



Original Article

Integrating quality certification to optimize traumatic brain injury care: A retrospective study

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ABSTRACT

Objectives: This study assesses the clinical and operational impact of implementing a quality certification program on the care of traumatic brain injury (TBI) patients at a medical center. By evaluating key performance metrics before and after program implementation, this study aims to determine the program's effectiveness in enhancing patient outcomes. **Materials and Methods:** The study retrospectively analyzed 1197 cases, with 827 cases precertification (January 2019–June 2023) and 370 cases postcertification (July 2023–June 2024). Key metrics included Glasgow Coma Scale (GCS) scores, modified Rankin Scale (mRS) scores, Barthel Index (BI) scores, compliance with clinical protocols, hospital length of stay (LOS), healthcare costs, readmission rates, and patient satisfaction. Statistical significance was determined at $P < 0.05$. **Results:** The implementation of the quality certification program significantly improved compliance with key protocols. GCS assessment compliance increased from 79.61% to 100%, and timely computed tomography imaging improved from 94.17% to 96.64%. Functional recovery also improved, with mean mRS scores decreasing from 3.63 to 2.79, and mean BI scores increasing from 27.2 to 59.9. Hospital LOS decreased from 10.94 to 9.00 days ($P = 0.027$). Thirty-day unplanned readmission rates dropped from 5.88% to 3.54%, and patient satisfaction scores improved from 87 to 89, including increases in physician care (+5.84 points) and respect for autonomy (+4.80 points). Healthcare costs decreased marginally from New Taiwan Dollar (NTD) 106,530 to NTD 86,182, though this reduction was not statistically significant ($P = 0.23$). **Conclusion:** The quality certification program fostered multidisciplinary collaboration and standardized care, resulting in improved clinical outcomes, greater functional recovery, and enhanced patient satisfaction. These findings underscore the program's value in modern healthcare settings and its potential to optimize TBI care.

KEYWORDS: *Barthel index, Glasgow Coma Scale, Modified Rankin scale, Quality certification program, Traumatic brain injury*

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INTRODUCTION

Traumatic brain injury (TBI) is one of the leading causes of death and long-term disability worldwide, affecting millions of individuals annually [1,2]. Despite significant advancements in acute and critical care, inconsistencies in clinical outcomes and challenges in postacute rehabilitation persist, underlining gaps in the delivery of standardized care for TBI patients. Previous studies have highlighted the potential benefits of guideline adherence and systematic care coordination in improving clinical outcomes for TBI patients [3,4]. However, there remains a lack of research examining how quality certification programs specifically address these gaps, particularly in terms of enhancing multidisciplinary collaboration, streamlining workflows, and reducing variability in care protocols between institutions.


Existing literature has primarily focused on the impact of individual interventions, such as early rehabilitation or adherence to Brain Trauma Foundation guidelines, without evaluating the cumulative effects of an integrated quality improvement framework [5-8]. For example, while early rehabilitation has been associated with improved functional outcomes [9], and compliance with guideline-recommended practices has reduced mortality rates [10], there is limited

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evidence on how combining these strategies under a structured certification program can simultaneously improve clinical and operational outcomes. Moreover, the scalability and reproducibility of such frameworks in diverse healthcare settings remain underexplored.

Another critical gap is the paucity of studies assessing the impact of certification programs on patient-centered outcomes, such as satisfaction and shared decision-making (SDM). While patient engagement has been increasingly recognized as a cornerstone of high-quality care, previous research has largely overlooked how certification programs can foster a culture of patient-centeredness in acute care settings [11,12]. In addition, there is limited understanding of how these programs influence operational efficiency metrics, such as hospital length of stay (LOS), healthcare costs, and readmission rates, which are pivotal for optimizing resource utilization in modern healthcare systems.

By addressing these gaps, this study seeks to provide a comprehensive evaluation of the impact of implementing a quality certification program on both clinical and operational metrics in TBI care. This research builds on prior findings by integrating standardized protocols, multidisciplinary collaboration, and patient-centered approaches into a unified framework, thereby offering novel insights into the potential of certification programs to transform TBI care.

MATERIALS AND METHODS

This retrospective research study examined TBI patient outcomes before and after implementing a quality certification program. The hospital's Institutional Review Board (IRB) approved the study (Protocol No. 13-IRB123) with a waiver of informed consent. This study was conducted in accordance with the Declaration of Helsinki. The research period spanned January 2019–June 2024, comparing 827 precertification cases (January 2019–June 2023) with 370 postcertification cases (July 2023–June 2024). Specifically, 266 cases met the Quality Certification Program's defined criteria. The study adhered to International Conference on Harmonisation Good Clinical Practice ethical research standards.

The Quality Certification Program in our study follows the framework set by the Disease Care Certification of the Joint Commission of Taiwan (JCT). This program is developed based on continuous data collection and validation by authoritative experts in each disease field. According to JCT guidelines: "The JCT continuously collects and compiles key indicators and future trends for various diseases, which are validated by authoritative experts in each disease field, to formulate "required" and "optional" quality indicators for each disease. These indicators are provided to healthcare organizations applying for the "Disease Specific Care Certification Program" to assist healthcare teams in regularly monitoring and improving their outcomes." The classification of quality indicators into "required" and "optional" measures is determined by expert consensus based on clinical relevance, feasibility of implementation, and institutional variations. Required indicators ensure that all certified institutions maintain a standardized minimum quality of care, while

optional indicators allow flexibility to encourage continuous improvement beyond the baseline standards. The classification of rehabilitation and multi-team care as optional measures is based on several factors. Healthcare facilities vary in their access to rehabilitation specialists and multidisciplinary teams, making mandatory implementation impractical. In addition, the necessity and timing of rehabilitation depend on factors such as the severity of TBI, patient comorbidities, and functional status at admission. Furthermore, these optional indicators serve as benchmarks, encouraging institutions to exceed standard care requirements and adopt more patient-centered approaches.

The components of the quality certification program include the following

For TBI patients, required measures include monitoring Glasgow Coma Scale (GCS) scores hourly during the initial 2 h of admission. In addition, a computed tomography (CT) examination should be completed within 1 h of initiating a case for TBI patients. Upon discharge, these patients are to receive education about head injuries. Furthermore, the rate of unplanned readmissions within 30 days of discharge due to the same or related conditions is monitored for TBI inpatients.

Optional measures involve evaluating the percentage of TBI patients assessed by the rehabilitation team within 2 working days before transferring from the intensive care unit (ICU), as well as within 2 working days after the transfer. The percentage of TBI patients receiving multi-team care is also considered. Other optional measures include tracking early discharges and readmissions within 48 h due to TBI-related complications, monitoring unplanned returns to the operating room for TBI surgical patients during hospitalization, and assessing the rate of TBI-related returns to the emergency department within 72 h of discharge.

Autonomous monitoring measures focus on the percentage of TBI inpatients with a GCS score of 12 or less who receive multiteam care. They also include the percentage of TBI patients evaluated by the rehabilitation team before transferring from the ICU and the rate of TBI patients returning to the emergency department within 3 days after discharge.

Inclusion criteria

Patients eligible for inclusion are those diagnosed with TBI based on imaging results and injury mechanisms, corresponding to the ICD-10-CM code S06, and classified as emergency admissions. This includes patients admitted to the neurosurgery department through the emergency room who have been observed for more than 2 h, as well as those referred to neurosurgery after receiving initial emergency care.

Exclusion criteria

Patients are excluded if they refuse examination and treatment, if their families request a transfer to another hospital, or if they are discharged without medical authorization.

SDM in the context of critical care includes several key discussions. First, it involves exploring the available treatment options during the acute phase for a loved one suffering from a severe brain injury. Second, it requires evaluating whether a tracheostomy is appropriate for a patient who cannot be

weaned off the ventilator in the short term. Finally, it addresses the long-term implications of ventilator dependence, ensuring that future care strategies are carefully considered.

The certification program was designed to improve the quality of care by focusing on several key aspects: enhancing multidisciplinary collaboration, standardizing clinical protocols, promoting early initiation of rehabilitation, and fostering SDM between healthcare teams and patients. To ensure that treatment plans were optimized, clinical teams conducted regular reviews of patient progress throughout the course of care.

Data for this study were gathered retrospectively from the hospital’s electronic health records (EHRs). This included demographic information, clinical indicators such as GCS scores, modified Rankin Scale (mRS) scores, Barthel Index (BI) scores, and operational metrics such as hospital LOS, healthcare costs, and readmission rates. Standardized patient satisfaction surveys were also analyzed. All data required for this analysis were complete, with no missing values for the variables of interest. This ensured that the findings were based on a comprehensive dataset without the need for imputation or exclusion of cases due to incomplete records. The integrity of the dataset was verified by cross-checking EHR entries against hospital audit logs.

Statistical analysis

Independent *t*-tests were employed to analyze continuous variables such as LOS and healthcare costs, allowing for a comparison of means between groups. For categorical variables, such as readmission rates, Chi-square tests were utilized to examine differences in proportions. Statistical significance for all analyses was determined by setting the threshold at $P < 0.05$, indicating that any observed differences were considered statistically significant if the *P* value fell below this level.

RESULTS

Overview of patient demographics and injury mechanisms

Table 1 illustrates no statistically significant differences in patient demographics or injury mechanisms between the pre- and postteam formation groups. The distributions of sex ($P = 0.42$), median age ($P = 0.58$), and the proportions of falls ($P = 0.31$), car accidents ($P = 0.61$), and other mechanisms ($P = 0.34$) were comparable.

Key performance indicators

Compliance with Glasgow Coma Scale assessment

Following the team’s establishment in July 2023, compliance with GCS assessment for TBI patients improved significantly, rising from 79.61% to 92.5%. By early 2024, compliance reached 100%, surpassing the 90% target and demonstrating the effectiveness of team-based interventions [Figure 1a].

Timely computed tomography imaging

Before the team’s formation, 94.17% of patients underwent timely CT imaging. Implementation of team

Table 1: Baseline demographics and mechanisms of injury before and after team formation

Demographics	Before team formation (n=827)	After team formation (n=266)	<i>P</i>
Patient characteristics			
Sex (male:female), <i>n</i> (%)	464:363 (56:44)	141:125 (53:47)	0.42
Age (years), median	70	72	0.58
Mechanism of injury			
Fall	507 (61)	173 (65)	0.31
Car accident	271 (33)	82 (31)	0.61
Other	49(6)	11 (4)	0.34

strategies increased this rate to 96.64%, streamlining workflows and accelerating access to critical diagnostic services. These improvements highlight the team’s role in reducing imaging delays, expediting diagnosis, and initiating treatment [Figure 1b].

Discharge education

Completion rates for TBI discharge education rose from 88.17% before the team’s establishment to 95.9%. From December 2023 to March 2024, a sustained 100% completion rate demonstrated the success of team-driven initiatives in achieving compliance [Figure 1c].

30-day unplanned readmissions

The low 30-day unplanned readmission rate for TBI patients reflects effective discharge planning and follow-up care. Despite a temporary spike in October 2023, regular reviews and scheduled follow-up meetings addressed potential issues, ensuring high-quality care [Figure 1d].

Reduction in hospital length of stay

The average hospital stay for TBI patients decreased from 10.94 days preteam formation to 9.00 days afterward ($t = -2.21$, $P = 0.027$). This reduction indicates enhanced care coordination, earlier rehabilitation initiation, and improved postoperative management [Figure 2a].

Reduction in hospital costs

Hospitalization costs decreased from NTD 106,530 before team formation to NTD 86,182 afterward. Although not statistically significant ($t = -1.20$, $P = 0.23$), this decline suggests more efficient resource use and reduced complications [Figure 2b].

Improvement in Glasgow Coma Scale scores

The proportion of patients discharged with mild TBI (GCS 13–15) increased from 65.79% preteam formation to 78.76% postteam formation ($P = 0.0018$). Concurrently, the proportion of moderate and severe cases declined from 34.21 to 21.24 ($P = 0.0018$), reflecting improved recovery outcomes [Figure 3].

Functional recovery (modified Rankin scale and Barthel Index)

Significant improvements in functional independence were observed, with the mRS score improving from 3.63 to 2.79 ($P = 2.59 \times 10^{-8}$) and the BI score increasing from 27.2 to 59.9 ($P = 3.01 \times 10^{-7}$).

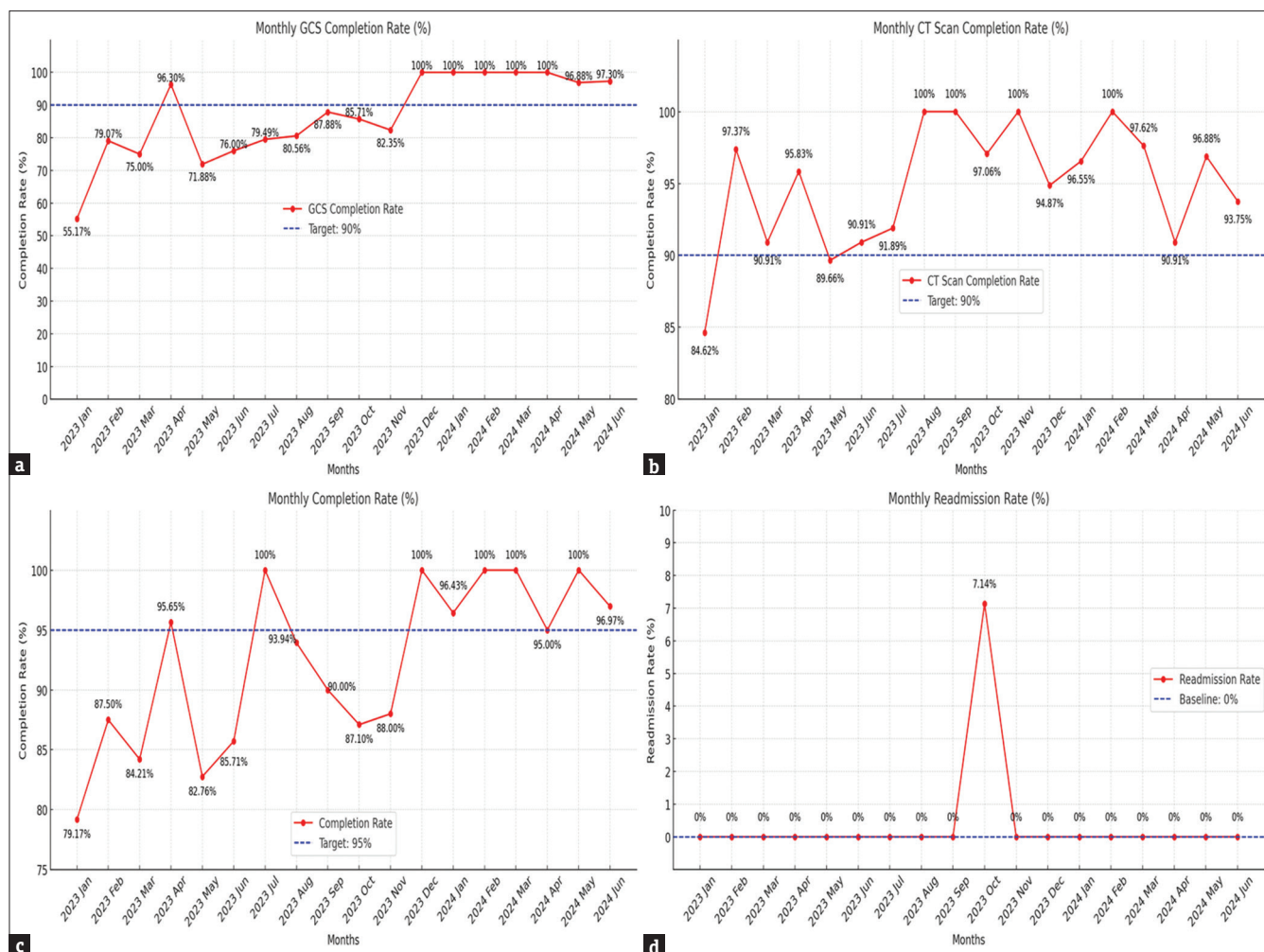


Figure 1: Monthly Glasgow Coma Scale score completion rates for TBI patients (within 2 h of arrival) from January 2023 to June 2024. The red line shows rates, with a 90% target marked by a blue dashed line. Performance improved over time, reaching consistent compliance from December 2023 onward (a). Monthly computed tomography scan completion rates for TBI patients (within 1 h of arrival) from January 2023 to June 2024. The red line shows monthly rates, with a 90% target indicated by a blue dashed line. Rates show variability, with consistent achievement of 100% from August to October 2023, followed by fluctuations around the target in 2024 (b). Monthly education completion rates for TBI patients at discharge from January 2023 to June 2024. The red line represents the completion rate, with a 95% target indicated by a blue dashed line. Rates show variability, with consistent achievement of 100% in several months, particularly from December 2023 to March 2024. Fluctuations below the target are observed earlier in the timeline (c). Monthly 30-day unplanned readmission rates for TBI patients from January 2023 to June 2024. The red line represents readmission rates, with a baseline target of 0% indicated by a blue dashed line. A single unplanned readmission occurred in October 2023, resulting in a rate of 7.14%. All other months maintained a 0% readmission rate (d)

Slight decrease in mortality rate

The mortality rate showed a minor decline from 16.47% to 15.66%. Although this trend suggests better healthcare strategies and patient outcomes, it did not reach statistical significance ($P = 0.941$).

Reduction in unplanned readmissions

The rate of unplanned readmissions decreased from 5.88% to 3.54%, but this change did not reach statistical significance ($P = 0.435$). While the trend suggests improvements in discharge planning and follow-up care, the lack of statistical significance indicates that further investigations are needed to confirm a meaningful impact.

Patient satisfaction and physician ratings

Overall patient satisfaction scores increased from 87 to 89 ($P = 0.440$), and physician care ratings improved from 82.63 to 88.95 ($P = 0.088$). However, these differences were not

statistically significant. In contrast, respect for patient autonomy demonstrated a statistically significant improvement, rising from 88.37 to 95.11 ($P = 0.031$). These findings suggest a positive trend in patient-centered care, though the improvements in satisfaction and physician ratings should be interpreted with caution given the lack of statistical significance.

Table 2 provides a comparison of quality certification outcomes, highlighting key clinical indicators such as unplanned readmission rates, mortality rates, patient satisfaction, and physician ratings before and after certification. In addition, the hospitalization comparison outlines changes in the severity distribution of TBI, along with improvements in functional recovery, as measured by the mRS and BI, as well as other relevant patient outcomes.

DISCUSSION

Our findings demonstrate that the implementation of a team-based approach in July 2023 significantly improved key performance

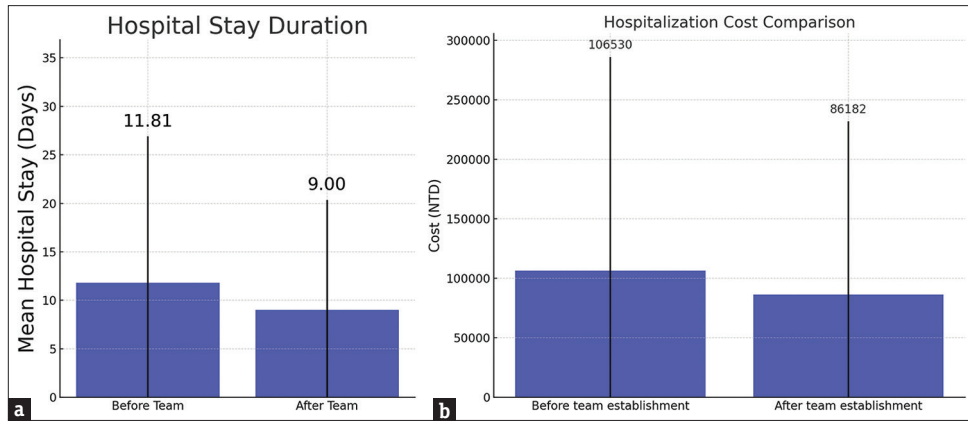


Figure 2: Comparison of mean hospitalization days before and after team formation. The average hospital stay for patients decreased from 10.94 days before team formation to 9.00 days afterward ($t = -2.21, P = 0.027$). This statistically significant reduction reflects improved care coordination, earlier initiation of rehabilitation, and better postoperative management. Bars represent mean values in days (a). Comparison of hospitalization costs before and after team formation. The average hospitalization cost decreased from NTD 106,530 before team formation to NTD 86,182 afterward. Although this reduction reflects improved resource utilization and a decrease in complications, the change was not statistically significant ($t = -1.20, P = 0.23$). Bars represent mean values in NTD (b)

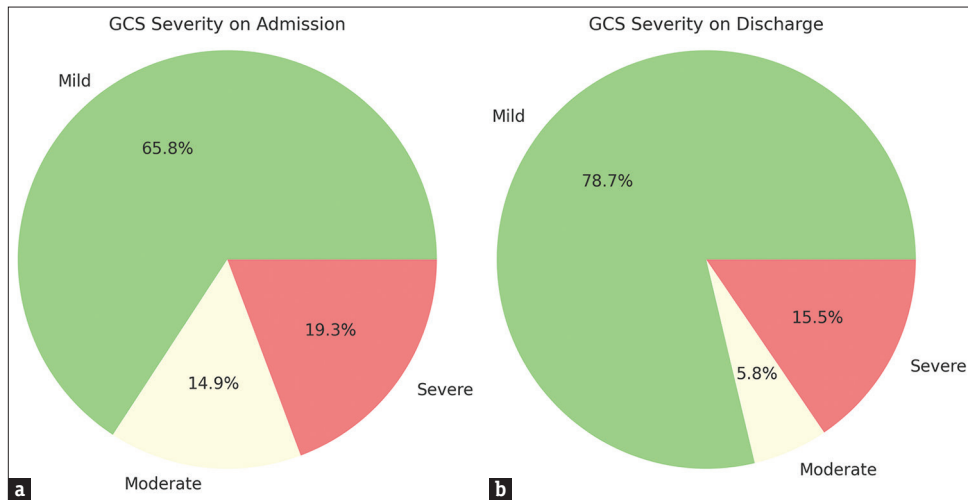


Figure 3: Pie charts illustrating the distribution of Glasgow Coma Scale scores upon admission and discharge. (a) Left chart represents admission, 65.8% of patients had mild scores (13–15), 14.9% had moderate scores (9–12), and 19.3% had severe scores (3–8). (b) Right chart represents discharge, 78.7% of patients had mild scores, 5.8% had moderate scores, and 15.5% had severe scores

Table 2: Quality certification comparison and hospitalization comparison

Quality certification comparison			
Indicator	Before certification	After certification	P
Unplanned readmission rate	5.88	3.54	0.435
Mortality rate	16.47	15.66	0.941
Patient satisfaction score	87.0	89.0	0.44
Medical care quality improvement (physician ratings)	82.63	88.95	0.088
Respect for patient autonomy (ratings)	88.37	95.11	0.031
Hospitalization comparison			
Indicator	Admission	Discharge	P
Mild TBI cases (%)	65.79	78.76	0.0018
Moderate-to-severe TBI cases (%)	34.21	21.24	0.0018
mRS score	3.63	2.79	2.59e-08
BI score	27.2	59.9	3.01e-07

mRS: Modified Rankin Scale, BI: Barthel Index, TBI: Traumatic brain injury

indicators, patient outcomes, and satisfaction for TBI patients. The absence of significant differences in baseline characteristics, such as age, sex, and injury mechanisms, between the two groups

suggests that observed improvements in patient outcomes are likely attributable to the interventions implemented postteam formation rather than preexisting demographic differences.

GCS assessment compliance increased from 79.61% to 100% by early 2024, surpassing the 90% target and highlighting the success of systematic, coordinated care practices. Similarly, timely CT imaging rates improved from 94.17% to 96.64%, reflecting streamlined workflows that reduced wait times and enhanced diagnostic efficiency. Discharge education compliance also increased from 88.17% to 100% by early 2024, showcasing the team's role in ensuring patient understanding and adherence to postdischarge instructions. The low 30-day unplanned readmission rate, aside from a single spike in October 2023, further reflects effective discharge planning and proactive follow-up care.

The team's efforts reduced the average hospital LOS from 10.94 days to 9.00 days ($P = 0.027$), suggesting improved care coordination and earlier rehabilitation. While the reduction in hospital costs from NTD 106,530 to NTD 86,182 was not statistically significant ($P = 0.23$), the trend indicates more efficient resource utilization and fewer complications. Patient outcomes showed marked improvement, with the proportion of patients discharged with mild TBI (GCS 13–15) increasing from 65.79% to 78.76% ($P = 1.8 \times 10^{-3}$), while moderate and severe cases declined from 34.21% to 21.24% ($P = 1.8 \times 10^{-3}$). Functional independence improved, as evidenced by a reduction in the average mRS score from 3.63 to 2.79 ($P = 2.59 \times 10^{-8}$) and an increase in the BI score from 27.2 to 59.9 ($P = 3.01 \times 10^{-7}$), driven by early rehabilitation and comprehensive care. The mortality rate showed a slight decline from 16.47% to 15.66%; however, this change was not statistically significant ($P = 0.941$), indicating that it may be due to random variation rather than an actual improvement in outcomes. Similarly, the rate of unplanned readmissions within 3 days decreased from 5.88% to 3.54%, but this reduction did not reach statistical significance ($P = 0.435$). While these trends suggest potential improvements in healthcare strategies, discharge planning, and follow-up care, the lack of statistical significance warrants cautious interpretation. Patient satisfaction scores increased from 87 to 89 ($P = 0.440$), and physician care ratings improved from 82.63 to 88.95 ($P = 0.088$); however, neither of these differences met the predefined threshold for statistical significance ($P < 0.05$). In contrast, respect for patient autonomy demonstrated a statistically significant improvement, increasing from 88.37 to 95.11 ($P = 0.031$), suggesting a positive impact of the quality certification program on patient-centered care.

Alkhalwaleh *et al.* [13] showed that early occupational therapy reduced LOS and improved functional independence in moderate-to-severe TBI patients. Fuke *et al.* [9] highlighted early rehabilitation's benefits for short-term physical outcomes in critically ill patients, while Siddique *et al.* [14] identified discharge planning and interdisciplinary care as effective in reducing LOS for high-risk populations. Building on these findings, our study emphasizes the value of integrated care. By coordinating emergency, neurosurgical, and rehabilitation services, we reduced LOS from 10.94 to 9.00 days. Combining early physical and cognitive rehabilitation further improved recovery, facilitated earlier discharges, and enhanced functional outcomes. In addition, incorporating these interventions into a

certification program minimized hospital-acquired infections and improved overall care quality, offering a replicable model for TBI management.

Our findings related to functional recovery, assessed using the mRS and BI, also distinguish this study from previous research. For instance, while Liu *et al.* [15] explored correlations between mRS and BI scores in stroke patients, our study extends the application of these metrics to TBI populations, illustrating their broader relevance. Functional recovery, as evidenced by a reduction in mean mRS scores and an increase in BI scores, was driven by early initiation of rehabilitation within two working days of ICU transfer. This timing maximized neuroplasticity and motor recovery while ensuring seamless coordination among emergency, neurosurgical, and rehabilitation teams. Adherence to standardized protocols, such as prompt GCS monitoring and timely CT imaging, minimized delays in care and secondary brain injuries, further optimizing recovery outcomes. In addition, structured patient and caregiver education empowered patients to adhere to rehabilitation plans and avoid complications postdischarge.

The overall mortality rate for TBI patients in our study (15.90%) is comparable to the findings of Gerber *et al.* [10], which reported a decrease in mortality from 22% in 2001 to 13% in 2009, attributed to improved adherence to Brain Trauma Foundation Guidelines. While our study shows a modest decline in mortality from 16.47% before team formation to 15.66% afterward, this reduction is less pronounced than that reported in their study. This disparity may be due to differences in study populations, seasonal factors, or variations in injury severity during the observation periods.

Moreover, our study uniquely documented a reduction in unplanned hospital readmissions, which decreased from 5.88% to 3.54% after implementing the certification program. While similar benefits have been observed in chronic disease populations by researchers such as Zhu *et al.* [11], our findings adapt these interventions to TBI patients, emphasizing the critical role of tailored discharge planning and follow-up care. By leveraging mobile health technologies, we empowered patients to actively engage in their recovery, thereby minimizing complications and fostering improved long-term outcomes.

Patient satisfaction saw marked improvements, driven by enhanced communication and the integration of SDM. Unlike the primary care context explored by Altin and Stock [12], our study demonstrates the effectiveness of SDM in acute care, particularly for TBI patients. By involving patients in their care plans, we fostered greater adherence to treatment protocols, substantially enhanced satisfaction levels, and reinforced a patient-centered approach to recovery.

While our research primarily focused on short-term outcomes, the observed trends suggest potential opportunities for exploring long-term effects, aligning with findings from longitudinal studies like that of McCrea *et al.* [16], who documented significant functional gains in TBI patients over 12 months. These sustained improvements further underscore the enduring value of structured interventions,

paving the way for future research on extended recovery trajectories in TBI care.

Limitations

This study has certain limitations. First, its retrospective design and single-center setting limit the generalizability of the findings. In addition, we only tracked patient outcomes for up to 30 days postdischarge, which restricts our understanding of long-term functional recovery. A longer follow-up period would provide more comprehensive insights into the sustainability of the improvements observed.

CONCLUSION

Our findings demonstrate significant improvements in TBI care through a team-based approach. Compliance with assessments and diagnostic procedures improved, discharge education reached full adherence, and care coordination became more efficient. Hospital stays were shortened, functional recovery was enhanced, and patient outcomes showed marked progress. Mortality and unplanned readmissions decreased, while patient satisfaction improved, driven by better communication and SDM. These results highlight the value of integrated care and structured interventions for sustained improvements in TBI management.

Data availability statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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