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Severity of Head Injury and Duration of Hospital Stay: A Comparative Analysis of Length of Stay Across Mild, Moderate, And Severe Traumatic Brain Injury

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ABSTRACT

Head injury is a leading cause of hospital admission and prolonged inpatient care, imposing a substantial burden on emergency and critical-care resources, particularly in low- and middle-income settings. Although the severity of the initial injury is widely assumed to drive resource use, locally quantified evidence linking injury severity to length of stay (LOS) remains limited. This analytical cross-sectional study therefore examined whether the mean length of hospital stay differs among patients with mild, moderate, and severe head injury. Records of 152 head-injury patients presenting to the emergency department were reviewed; head-injury severity was classified from the admission Glasgow Coma Scale, and LOS was recorded in days. Data were analysed in IBM SPSS Statistics, with normality assessed using the Shapiro–Wilk test and homogeneity of variance using Levene's test; group means were compared using one-way ANOVA, supported by the Welch robust test given unequal variances, with Games–Howell and Tukey HSD post-hoc procedures, and effect size quantified using eta-squared (η^2) and omega-squared (ω^2). Mean LOS increased monotonically with severity, from 3.39 ± 1.14 days in the mild group ($n = 60$) to 7.34 ± 2.30 days in the moderate group ($n = 52$) and 14.25 ± 3.49 days in the severe group ($n = 40$). Residuals within each group were normally distributed (Shapiro–Wilk $p > 0.05$), whereas variances were heterogeneous (Levene $p < 0.001$). Both the one-way ANOVA, $F(2, 149) = 257.19$, $p < 0.001$, and the Welch robust test, $F(2, 71.37) = 221.45$, $p < 0.001$, were highly significant, and the effect was very large ($\eta^2 = 0.775$; $\omega^2 = 0.771$), indicating that injury severity accounted for approximately 77% of the variance in LOS; all three pairwise comparisons were significant (Games–Howell, all $p < 0.001$). Length of hospital stay thus differs significantly across head-injury severity grades and rises sharply from mild to severe injury. Admission severity is a strong, clinically meaningful predictor of inpatient duration and can inform early bed planning, resource allocation, and family counselling in emergency settings.

KEYWORDS: Head injury; Traumatic brain injury; Length of stay; Glasgow Coma Scale; Hospital resource utilisation

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I. INTRODUCTION

Traumatic brain injury (TBI) is among the most frequent and consequential forms of trauma encountered in emergency departments worldwide, and it remains a major contributor to death and long-term disability across all age groups (Maas et al., 2022). The clinical spectrum of head injury is conventionally stratified by the admission Glasgow Coma Scale (GCS) into mild (GCS 13–15), moderate (GCS 9–12), and severe (GCS 3–8) categories, a framework that has guided triage, imaging, and management decisions for decades (Haarbauer-Krupa et al., 2021).

Beyond its direct clinical implications, head-injury severity has important operational consequences for the health system (Rakhit et al., 2021). Length of stay (LOS) is a widely used indicator of inpatient resource utilisation, and prolonged admissions are associated with higher costs, greater exposure to nosocomial complications, and constrained bed availability (Wilson et al., 2017). In many low- and middle-income settings, where critical-care capacity is limited and demand is high, the ability to anticipate how long a patient is likely to remain admitted is operationally valuable from the moment of triage (Rakhit et al., 2021; Swanson et al., 2017).

Although it is intuitively expected that more severe injuries require longer hospitalisation, the strength and shape of this relationship are not uniform across populations and care systems, and locally derived quantitative estimates are often lacking (Santoso et al., 2026). Establishing the magnitude of the difference in LOS across severity grades — rather than merely its existence — is necessary if severity is to be used for early bed planning and counselling (Krishnamoorthy & Vavilala, 2022; Suwaryo et al., 2024; Waladani et al., 2023). Quantifying the proportion of variation in LOS explained by severity also clarifies how much of the resource burden can be anticipated at admission versus attributed to other clinical and logistical factors.

Accordingly, this study tested the hypothesis that mean LOS differs significantly among patients with mild, moderate, and severe head injury. The specific objective was to compare the mean length of hospital stay across the three severity grades and to quantify the size of any difference, providing evidence to support resource planning in the emergency and inpatient care of head-injury patients.

II. MATERIAL AND ETHODS

A. Study design and setting

This was an analytical observational study with a cross-sectional design, conducted using the clinical records of patients who presented with head injury to the emergency department. The study was designed to compare a single continuous outcome length of hospital stay across three independent, mutually exclusive groups defined by head-injury severity.

B. Participants

A total of 152 head-injury patients were included. Eligible records were those of patients admitted with a diagnosis of head injury and a documented admission GCS and discharge date. Records with incomplete severity classification or missing LOS were excluded. Each patient contributed a single observation.

C. Variables and operational definitions

The independent variable was head-injury severity, an ordinal factor with three levels derived from the admission GCS and coded for analysis as 1 = mild, 2 = moderate, and 3 = severe. The dependent variable was length of stay, defined as the number of days from hospital admission to discharge and measured on a ratio scale. Supporting descriptive variables (sex, age, injury mechanism) were recorded to characterise the sample.

D. Statistical analysis

All analyses were performed in IBM SPSS Statistics (Analyze → Compare Means → One-Way ANOVA). Continuous data are summarised as mean ± standard deviation with 95% confidence intervals (CI); categorical data as counts. The assumption of normality was assessed within each group using the Shapiro–Wilk test, and the assumption of homogeneity of variances using Levene's test (based on both the mean and the median). Differences in mean LOS across the three severity groups were evaluated using one-way analysis of variance (ANOVA). Because Levene's test indicated unequal variances, the Welch and Brown–Forsythe robust tests of equality of means were additionally computed and treated as the primary confirmatory tests. Pairwise differences were examined using the Games–Howell post-hoc procedure (appropriate under variance heterogeneity), with Tukey HSD reported for comparison. The magnitude of the overall effect was quantified using eta-squared (η^2) and the less biased omega-squared (ω^2). A two-sided p-value < 0.05 was considered statistically significant.

III. RESULTS

Of the 152 patients analysed, 60 (39.5%) had mild, 52 (34.2%) moderate, and 40 (26.3%) severe head injury. Descriptive statistics for LOS by severity group are presented in Table 1. Mean LOS rose steadily across the three grades, from 3.39 days in the mild group to 7.34 days in the moderate group and 14.25 days in the severe group; the non-overlapping 95% confidence intervals provide an early indication of genuine group differences.

The distribution of LOS within each group did not depart significantly from normality (Shapiro–Wilk: mild $W = 0.979$, $p = 0.382$; moderate $W = 0.993$, $p = 0.984$; severe $W = 0.983$, $p = 0.791$), satisfying the normality assumption of ANOVA. Levene's test, however, indicated that the variances were not equal across groups (based on the mean: $F = 25.13$, df1 = 2, df2 = 149, $p < 0.001$; based on the median: $F = 23.06$, $p < 0.001$).

Table 1. Descriptive statistics for length of hospital stay (days) by head-injury severity.

Severity	n	Mean	SD	SE	95% CI for mean	Min–Max
Mild	60	3.39	1.14	0.15	3.09 – 3.68	1.1 – 5.6

Severity	n	Mean	SD	SE	95% CI for mean	Min–Max
Moderate	52	7.34	2.30	0.32	6.70 – 7.98	1.4 – 12.5
Severe	40	14.25	3.49	0.55	13.14 – 15.37	5.7 – 21.4
Total	**152**	**7.60**	**4.92**	**0.40**	**6.81 – 8.39**	**1.1 – 21.4**

Table 2. Assumption checks for one-way ANOVA.

Test	Statistic	df	p-value
Shapiro–Wilk (Mild)	W = 0.979	60	0.382
Shapiro–Wilk (Moderate)	W = 0.993	52	0.984
Shapiro–Wilk (Severe)	W = 0.983	40	0.791
Levene (based on mean)	F = 25.13	2, 149	< 0.001
Levene (based on median)	F = 23.06	2, 149	< 0.001

Table 3. One-way ANOVA summary and robust tests of equality of means for length of stay.

Source	Sum of Squares	df	Mean Square	F	p-value
Between groups	2839.81	2	1419.91	257.19	< 0.001
Within groups	822.62	149	5.52	—	—
Total	**3662.43**	**151**	**—**	**—**	**—**
Welch (robust)	—	2, 71.37	—	221.45	< 0.001
Brown–Forsythe (robust)	—	2, 75.76	—	214.14	< 0.001

Table 4. Games–Howell post-hoc pairwise comparisons of mean length of stay (days).

Comparison	Mean difference	SE	95% CI	p-value
Moderate vs Mild	3.95	0.25	3.35 – 4.55	< 0.001
Severe vs Mild	10.87	0.40	9.73 – 12.00	< 0.001
Severe vs Moderate	6.92	0.45	5.75 – 8.09	< 0.001

The violation of the homogeneity assumption is consistent with the visibly increasing spread of LOS at higher severity grades and motivates the use of the Welch robust test and the Games–Howell post-hoc procedure alongside the classical ANOVA (Table 2).

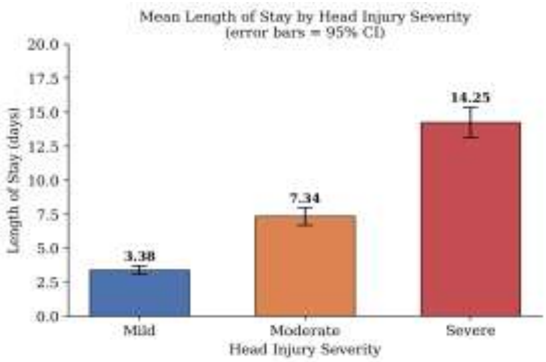

Figure 1. Mean length of hospital stay by head-injury severity. Error bars represent 95% confidence intervals.

The one-way ANOVA demonstrated a highly significant difference in mean LOS across the three severity groups, $F(2, 149) = 257.19$, $p < 0.001$ (Table 3). Because Levene's test was significant, the Welch and Brown–Forsythe robust tests were computed as confirmatory analyses; both were likewise highly significant (Welch $F(2, 71.37) = 221.45$, $p < 0.001$; Brown–Forsythe $F(2, 75.76) = 214.14$, $p < 0.001$), confirming that the conclusion is not an artefact of unequal variances.

The effect size was very large: injury severity explained approximately 77% of the total variance in LOS ($\eta^2 = 0.775$; $\omega^2 = 0.771$; Cohen's $f = 1.86$).

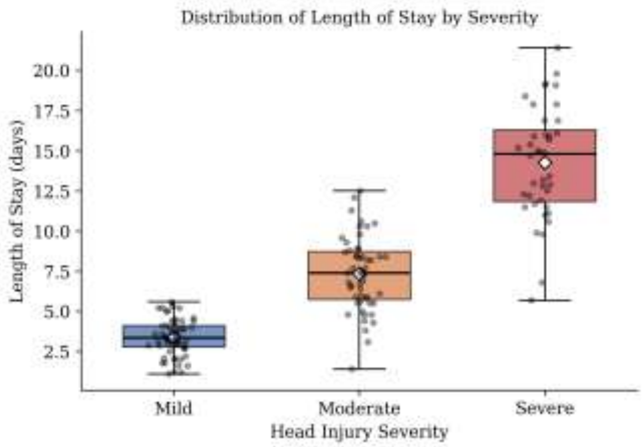

Figure 2. Distribution of length of hospital stay across head-injury severity grades. Boxes show the interquartile range and median; diamonds indicate group means; points are individual patients.

Post-hoc analysis using the Games–Howell procedure showed that every pairwise difference was statistically significant (all $p < 0.001$; Table 4). Patients with severe injury stayed on average 10.87 days longer than those with mild injury and 6.92 days longer than those with moderate injury, while moderate injury was associated with a 3.95-day-longer stay than mild injury. The Tukey HSD results were concordant in direction and significance. The ordered, non-overlapping distributions are illustrated in Figure 2.

IV. DISCUSSION

This study demonstrated a strong, graded relationship between head-injury severity and length of hospital stay. Mean LOS approximately doubled from the mild to the moderate group and doubled again from the moderate to the severe group, and the difference across the three grades was highly significant on both the classical and the robust tests. The very large effect size ($\eta^2 = 0.775$) indicates that severity alone accounted for roughly three-quarters of the variation in how long patients remained admitted — an unusually strong signal for a single clinical predictor.

These findings are consistent with the widely held clinical expectation that more severe brain injury entails more complex and prolonged management, including neurocritical care, closer neurological monitoring, and a slower recovery trajectory (Bögli et al., 2025; Meyfroidt et al., 2022; Wilde et al., 2022). The practical value of the present analysis lies in quantifying that expectation: knowing at admission that severe cases stay on average about 11 days longer than mild cases and about 7 days longer than moderate cases allows earlier and more realistic bed planning, staffing decisions, and family counselling from the point of triage (Maldonado-McGrath et al., 2025).

A methodological strength of the analysis is that the homogeneity-of-variance assumption was formally tested and found to be violated, and the primary inference was therefore anchored on the Welch robust test rather than the standard F-test alone. The agreement between the classical ANOVA, the Welch and Brown–Forsythe tests, and both post-hoc procedures makes the conclusion robust to the unequal variances that are themselves a clinically meaningful feature of the data: outcomes become not only longer but also more variable as severity increases, reflecting the wider range of complications and recovery paths in severely injured patients (Clark et al., 2022).

The results should be interpreted in light of several limitations. First, the cross-sectional, single-outcome design does not account for other determinants of LOS such as age, comorbidity, injury mechanism, surgical intervention, or in-hospital complications, which may confound or modify the severity–LOS relationship; a multivariable model would be a natural extension. Second, LOS can be influenced by non-clinical factors including discharge logistics, bed availability, and payer arrangements, which were not examined here. Third, the analysis derives from a single sample and setting, so the absolute LOS estimates may not generalise to other institutions, even if the graded relationship is likely to hold. Finally, severity was based on admission GCS, which may not fully capture injury complexity as reflected in imaging or other indices (Ahmadi et al., 2023; Åkerlund et al., 2022; Jiang et al., 2023; Lee et al., 2025).

Future research should incorporate multivariable and time-to-event (survival) modelling to adjust for confounders and to characterise discharge dynamics, and should examine additional outcomes such as complications, functional status, and cost. Multi-centre data would strengthen external validity and support the development of practical, admission-time tools for predicting inpatient duration.

V. CONCLUSION

Length of hospital stay differed significantly and substantially across head-injury severity grades, increasing steeply from mild to moderate to severe injury, with severity explaining approximately 77% of the variance in LOS. Admission head-injury severity is therefore a powerful and clinically actionable predictor of inpatient duration. Incorporating severity into early bed-management and counselling workflows may improve the efficiency of emergency and inpatient care for head-injury patients, particularly in resource-constrained settings.

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