledge, this is the first study investigating the demographic characteristics and outcomes of severe head injury patients associated with the day and time of admission to a specialised NICU in a tertiary hospital. Our study demonstrates that the demographic characteristics and mechanism of injury were similar for severe head injury patients regardless of the day and time of NICU admission. It was not surprising that a significantly larger number of patients under the influence of alcohol were admitted at night and on weekends. Although alcohol intoxication may hamper the clinical assessment of severity of head injury because of the depression of GCS,<sup>3</sup> it has not been shown to affect ICU mortality in our study.

Consistent with the studies with a similar definition of day and time of admission,<sup>9,11-13,16</sup> more patients were admitted at night and on weekends. Unlike the findings of Carmody et al<sup>11</sup> where trauma patients admitted at night and weekends had higher injury severity scores (ISS) and a higher likelihood of undergoing operative intervention, we found that day and time of admission did not affect the need for neurosurgical procedures and in fact, neurosurgical interventions for severe head injury patients were performed more frequently at night and on weekend.

Although nights and weekends are frequently considered the “off” hours, with lower staffing levels and availability of services or resources with higher risks of mortality and poorer outcome, we found no significant differences in hospital or ICU mortality, lengths of stay and duration for mechanical ventilation associated with the day and time of ICU admission. Consistent with severe head injury outcome studies, the risk factors for ICU mortality, including increasing age, lower post-resuscitation GCS, presence of post-resuscitation pupil abnormality and hypotension,<sup>17</sup> were also identified in our study population, even after adjusting for confounding factors.

There are several possible explanations for our findings. The differences in institutional practice in organisational aspects of care (e.g., staffing numbers, trained personnel, protocol and guidelines, diagnostic and therapeutic services) may be responsible for the absence of increased mortality in patients admitted to the ICU at night or on weekends in our study. Although evidence-based severe head injury guidelines have been published, and clinical management protocols and guidelines are frequently implemented, wide variations in institutional practices persist.<sup>18,19</sup>

It has been well-documented that a neurointensivist-led

Table 3. Crude and Adjusted ORs in Predicting ICU Mortality by Weekday, Weeknight and Weekend ICU Admission

Factor	Crude OR (95% CI)	P value	Adjusted OR (95% CI)	P value
Age	1.03 (1.02-1.04)	<0.001	1.04 (1.02-1.05)	<0.001
Male gender	1.34 (0.96-1.87)	0.081	1.20 (0.74-1.92)	0.468
Weekday admission				
Weeknight	1.11 (0.77-1.61)	0.58	1.04 (0.64-1.68)	0.884
Weekend	1.10 (0.78-1.55)	0.61	1.03 (0.61-1.73)	0.916
Alcohol influence	0.64 (0.4-1.02)	0.061	0.90 (0.48-1.71)	0.757
PR-GCS	0.69 (0.57-0.67)	<0.001	0.73 (0.68-0.80)	<0.001
PR-pupil abnormality	14.32 (10.06-20.39)	<0.001	4.81 (3.07-7.54)	<0.001
Multiple injuries	1.26 (0.89-1.80)	0.191	0.72 (0.43-1.20)	0.204
Hypotension	6.69 (4.15-10.80)	<0.001	2.68 (1.31-5.48)	0.007
Hypoxia	5.49 (3.39-8.85)	<0.001	1.50 (0.73-3.10)	0.271

GCS: Glasgow Coma Scale; ICU: intensive care unit; OR: odds ratio; PR: post-resuscitation

Table 4. Crude and Adjusted ORs in Predicting ICU Mortality by Day-time and Night-time ICU Admission

Factor	Crude OR (95% CI)	P value	Adjusted OR (95% CI)	P value
Age	1.03 (1.02-1.04)	<0.001	1.04 (1.24-1.05)	<0.001
Male gender	1.34 (0.96-1.87)	0.081	1.18 (0.74-1.90)	0.489
Night time admission	0.94 (0.70-1.27)	0.684	0.82 (0.54-1.24)	0.34
Alcohol influence	0.64 (0.4-1.02)	0.061	0.94 (0.50-1.80)	0.855
PR-GCS	0.69 (0.57-0.67)	<0.001	0.73 (0.67-0.80)	<0.001
PR-pupil abnormality	14.32 (10.06-20.39)	<0.001	4.81 (3.07-7.54)	<0.001
Multiple injuries	1.26 (0.89-1.80)	0.191	0.71 (0.43-1.18)	0.19
Hypotension	6.69 (4.15-10.80)	<0.001	2.60 (1.27-5.32)	0.009
Hypoxia	5.49 (3.39-8.85)	<0.001	1.52 (0.74-3.13)	0.257

GCS: Glasgow Coma Scale; OR: odds ratio; PR: post-resuscitation

team coordinating care for patients admitted to NICU has an independent, positive impact on patient outcomes, including a lower NICU-associated mortality rate and a shorter length of stay.<sup>20-23</sup> The results probably reflect the value of having an experienced intensivist at the bedside to diagnose and initiate early treatment through a more consistent and thorough approach to problems. Nursing staff are also crucial and have an impact on patient outcome. It has been suggested that a low nurse/patient ratio in the ICU at night is associated with an increased risk for postoperative complications in patients.<sup>24</sup> Neurocritical nurses conduct neurological assessments, including the GCS, which cannot be done by machines, no matter how sophisticated. Moreover, nurses are the ideal medical professionals to ensure that everyone in the ICU is aware of, and adhere to, existing protocols.<sup>25</sup> Our NICU has a relatively uniform array of specialised doctors and nurses,

as well as adequate support services and resources such as a CT scanner. Ensminger et al<sup>7</sup> showed that patients admitted to a surgical ICU during the weekend had a higher adjusted mortality rate. The impact of specialised neurointensive care unit favouring patient mortality and outcome has been discussed.<sup>20,22,26-28</sup> The benefits of specialised NICU are based on the belief that neuro patients are better served in ICUs staffed by healthcare personnel trained to recognise and treat intracranial processes as well as the systemic factors affecting them.<sup>29</sup> Studies involving a single specialised medical ICU<sup>13</sup> and a trauma unit<sup>11</sup> have shown findings consistent with those of our study.

Differences in the definition of day and time of admission may also partly explain the differences in results between studies. In contrast to studies that utilise administrative data [e.g., calendar days – midnight to 2359 hours;<sup>4</sup> hospital administrative timing versus actual timing patient admitted

to the ICU,<sup>12]</sup> we used the actual time on arrival to ICU, which allowed us to define the day and time of admission precisely by hours<sup>9</sup> and better reflect the actual practice in the clinical setting. Specifically, the first few hours after ICU admission, where patients' conditions stabilise and treatment plans are formulated, are crucial to patient outcomes.<sup>16,30</sup> As suggested by Arabi et al<sup>9</sup> and Ensminger et al,<sup>7</sup> we have also reduced the risks of spillover of cases as seen in some other studies.

As postulated by some authors,<sup>5,6</sup> diagnoses and severity of diseases and conditions will have an impact on patterns of admission, lengths of stay and mortality rates. Studies including elective ICU admissions may not reflect trauma cases such as severe head injury, as elective admissions are more likely to be admitted during weekdays and have lower severity of illness and better outcome. Therefore, their inclusion in related studies represent a significant confounding factor that complicates the interpretation of results.<sup>9,10</sup> Our study only involved severe head injury patients, and is consistent with other emergency or trauma studies revealing no associations between day and time of admission, and outcomes, although some differences in patient characteristics were found in those studies.<sup>9-11</sup> The differences in patient characteristics may be explained by the inclusion of different categories of patients and institutional practices in those studies unlike ours. For example, a study by Carmody et al,<sup>11</sup> which included all trauma cases, found a higher ISS and frequency of penetrating trauma among patients admitted at night. In our institution, most of the penetrating trauma cases would have been admitted to the surgical ICU and managed by the general surgical team.

Severe head injury is one of the most complex diseases encountered in the ICU. The concept of secondary brain injury, and the increasingly widespread use of multi-modality neuromonitoring requires specialised staffing to monitor and interpret the findings. The critical care of severe head injury patient requires close collaboration among multidisciplinary teams comprising neurosurgeons, intensivists and nursing staff in a setting capable of comprehensive physiologic neuromonitoring, supported by timely diagnostic and therapeutic services. Our study demonstrates that most patients were admitted at night or during weekends, whereupon most neurosurgical interventions were performed, implying a need for specialised staffing and services after-hours.

Our study adds to the recent debate surrounding case volume, hospital volume and outcome related to time of day or availability of services. It shows that in appropriate staffed and serviced units, excellent 24-hour care is possible. As this level of care may not always be available in all centres, there are policy implications for service provision

and accreditation of institutions for certain patient groups or diseases. These considerations must be weighed against access to care.

As our study population is small compared to other studies and was conducted in a single centre of a specialised NICU with optimal staffing, diagnostic and therapeutic services, our findings may not apply to other institutions. Future studies may be conducted in collaboration with other specialised NICU centre. Our analysis did not take public holidays into account, which may be similar to nights and weekends admissions, however, as there are only 11 official holidays per year in Singapore, it is unlikely that this will significantly affect our results.

## Conclusions

There were more severe head injury patients admitted to the NICU at night and during weekends, with no significant differences in demographic profile, types of injuries, and duration of ICU stay or mortality. In a specialised neurointensive care unit with adequate staffing and necessary diagnostic and therapeutic modalities, timing of severe head injury ICU admission is unlikely to be associated with mortality rate.

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