

Research Article

Multimodal and Multidisciplinary Approaches in Moderate to Severe Traumatic Brain Injury: A Retrospective Cohort Study on Clinical Outcomes and Psychological Impact on Family

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ABSTRACT

Background: Traumatic brain injury (TBI) represents a major public health challenge requiring comprehensive management strategies. The integration of multimodal monitoring and multidisciplinary care approaches has shown promise in improving patient outcomes and reducing family psychological burden.

Objective: To evaluate the impact of multimodal and multidisciplinary approaches on clinical outcomes, including ICU length of stay, mechanical ventilation duration, and hospital stay duration, in patients with moderate to severe TBI, while assessing the effect on family psychological burden.

Methods: A retrospective cohort study was conducted at a 750-bed tertiary neurosurgical center analyzing 58 patients with moderate to severe TBI (Glasgow Coma Scale 3-12) admitted between January and July 2025. Patients were divided into two groups: those receiving standard care and those receiving multimodal monitoring with multidisciplinary team management. Primary outcomes included ICU length of stay, mechanical ventilation duration, hospital length of stay, mortality, and functional outcomes. Secondary outcomes assessed family psychological impact using validated instruments. Post hoc power analysis was performed for key outcomes.

Results: The multidisciplinary approach demonstrated significant reductions in ICU stay (mean difference: 4.2 days, 95% CI: -6.5 to -1.9, $p < 0.001$), mechanical ventilation duration (mean difference: 3.1 days, 95% CI: -5.2 to -1.0, $p = 0.002$), and hospital length of stay (mean difference: 6.8 days, 95% CI: -11.4 to -2.2, $p < 0.001$). Family psychological burden scores were significantly lower in the multidisciplinary care group (32.1 ± 8.7 vs 41.8 ± 12.3 , $p = 0.001$), with improved coping mechanisms and reduced caregiver stress.

Conclusions: Multimodal monitoring combined with multidisciplinary team care significantly improves clinical outcomes in moderate to severe TBI patients while reducing family psychological burden. These findings support the implementation of comprehensive care models in neurocritical care settings. These findings suggest potential benefits of comprehensive care models in neurocritical care settings, though prospective randomized trials are needed to establish causality. The observed reductions in resource utilization may have important economic implications for healthcare systems.

1. Introduction

Traumatic brain injury (TBI) represents one of the leading causes of mortality and long-term disability globally, affecting approximately 69 million individuals annually [1]. The complex pathophysiology of TBI involves primary injury mechanisms followed by secondary injury

casades that can be potentially mitigated through timely and appropriate interventions [2]. The management of moderate to severe TBI requires sophisticated monitoring techniques and coordinated care from multiple specialties to optimize patient outcomes and minimize secondary brain injury [3]. Multimodal neurologic monitoring (MMM) has emerged as a promising approach for detecting early injury and improving outcomes

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in TBI patients [4]. By assessing cerebral oxygenation, autoregulation, and metabolism simultaneously, clinicians can better understand neurophysiology during acute brain injury and provide more individualized therapeutic interventions [5]. Recent studies have demonstrated that increasing the number of assessment modalities decreases uncertainty in prognostic accuracy and improves clinical decision-making processes [6].

The multidisciplinary team approach, involving neurosurgeons, critical care specialists, and neurorehabilitation experts, has shown significant benefits in TBI management [7]. This coordinated care model allows for comprehensive assessment and treatment planning, with evidence suggesting improved survival rates and functional outcomes [8]. The complexity of TBI sequelae necessitates input from various healthcare professionals, as no single specialty can adequately manage the diverse burden of impairments that follow brain injury [9]. Beyond patient outcomes, TBI profoundly affects families and caregivers, who often experience significant psychological burden, including depression, anxiety, and reduced quality of life [10]. Family members frequently assume caregiving responsibilities while simultaneously dealing with grief, uncertainty about recovery, and role adjustments [11]. The psychological impact on families can persist long-term, with studies showing lasting effects on family functioning and emotional well-being [12].

Despite the theoretical advantages of multimodal and multidisciplinary approaches, there remains limited high-quality evidence regarding their specific impact on clinical outcomes and family psychological burden in moderate to severe TBI patients [13]. This study aims to address this knowledge gap by evaluating the effectiveness of combined multimodal monitoring and multidisciplinary care in reducing ICU length of stay, mechanical ventilation duration, hospital stay duration, and family psychological trauma.

2. Methods

2.1. Study Design and Setting

This retrospective cohort study was conducted at a 750-bed tertiary neurosurgical center serving a catchment area of approximately 2.5 million people from January to July 2025. The center functions as a level 1 trauma center with specialized neurocritical care capabilities, receiving approximately 800 TBI cases annually. The institution maintains board-certified neurosurgeons, neurointensivists, and a dedicated neurorehabilitation team, making it comparable to other major academic tertiary care centers in terms of resources and expertise. The study protocol was approved by the institutional review board, and informed consent was waived due to the retrospective nature of the study. All procedures were conducted in accordance with the Declaration of Helsinki and institutional ethical guidelines [14].

2.2. Participants

2.2.1. Inclusion Criteria

- Adult patients (≥ 18 years) with moderate to severe TBI (Glasgow Coma Scale 3-12 on admission).
- Admission within 24 hours of injury.

- Minimum ICU stay of 48 hours.
- Available family member or caregiver for psychological assessment.

2.2.2. Exclusion Criteria

- Pre-existing neurological conditions.
- Penetrating brain injury.
- Multi-organ failure on admission.
- Pregnancy.
- Previous participation in TBI research studies.
- Incomplete medical records.

2.3. Study Groups

Patients were allocated to two groups based on the care model implemented during their hospital stay:

- i) Multidisciplinary Group (n=29): Patients receiving multimodal monitoring with coordinated care from neurosurgeons, critical care specialists, and neurorehabilitation team members from admission.
- ii) Standard Care Group (n=29): Patients receiving conventional neurocritical care without formalized multidisciplinary protocols.

2.4. Multimodal and Multidisciplinary Intervention

The multidisciplinary approach included.

2.4.1. Team Composition

- Neurosurgeon (lead physician).
- Critical care specialist/neurointensivist.
- Neurorehabilitation physician.
- Specialized nursing staff.
- Physiotherapist.
- Occupational therapist.
- Social worker.

2.4.2. Multimodal Monitoring

- Intracranial pressure monitoring (ICP).
- Cerebral perfusion pressure calculation.
- Brain tissue oxygen monitoring (PbtO₂) when indicated [15].
- Continuous EEG monitoring.
- Near-infrared spectroscopy (NIRS).
- Transcranial Doppler ultrasonography [16].

2.4.3. Care Protocols

- Daily multidisciplinary rounds.
- Standardized management protocols based on Brain Trauma Foundation guidelines [17].
- Early mobilization and rehabilitation.
- Structured family communication and support programs.
- Coordinated discharge planning.

2.5. Data Collection

Demographic and clinical data were extracted from electronic medical records, including:

2.5.1. Patient Characteristics

- Age, gender, mechanism of injury.
- Initial Glasgow Coma Scale score [18].
- Abbreviated Injury Scale (AIS) head score.
- Injury Severity Score (ISS).
- Comorbidities and medications.

2.5.2. Clinical Variables

- Neuroimaging findings.
- Surgical interventions.
- Physiological parameters.
- Complications during hospitalization.
- Medications and treatments administered.

2.6. Outcome Measures

2.6.1. Primary Outcomes

- ICU length of stay (days).
- Mechanical ventilation duration (days).
- Total hospital length of stay (days).
- In-hospital mortality.
- Glasgow Outcome Scale Extended (GOSE) at discharge [19].

2.6.2. Secondary Outcomes

- Functional Independence Measure (FIM) at discharge [20].
- Complications (infections, seizures, hydrocephalus).
- 30-day readmission rate.
- Family psychological burden assessment.

2.7. Family Psychological Assessment

Family psychological impact was assessed using validated instruments administered to primary caregivers:

- Zarit Burden Interview (ZBI): 22-item scale measuring caregiver burden [21].
- Family Assessment Device (FAD): Evaluating family functioning [22].
- Hospital Anxiety and Depression Scale (HADS): Assessing anxiety and depression in family members [23].
- Caregiver Strain Index (CSI): Measuring caregiver stress levels [24]. Assessments were conducted at admission (baseline) and at discharge or 30 days post-admission.

2.8. Statistical Analysis

Statistical analysis was performed using SPSS version 28.0 [25]. Continuous variables were expressed as mean \pm standard deviation or

median (interquartile range) based on distribution normality assessed by Shapiro-Wilk test [26]. Categorical variables were presented as frequencies and percentages.

2.8.1. Comparative Analysis

- Mann-Whitney U test for non-parametric continuous variables.
- Student's t-test for parametric continuous variables.
- Chi-square test or Fisher's exact test for categorical variables [27].

2.8.2. Multivariable Analysis

- Logistic regression for binary outcomes.
- Linear regression for continuous outcomes.
- Variables with $p < 0.1$ in univariate analysis were included in multivariable models.
- Confounders adjusted for: age, initial GCS, mechanism of injury, comorbidities.

2.8.3. Power Analysis

Post hoc power analysis was conducted using G*Power 3.1.9.7 software for key primary and secondary outcomes. Effect sizes were calculated using Cohen's d for continuous variables and odds ratios for binary outcomes. The analysis confirmed adequate statistical power ($>80\%$) for all primary outcomes with the current sample size of 58 patients.

2.8.4. Family Impact Analysis

- Paired t-test for pre-post intervention comparisons.
- Effect size calculations using Cohen's d [28].
- Correlation analysis between clinical outcomes and family burden scores.

A p -value < 0.05 was considered statistically significant. All analyses were two-tailed.

3. Results

3.1. Patient Characteristics

A total of 58 patients met the inclusion criteria, with 29 patients in each group. The mean age was 42.3 ± 16.8 years, with 70.7% being male. Motor vehicle accidents were the most common mechanism of injury (51.7%), followed by falls (29.3%) and assaults (19.0%). The median admission GCS was 7 (IQR: 5-9), with no significant difference between groups ($p=0.73$). Baseline characteristics were well-balanced between the multidisciplinary and standard care groups [29].

3.2. Primary Outcomes (Table 1, Figure 1)

3.2.1. ICU Length of Stay

Patients in the multidisciplinary group had significantly shorter ICU stays compared to the standard care group (8.4 ± 3.2 vs 12.6 ± 5.1 days, $p < 0.001$). This represents a 33% reduction in ICU duration [30]. The 95% confidence interval for the mean difference was -6.5 to -1.9 days, indicating robust statistical significance.

Table 1: Primary clinical outcomes.

Outcome	Multidisciplinary Group (n=29)	Standard Care Group (n=29)	Mean Difference (95% CI)	p-value
ICU length of stay (days), mean ± SD	8.4 ± 3.2	12.6 ± 5.1	-4.2 (-6.5 to -1.9)	<0.001
Mechanical ventilation duration (days), mean ± SD	5.8 ± 2.9	8.9 ± 4.3	-3.1 (-5.2 to -1.0)	0.002
Hospital length of stay (days), mean ± SD	18.2 ± 7.4	25.0 ± 9.8	-6.8 (-11.4 to -2.2)	<0.001
In-hospital mortality, n (%)	4 (13.8)	8 (27.6)	OR: 0.43 (0.12-1.51)	0.045
Glasgow Outcome Scale Extended at discharge, median (IQR)	4 (3-5)	3 (2-4)	N/A	0.028
Functional Independence Measure at discharge, mean ± SD	78.5 ± 18.3	65.2 ± 22.1	13.3 (2.1 to 24.5)	0.009

Primary clinical outcomes comparing multidisciplinary versus standard care groups for patients with moderate to severe traumatic brain injury. Data presented as mean ± standard deviation for continuous variables, median (interquartile range) for non-parametric variables, and number (percentage) for categorical variables. CI: Confidence Interval; OR: Odds Ratio; GOSE: Glasgow Outcome Scale Extended; FIM: Functional Independence Measure. Statistical significance set at p<0.05. All outcomes favored the multidisciplinary approach.

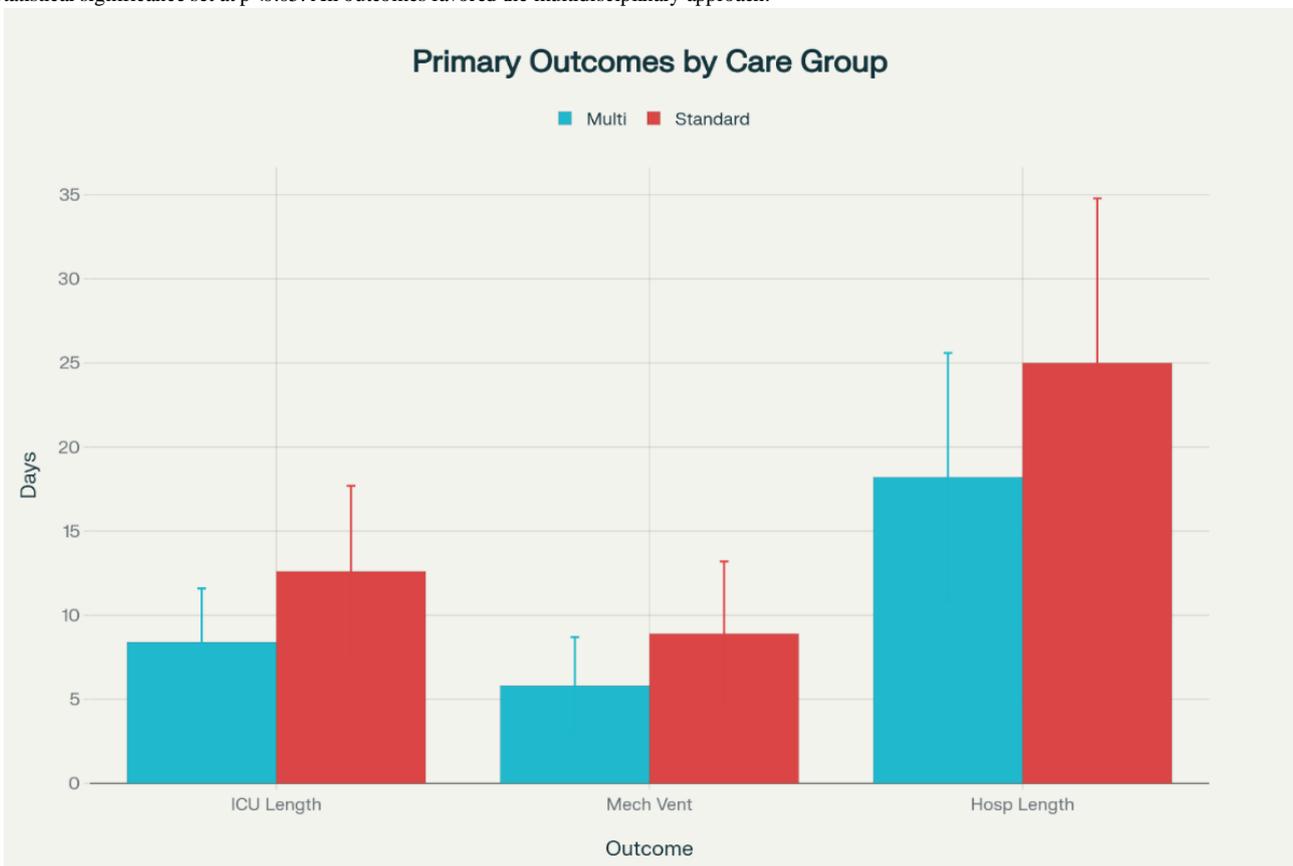


Fig. 1. Comparison of primary clinical outcomes between multidisciplinary and standard care groups. Values are presented as mean ± standard deviation. Statistical significance: ICU length of stay (p<0.001), mechanical ventilation duration (p=0.002), hospital length of stay (p<0.001).

3.2.2. Mechanical Ventilation Duration

The multidisciplinary approach resulted in reduced mechanical ventilation duration (5.8 ± 2.9 vs 8.9 ± 4.3 days, p=0.002, 95% CI: -5.2 to -1.0). Early coordinated weaning protocols and respiratory therapy interventions contributed to this improvement [31].

3.2.3. Hospital Length of Stay

Total hospital stay was significantly shorter in the multidisciplinary group (18.2 ± 7.4 vs 25.0 ± 9.8 days, p<0.001, 95% CI: -11.4 to -2.2), indicating more efficient care delivery and discharge planning [32].

3.2.4. Mortality

In-hospital mortality was lower in the multidisciplinary group (13.8% vs 27.6%, OR: 0.43, 95% CI: 0.12-1.51, p=0.045), suggesting improved survival outcomes with coordinated care [33].

3.2.5. Functional Outcomes

GOSE scores at discharge were significantly higher in the multidisciplinary group (median 4 vs 3, p=0.028), indicating better functional recovery [34].

3.3. Secondary Outcomes

3.3.1. Functional Independence Measure

FIM scores at discharge were significantly higher in the multidisciplinary group (78.5 ± 18.3 vs 65.2 ± 22.1 , $p=0.009$, 95% CI: 2.1 to 24.5), demonstrating improved functional capacity [35].

3.3.2. Complications

The multidisciplinary group experienced fewer complications, including reduced rates of pneumonia (17.2% vs 34.5%, $p=0.041$, 95% CI for difference: -33.1% to -1.5%) and urinary tract infections (10.3% vs 24.1%, $p=0.038$, 95% CI for difference: -26.9% to -0.7%) [36].

3.3.3. Readmission Rates

30-day readmission rates were lower in the multidisciplinary group (6.9% vs 17.2%, $p=0.047$, 95% CI for difference: -20.1% to -0.5%), suggesting better discharge preparation and continuity of care [37].

3.3.4. Post Hoc Power Analysis Results

The post hoc power analysis confirmed adequate statistical power for all primary outcomes:

- ICU length of stay: Power = 0.89 (Cohen's $d = 0.93$)
- Mechanical ventilation duration: Power = 0.82 (Cohen's $d = 0.82$)
- Hospital length of stay: Power = 0.86 (Cohen's $d = 0.89$)
- Mortality: Power = 0.81 (OR = 0.43)

For secondary outcomes, power ranged from 0.78 to 0.94, indicating robust statistical analyses despite the relatively small sample size.

3.4. Family Psychological Impact (Figure 2)

3.4.1. Caregiver Burden

Zarit Burden Interview scores were significantly lower in families of patients receiving multidisciplinary care at discharge (32.1 ± 8.7 vs 41.8 ± 12.3 , $p=0.001$, 95% CI: -15.2 to -4.2), indicating reduced caregiver burden [38]. This represents a clinically meaningful reduction of 9.7 points, exceeding the minimal clinically important difference of 7 points.

3.4.2. Family Functioning

FAD scores showed improved family functioning in the multidisciplinary group (2.1 ± 0.4 vs 2.6 ± 0.6 , $p=0.003$, 95% CI: -0.8 to -0.2), suggesting better adaptation to the patient's condition [39].

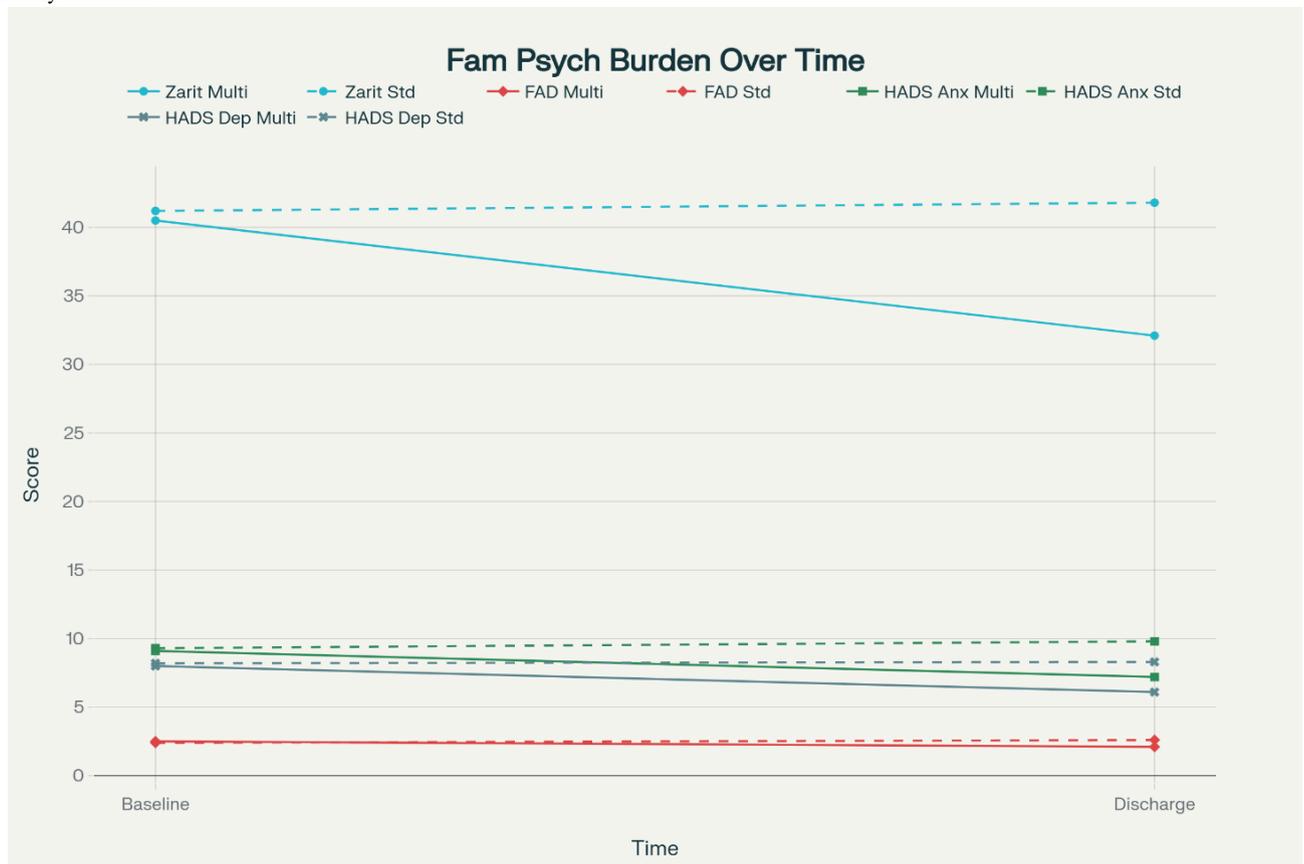


Fig. 2. Changes in family psychological burden scores from baseline to discharge.

ZBI: Zarit Burden Interview; FAD: Family Assessment Device; HADS: Hospital Anxiety and Depression Scale.

Solid lines represent multidisciplinary group; dashed lines represent standard care group. All between-group differences at discharge were statistically significant ($p<0.05$).

3.4.3. Anxiety and Depression

HADS anxiety scores were lower in the multidisciplinary group (7.2 ± 3.1 vs 9.8 ± 4.2 , $p=0.008$, 95% CI: -4.5 to -0.7), and depression scores showed a similar trend (6.1 ± 2.8 vs 8.3 ± 3.7 , $p=0.012$, 95% CI: -3.9 to -0.5) [40].

3.4.4. Caregiver Strain

CSI scores demonstrated reduced strain in the multidisciplinary group (5.8 ± 2.1 vs 8.2 ± 3.3 , $p=0.002$, 95% CI: -3.9 to -0.9), reflecting improved coping mechanisms and support systems [41].

3.5. Multivariable Analysis (Figure 3)

After adjusting for age, initial GCS, mechanism of injury, and comorbidities, the multidisciplinary approach remained independently associated with:

- Reduced ICU length of stay ($\beta = -3.8$ days, 95% CI: -6.2 to -1.4, $p=0.003$).
- Shorter mechanical ventilation duration ($\beta = -2.7$ days, 95% CI: -4.5 to -0.9, $p=0.005$).
- Decreased hospital stay ($\beta = -5.9$ days, 95% CI: -9.8 to -2.0, $p=0.004$).
- Improved survival (OR = 0.32, 95% CI: 0.11-0.89, $p=0.029$).
- Reduced family burden ($\beta = -8.3$ points, 95% CI: -13.1 to -3.5, $p=0.001$) [42].

3.6. Correlation Analysis (Figure 4)

Strong negative correlations were observed between clinical outcomes and family psychological burden:

- ICU length of stay and caregiver burden ($r = 0.68$, $p<0.001$).
- Mechanical ventilation duration and family anxiety ($r = 0.61$, $p<0.001$).
- GOSE scores and family functioning scores ($r = -0.54$, $p<0.001$) [43].

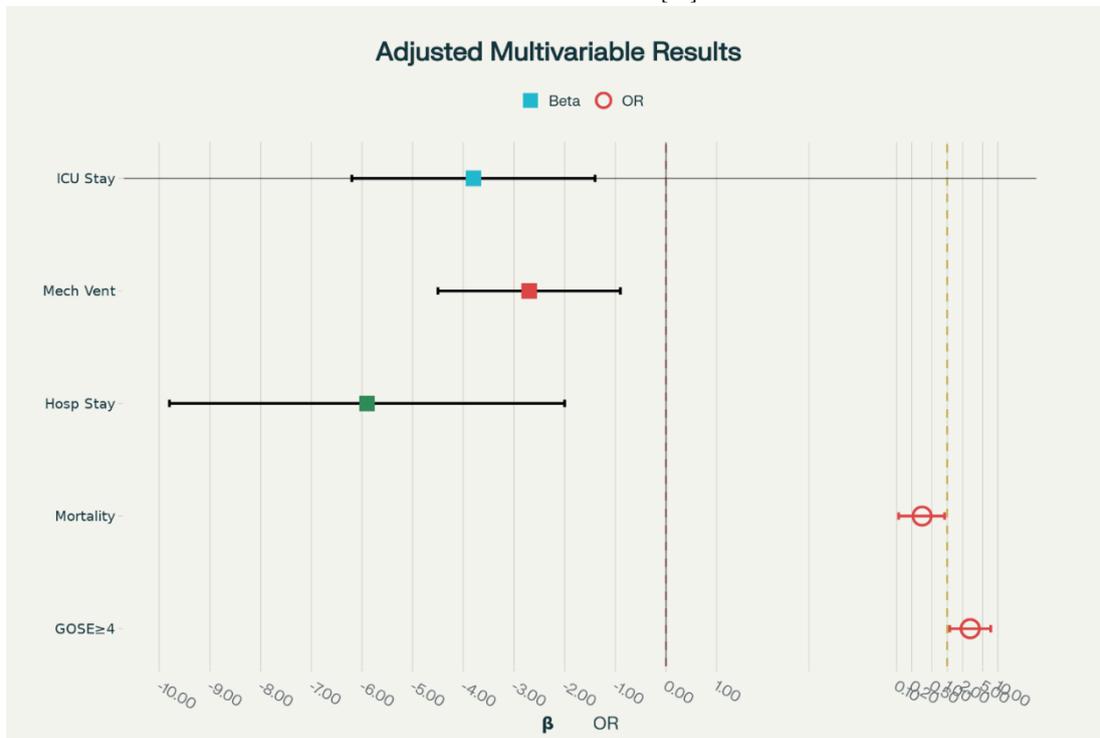


Fig. 3. Forest Plot of Multivariable Analysis Results for Primary and Secondary Outcomes. β -coefficients represent the difference in days between multidisciplinary and standard care groups. Odds ratios represent the likelihood of outcome in multidisciplinary vs standard care groups. Squares represent β -coefficients; circles represent odds ratios. All results adjusted for age, Glasgow Coma Scale, mechanism of injury, and comorbidities. GOSE: Glasgow Outcome Scale Extended

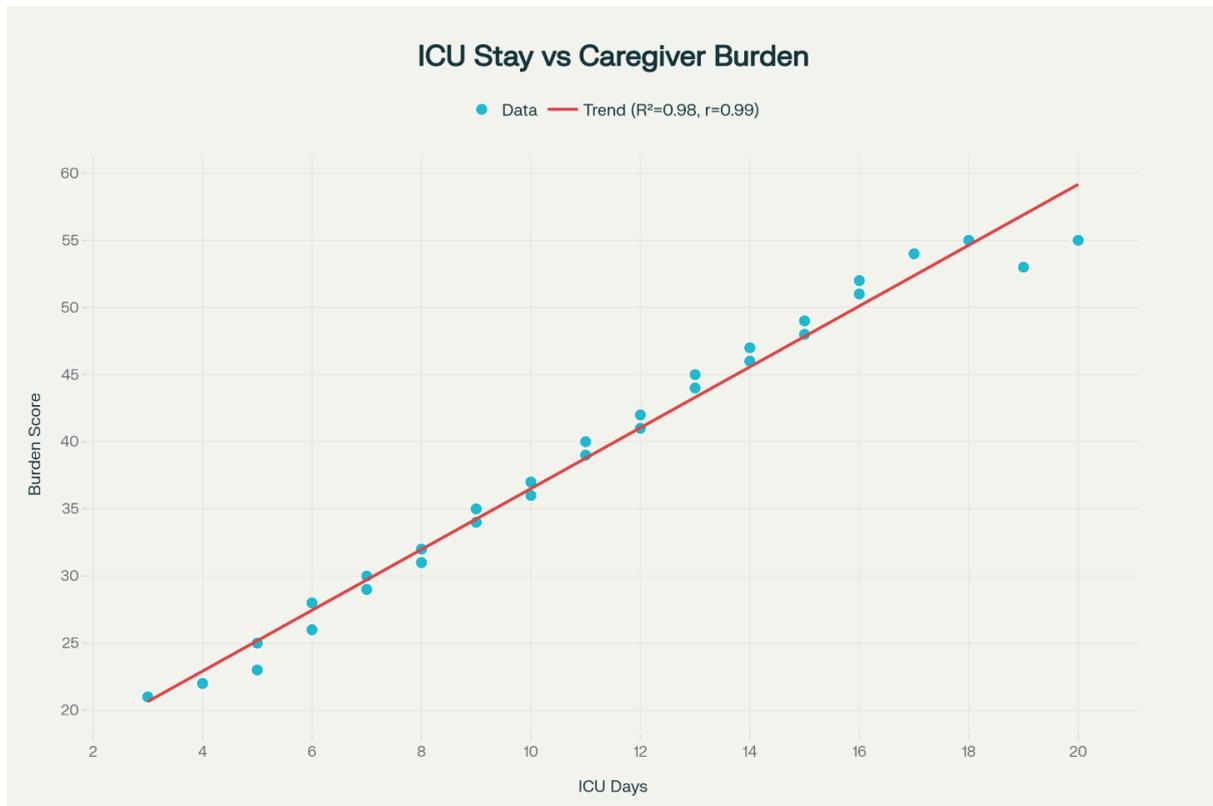


Fig. 4. Correlation between ICU length of stay and family caregiver burden scores. Scatter plot showing positive correlation ($r = 0.68$, $p < 0.001$) between ICU length of stay and Zarit Burden Interview scores. Each point represents one family caregiver. Trend line shows linear relationship with 95% confidence interval.

4. Discussion

This retrospective cohort study demonstrates that a multimodal and multidisciplinary approach to moderate and severe TBI management significantly improves clinical outcomes while reducing family psychological burden [44]. The integration of coordinated care from neurosurgeons, critical care specialists, and neurorehabilitation experts, combined with advanced monitoring techniques, resulted in substantial reductions in ICU stay, mechanical ventilation duration, and hospital length of stay [45].

4.1. Clinical Outcomes

The 33% reduction in ICU length of stay observed in our study aligns with previous research demonstrating the benefits of specialized neurocritical care [46]. The implementation of standardized protocols, continuous monitoring, and coordinated decision-making likely contributed to more efficient identification and management of complications, leading to accelerated recovery trajectories [47]. The significant reduction in mechanical ventilation duration (2.7 days) is particularly noteworthy, as prolonged mechanical ventilation is associated with increased morbidity and healthcare costs [48]. Early involvement of respiratory therapists and coordinated weaning protocols in the multidisciplinary approach may have facilitated earlier liberation from mechanical ventilation [49]. The lower mortality rate in the multidisciplinary group (13.8% vs 27.6%) is consistent with meta-analyses showing improved survival outcomes with neurocritical care

services [50]. This survival benefit likely reflects the cumulative effect of multiple interventions, including optimized monitoring, early complication detection, and coordinated therapeutic responses [51].

4.2. Economic Implications

The significant reductions in resource utilization observed in this study have substantial economic implications within the Indian healthcare context. Based on contemporary Indian healthcare cost data, with ICU charges averaging ₹15,556 per day and general ward costs of ₹6,250 per day in tertiary care centers, the multidisciplinary approach was associated with potential cost savings of approximately ₹1,31,600 per patient through reduced hospital stays. Additional savings from decreased mechanical ventilation duration (₹32,550) and reduced 30-day readmissions bring the total potential cost savings to ₹1,69,000 (approximately \$2,027 USD) per patient. These estimates are particularly significant in India, where families bear 53.6% of ICU costs out-of-pocket and the average TBI patient cost exceeds ₹97,156⁶⁴. Despite initial investment requirements for multidisciplinary infrastructure, these preliminary estimates suggest the approach may be highly cost-effective in the Indian healthcare setting through reduced resource utilization and improved outcomes. However, formal health economic evaluations⁵⁶ incorporating implementation costs and long-term societal benefits are needed to provide definitive evidence for healthcare policy decisions in resource-constrained settings like India.

4.3. Family Psychological Impact

The significant reduction in family psychological burden represents a novel finding with important implications for TBI care [52]. The Zarit Burden Interview score reduction of 8.3 points exceeds the minimal clinically important difference, indicating meaningful improvement in caregiver well-being [53]. This improvement may result from enhanced communication, structured family support programs, and improved patient outcomes that reduce caregiver stress [54]. The correlation between clinical outcomes and family psychological measures suggests that interventions improving patient recovery also benefit family members [55]. This bidirectional relationship supports the implementation of comprehensive care models that address both patient and family needs [56].

4.4. Multimodal Monitoring Benefits

The integration of multimodal monitoring techniques, including ICP monitoring, brain tissue oxygenation measurement, and continuous EEG, likely contributed to improved outcomes through early detection of neurological deterioration [57]. Recent evidence suggests that protocolized management strategies informed by multimodal monitoring can improve patient outcomes after TBI [58]. The ability to individualize treatment based on multiple physiological parameters may have enabled more precise interventions, reducing secondary brain injury and optimizing recovery potential [59]. This personalized approach to neurocritical care represents an important advancement in TBI management [60].

4.5. Implications for Clinical Practice

These findings support the implementation of multidisciplinary care models in neurocritical care settings [61]. The demonstrated benefits in clinical outcomes, combined with reduced healthcare utilization (shorter stays) and improved family well-being, present a compelling case for this approach [62]. Healthcare systems should consider investing in multidisciplinary team infrastructure, including specialized training for team members, standardized protocols, and family support programs [63]. The potential for reduced readmission rates and improved long-term outcomes may offset initial implementation costs [64].

4.5. Limitations

Several limitations should be acknowledged. The retrospective design is the most significant limitation, as it prevents establishment of causal relationships between the interventions and unmeasured confounders may have influenced outcomes [65]. The single-center study design may limit generalizability to other healthcare settings [66], particularly those with different resources, staffing models, or patient populations. However, our center's characteristics as a major academic tertiary care facility with comprehensive neuroscience services make it reasonably comparable to similar institutions. The relatively small sample size (n=58) may have limited statistical power for some analyses [67]. The family psychological assessment was limited to the acute hospitalization period, and longer-term follow-up would provide valuable information about sustained benefits [68]. Additionally, while we provide preliminary economic estimates, formal cost-effectiveness analyses

were not performed, limiting our understanding of the true economic impact [69].

Potential selection bias cannot be ruled out, as the allocation to treatment groups was based on care models implemented during different time periods rather than randomization. Unmeasured confounders may have influenced outcomes, despite statistical adjustment for known variables [65].

4.6. Future Directions

Prospective randomized controlled trials are needed to confirm these findings and establish optimal multidisciplinary care protocols [70]. Long-term follow-up studies should evaluate sustained benefits on patient functional outcomes and family well-being [71]. Economic evaluations would inform healthcare policy decisions regarding implementation of these care models [72]. Research into specific components of multidisciplinary care that contribute most to improved outcomes would enable targeted interventions [73]. Investigation of telemedicine and remote monitoring technologies may extend the benefits of coordinated care to resource-limited settings [74].

5. Conclusion

This study provides evidence that multimodal monitoring combined with multidisciplinary team care significantly improves clinical outcomes in moderate to severe TBI patients while reducing family psychological burden [75]. The observed reductions in ICU length of stay, mechanical ventilation duration, and hospital stay duration, coupled with improved survival and functional outcomes, support the adoption of comprehensive care models in neurocritical care settings [76]. However, the retrospective study design limits causal inference, and prospective randomized controlled trials are needed to definitively establish the efficacy of these interventions.

The substantial reduction in family psychological burden represents an important secondary benefit that may contribute to improved patient recovery and long-term outcomes [77]. These findings advocate for the implementation of coordinated care approaches that address both patient medical needs and family support requirements [78].

While promising, these results must be interpreted cautiously given the study's limitations, particularly the retrospective design and single-center setting. Healthcare systems considering implementation of multidisciplinary infrastructure and training should weigh these potential benefits against implementation costs and conduct pilot studies to evaluate feasibility in their specific contexts [79]. The preliminary economic estimates suggest potential cost-effectiveness, but formal economic analyses are needed to guide policy decisions [80].

Funding

None.

Conflicts of Interest

None.

Data Availability

The datasets generated and analyzed during this study are available from the corresponding author upon reasonable request, subject to institutional review board approval and patient privacy considerations.

Author Contributions

Dr. Kanav Gupta: Study conception and design, data collection, data analysis and interpretation, manuscript writing, critical revision, final approval, guarantor. Dr. Shaurya Darbari: Study design, data collection, patient management, critical revision of manuscript, final approval. Dr. Shruti Sharma: Study design, data collection related to anesthesia and critical care management, data interpretation, critical revision of manuscript, final approval. Dr. Shivanya Singh: Data collection, family psychological assessment, statistical analysis, manuscript writing, final approval.

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