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Trauma Care Performance in Western China: A Single-Center Benchmark Analysis Using Provincial and National Trauma Registry Data

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Abstract

Introduction: With urbanization, trauma has become a critical public health issue in western China. However, detailed performance evaluations of regional trauma centers using provincial and national registry benchmarks remain limited. Objective: This study aimed to investigate the clinical characteristics of trauma patients and evaluate the operational efficiency and outcomes of a tertiary trauma center in Suining using provincial and national benchmarks. Methods: A retrospective secondary analysis was conducted using the China Trauma Rescue Consortium (CTRC) database. Patient-level data were derived from a tertiary Grade A hospital in western Sichuan Province, while aggregated provincial and national CTRC data were used for benchmarking. A total of 8,257 patients treated between September 2021 and February 2025 were included. Descriptive statistics, univariate analysis, and multivariable binary logistic regression were performed using SPSS version 26.0. Statistical significance was set at $p < 0.05$. Results: Falls (including ground-level and height-related) and traffic-related injuries were the primary mechanisms of injury. The center demonstrated faster emergency department preparation time (4.03 min vs. 8.37 min nationally) and a lower mortality rate for severe trauma (1.67% vs. 2.32%). However, door-to-CT completion time (41.04 min) remained longer than benchmark values. The regression model showed high explanatory power (Nagelkerke $R^2 = 0.96$). Age (OR = 1.03, p = 0.01), ISS (OR = 1.24, $p < 0.01$), and GCS (OR = 0.62, $p < 0.01$) were significant independent predictors of 30-day mortality. Conclusion: This benchmarking analysis demonstrated strong early response performance but identified delays in diagnostic imaging workflows. Improving door-to-CT efficiency may further enhance trauma care outcomes in western China.

Keywords:
Trauma, Trauma Registry, Mortality, Injury Severity Score, Benchmarking

INTRODUCTION

With the acceleration of urbanization, traumatic events have become an inevitable consequence of urban development. In Western China, the incidence of trauma is particularly high, presenting a formidable challenge to the regional healthcare system (Zhang & Peng, 2022). Despite the prevalence of these injuries, current research on hospitalized trauma cases predominantly relies on single-center studies with limited sample sizes and often lacks benchmark comparisons with higher-level trauma systems. Previous studies have emphasized that benchmarking trauma center performance using multicenter registries can improve trauma system development and clinical quality management. Trauma remains one of the leading causes of mortality and disability globally, with a notably higher frequency in the western regions of China. Trauma system development in Western China remains uneven due to geographic and resource disparities (Jiang et al., 2019). Currently, there is a lack of comprehensive benchmarking research regarding the operational efficiency and resource allocation of trauma centers across China. These traumatic events not only severely impact patient health but also impose a significant economic burden on society.

To address these gaps, this study presents a registry-based benchmarking analysis using patient-level data from one tertiary trauma center together with provincial and national benchmark indicators from the China Trauma Care System. By utilizing 19 standardized quality control indicators and comparing hospital performance against provincial and national benchmarks (Wang & China Trauma Rescue Consortium, 2023), this research aims to investigate the clinical diagnostic and treatment characteristics of trauma patients and evaluate the current performance and operational challenges of a trauma center in Western China.

The objective of this study was to provide benchmarking evidence for improving trauma care quality in Western China. By analyzing standardized quality indicators within the China Trauma Care System, this research aimed to identify strengths, gaps, and operational challenges in the performance of a regional trauma center. The findings may provide an empirical basis for optimizing trauma system management and reducing regional disparities in trauma care delivery.

METHODS

1. Design

A retrospective cross-sectional observational study using secondary administrative data was conducted.

2. Data Source

The study utilized data from the China Trauma Rescue Consortium (CTRC) database, a national non-profit academic consortium led by the Trauma Medicine Center of Peking University and supported by the Ministry of Education. The CTRC was established to promote the development of trauma care systems and improve trauma care quality and efficiency across China (Huang et al., 2024).

The consortium has developed a trauma care quality control system comprising 19 key indicators. To ensure data quality, standardized admission and data collection procedures were implemented. Hospitals applying to join the consortium are required to complete three documents: the Survey of Urban Medical Service Status, the Hospital Information Questionnaire, and the Preliminary Investigation Form for the Regional Severe Trauma Treatment Project (three-year statistical data), which are submitted through the system for hierarchical review. Approved hospitals subsequently enter a three-year development period during which trauma care systems are optimized according to consortium standards.

In China, hospitals are classified into primary healthcare institutions, primary hospitals, secondary hospitals, and tertiary hospitals according to their functions and service capacity (Yin et al., 2021). Tertiary Grade A hospitals (3A hospitals) represent the highest level of hospital care, providing advanced medical services and serving as regional medical centers. This hierarchical system facilitates the rational allocation and efficient utilization of healthcare resources (General Office of the National Health Commission of the People's Republic of China, 2019).

To further ensure data reliability, the China National Trauma Care Network (CNTC) database operates on a voluntary participation basis and implements standardized training and management procedures. Participating hospitals must complete qualification assessments before enrollment, designate one to two reporting officers who receive annual national- and provincial-level training on data collection protocols and reporting standards, and receive standardized training materials and online technical support. These measures support the accuracy and reliability of the data used in this study. Although the CTRC is a multicenter registry, the present patient-level analysis was restricted to Suining Central Hospital; provincial and national

CTRC data were used only as aggregated benchmarks.

3. Population and Sampling Technique

The study was conducted using patient-level data from Suining Central Hospital, a tertiary Grade A hospital in western Sichuan Province, China.

Eligible participants included all trauma patients treated at the hospital between September 2021, when the hospital joined the consortium, and February 2025. Records with missing or inaccurate data were excluded. All data were independently reviewed by two researchers to ensure accuracy and consistency.

4. Data Collection Process

Data were obtained from Suining Central Hospital, a tertiary Grade A hospital in western Sichuan Province, China. Patient-level clinical data were extracted for all eligible trauma patients treated from September 2021 to February 2025.

In addition, aggregated provincial data from Sichuan and national benchmark data reported to the CTRC database were retrieved for external comparison. The dataset comprised annual data for the 19 trauma quality control indicators as well as detailed clinical records of trauma patients treated at the hospital.

Records with missing reports or inaccurate entries were excluded. All data were independently reviewed by two researchers to ensure completeness and accuracy before analysis.

5. Variables

Trauma remains one of the leading causes of mortality worldwide (Goddard et al., 2024). Therefore, the primary outcome of this study was 30-day mortality among trauma patients, which is widely used as a key indicator of trauma care outcomes (Brinck et al., 2021).

Based on the trauma care pathway and previous studies on trauma management (Boyd et al., 1987), independent variables were categorized into three domains: (1) Patient characteristics: Sex, age, Trauma Index (TI) score, Glasgow Coma Scale (GCS) score, and Injury Severity Score (ISS); (2) Emergency management process: Door-to-CT completion time and emergency department length of stay; and (3) In-hospital management: Admission to the intensive care unit (ICU).

6. Data Analysis

Statistical analysis was performed using SPSS version 26.0. First, univariate analysis was conducted to compare clinical characteristics and performance indicators between the survival and mortality groups. Continuous variables were expressed as mean ± standard deviation and compared using the independent samples t-test or Mann-Whitney U test, depending on the data distribution. Categorical variables were expressed as frequencies and percentages and compared using the χ^2 test.

Second, a multivariable binary logistic regression model was constructed to identify independent predictors of 30-day mortality (Yadav et al., 2023). Based on clinical relevance and the avoidance of multicollinearity, the final model included Age, Injury Severity Score (ISS) (Baker et al., 1974), Glasgow Coma Scale (GCS) (Teasdale & Jennett, 1974), and Door-to-CT completion time. Model fit was summarized using the likelihood-ratio test and Nagelkerke R^2. Because this study focused on identifying independent predictors rather than developing a fully validated prognostic tool, Receiver Operating Characteristic (ROC) Curve/Area Under the Curve (AUC) and calibration analyses were not performed in the current analysis and should be addressed in future validation studies. A two-sided $p < 0.05$ was considered statistically significant.

7. Research Ethics

This study was approved by the Ethics Committee of Suining Central Hospital (Approval No. 20240023). Permission to use the CNTC database was obtained prior to data access. Clinical trial registration was not applicable.

RESULTS

1. Study Population

Initially, 8,484 trauma cases were identified in the database. After excluding 227 records due to missing critical clinical indicators, specifically the Injury Severity Score (ISS) or Glasgow Coma Scale (GCS) scores, a final analytical cohort of 8,257 trauma cases was included in the study.

2. Characteristics of Trauma Patients

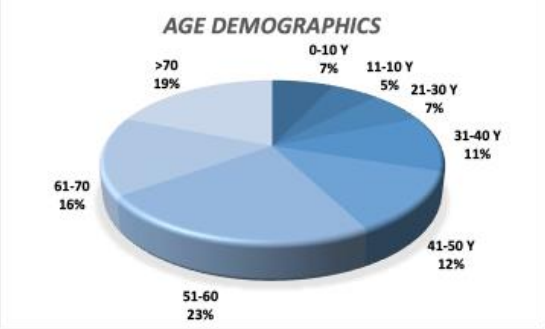

Figure 1. Age Distribution of Trauma Patients (N=8,257), Highlighting the trend of Trauma in the Aging Population of Western China.

The age distribution of the patients is shown in Figure 1. The largest proportion of patients was aged 51–60 years (22.36%), followed by ≥70 years (19.72%) and 61–70 years (16.19%). Regarding sex distribution, 5,119 patients (62.0%) were male and 3,138 (38.0%) were female.

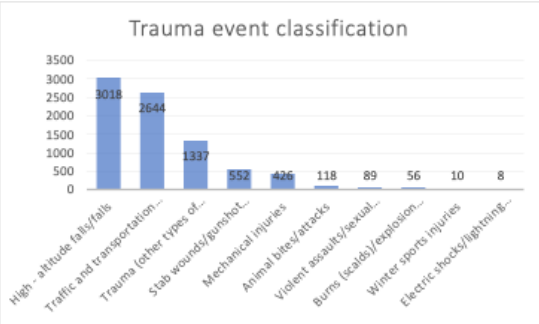

Figure 2. Distribution of Trauma Mechanisms among 8,257 Patients in Western China.

The distribution of trauma mechanisms is shown in Figure 2. Based on the Medical Priority Dispatch System (MPDS) classification of injury mechanisms, falls from height or ground-level falls were the most common cause of trauma (36.55%), followed by transportation-related injuries (31.99%). Other mechanisms included other trauma types (16.19%), penetrating injuries (6.68%), mechanical injuries (5.16%), animal attacks (1.43%), assault or sexual violence (1.08%), burn or explosion injuries (0.68%), winter sports injuries (0.12%), and electrical or lightning injuries (0.10%).

3. Univariate Analysis

A comparison of clinical characteristics and operational metrics between the survival and mortality groups is presented in Table 1. The univariate analysis indicated that patients in the mortality group were significantly older and presented with substantially higher Injury Severity Score (ISS) and Trauma Index (TI) scores, along with lower GCS scores (all $p < 0.05$). Regarding operational efficiency, the mortality group experienced a significantly longer Emergency Department (ED) length of stay compared with the survival group ($p < 0.01$). However, no statistically significant differences were observed between the two groups in terms of sex distribution or door-to-CT completion time ($p > 0.05$).

4. Multivariable Logistic Regression

Multivariable binary logistic regression showed good model performance and strong explanatory power (Nagelkerke $R^2 = 0.96$, $\chi^2 = 490.15$, $p < 0.01$). ISS and GCS were identified as the strongest independent predictors of mortality. Each one-point increase in ISS was associated with a 24% increase in the odds of death (OR = 1.24, 95% CI: 1.14–1.35, $p < 0.01$), while each one-point increase in GCS score reduced the odds of death by 38% (OR = 0.62, 95% CI: 0.49–0.77, $p < 0.01$). Age also remained a significant independent predictor (OR = 1.03, $p = 0.01$). Although door-to-CT completion time did not reach statistical significance in this model (OR = 1.00, $p = 0.126$), it remained a clinically relevant process indicator for workflow optimization.

5. Benchmark Analysis of Performance Metrics

The performance metrics of our center compared with provincial and national benchmarks are summarized in Table 2. Compared with national data, our center demonstrated higher efficiency in emergency department preparation (4.03 min vs. 8.37 min) and a lower mortality rate for severe trauma (1.67% vs. 2.32%). However, door-to-CT completion time (41.04 min) was longer than the national average (30.93 min).

Table 1. Baseline Characteristics and Clinical Metrics Categorized by Outcome (n = 8,257)

Variables	Survival (n = 8,217)	Mortality (n = 40)	(t/χ^2/Z)	*P*
Patient Characteristics:				
Age, years	49.2 ± 18.5	56.8 ± 21.3	t = 2.54	0.01
Male, %	5090 (61.9%)	29 (72.5%)	$\chi^2 = 1.78$	0.18
Clinical Assessment:				
Injury Severity Score (ISS)	8.4 ± 6.1	32.6 ± 14.5	Z = 11.42	< 0.01
Glasgow Coma Scale (GCS)	14.8 ± 1.2	7.4 ± 4.6	Z = 15.23	< 0.01
Trauma Index (TI)	4.2 ± 2.8	12.5 ± 5.4	Z = 10.85	< 0.01
Workflow Metrics:				
Door-to-CT completion time (min)	40.8 ± 12.4	44.2 ± 15.8	t = 1.68	0.09
ED Length of Stay (min)	86.5 ± 35.1	112.4 ± 48.6	t = 3.92	< 0.01

Note. Continuous variables are presented as mean ± SD; categorical variables are presented as n (%). Door-to-CT completion time is defined as the interval from hospital arrival to the completion of the whole-body rapid CT examination.

Table 2. Benchmark Comparison of Trauma Care Performance at Local, Provincial, and National Levels: September 2021 to February 2025

Indicators	Suining Central Hospital	Sichuan Province	China
Pre-hospital Emergency Transport Time (minutes)	18.99	16.65	19.96
Pre-alerting Proportion (%)	21.07%	9.68%	14.56%
Emergency Department Preparation Time (minutes)	4.03	8.19	8.37
Door-to-CT completion time (minutes)	41.04	30.19	30.93
Time to Completion of Chest X-ray (minutes)	28.26	29.66	41.13
Time to Completion of Pelvic X-ray (minutes)	45.4	25.93	29.94
Time to Completion of FAST Examination (minutes)	13.56	18.52	23.81
Time to Blood Transfusion Preparation in the Emergency Department (minutes)	40.3	72.25	55.48
Time to Establish Artificial Airway (minutes)	6.43	5.17	4.96
Time to Emergency Surgery Preparation (minutes)	70.51	67.16	70.62
Emergency Department Length of Stay (minutes)	87.29	82.27	96.12
Number of Severe Trauma Patients (persons)	2399	33879	782311
Mortality Rate of Severe Trauma Patients (%)	1.67%	2.78%	2.32%
Average Hospital Length of Stay for Severe Trauma Patients (days)	16.18	15.11	14.54
ICU Length of Stay for Severe Trauma Patients (days)	8.06	7.25	7.54
Number of Trauma Patients (persons)	8257	237779	5828500
Mortality Rate of Trauma Patients (%)	0.47%	0.42%	0.33%
Proportion of Patients Referred from Other Hospitals (%)	18.86%	4.12%	2.92%
Proportion of Trauma Patients Transferred for Further Treatment (%)	0.07%	0.54%	0.93%
TI Score Completion Rate (%)	100%	100%	100%
GCS Score Completion Rate (%)	100%	100%	100%
Abbreviated Injury Scale (AIS)/ ISS Score Completion Rate (%)	100%	100%	100%
Completeness of Trauma Data Reporting System (%)	100%	100%	100%
Frequency of Trauma Center Quality Control Meetings (times)	4	2.43	2.85

Note. The data for Suining Central Hospital represents the final analytical cohort (N = 8,257) after excluding 227 records with incomplete critical clinical indicators from the initial screening. Abbreviated Injury Scale (AIS).

DISCUSSION

1. Analysis of Independent Predictors for Trauma Mortality

The multivariable logistic regression model in this study showed strong explanatory power (Nagelkerke $R^2 = 0.96$), although this value should be interpreted cautiously. The relatively high R^2 likely reflects the dominant contributions of established severity indicators such as ISS and GCS, which capture both anatomical injury burden and neurological status. Rather than implying near-perfect prediction, this result indicates that these core clinical variables explained a large proportion of the variation in 30-day mortality in this cohort. Our findings confirm that anatomical Injury Severity Score (ISS) and physiological status (GCS) remain central determinants of survival. Specifically, ISS (OR = 1.24) emerged as the most significant risk factor, with every one-point increase in severity associated with a 24% increase in mortality risk. This finding underscores the necessity of prioritized triage and immediate aggressive intervention for patients presenting with high ISS (Chen et al., 2024), particularly in western China where transport distances to tertiary centers can be prolonged.

2. The "Efficiency Paradox" in Trauma Workflow

A key contribution of this study is the benchmark comparison of operational efficiency (Saar et al., 2019) (Table 2). We identified what can be termed an "efficiency paradox": while our center's administrative and preliminary response was highly

optimized, with emergency preparation time (4.03 min) approximately 50% faster than the national average (8.37 min), the diagnostic phase lagged behind benchmark levels.

Door-to-CT completion time (41.04 min) was notably longer than both provincial and national benchmarks (approximately 30 min). Although this delay did not show a direct statistical association with mortality in the adjusted model (p = 0.126), it represents an important procedural bottleneck (Ordoñez et al., 2020). In the golden hour of trauma care, delays in definitive diagnosis may contribute to secondary physiological deterioration (Huber-Wagner et al., 2009). This gap suggests that our center has made strong progress in rapid team mobilization but still needs to strengthen process-technology integration, for example by implementing a CT-first protocol or streamlining transfer between the emergency room and the imaging suite (Yamamoto et al., 2023).

3. Epidemiological Implications: Age and Mechanisms

As shown in Figure 1, the trauma population in this region is characterized by a high proportion of middle-aged and elderly individuals. The independent predictive value of Age (OR = 1.03, p = 0.01) reflects the physiological frailty of this demographic (Iddagoda et al., 2024). Combined with the prevalence of falls from height (Figure 2), these data suggest that regional trauma prevention strategies should focus on geriatric safety and occupational protection in the construction sector (Li et al., 2026), which are the primary drivers of severe trauma in western China.

Implications for Practice and Future Research

Practical Implication

These findings have several practical implications. The shorter emergency department preparation time and lower severe trauma mortality observed at our center suggest that early resuscitation and team mobilization are relatively effective. However, the longer door-to-CT completion time indicates that the imaging workflow still requires further optimization. In addition, patients with older age, higher ISS, and lower GCS should be identified early and prioritized for rapid assessment and close monitoring.

Policy Implication

At the policy level, these findings support the use of benchmarking as an important tool for trauma system evaluation and quality improvement. In western China, assessment of trauma centers should consider not only mortality outcomes but also key process indicators. Moreover, the local trauma profile suggests that prevention strategies should place greater emphasis on fall prevention and road traffic injury control.

Recommendations for Future Research

Future studies should include prospective multicenter analyses based on patient-level data to improve the generalizability of the findings. Further research is also needed to examine the reasons for prolonged door-to-CT time and to determine whether targeted workflow interventions can improve both process efficiency and clinical outcomes.

Limitations

Despite the large sample size, this study has several limitations. First, patient-level data were derived from a single regional center, while comparisons with other institutions were based on aggregated provincial and national benchmark data from the CTRC rather than pooled multicenter patient-level records. Accordingly, the study should be interpreted as a single-center benchmarking analysis. Second, the retrospective design may be subject to information bias and residual confounding. Third, although the logistic regression model showed strong explanatory power, additional discrimination and calibration analyses, such as ROC/AUC and calibration assessment, were not performed in the current study. Future prospective multicenter studies with patient-level data from multiple regions are needed to validate the generalizability of these findings across China.

CONCLUSION

This study provides a comprehensive benchmarking evaluation of a trauma center in western China using patient-level data compared with provincial and national registry indicators. The findings demonstrate strong performance in early emergency response and trauma care outcomes, particularly reflected in faster emergency department preparation time and lower mortality rates for severe trauma.

However, challenges remain in diagnostic imaging efficiency, especially prolonged door-to-CT completion time. Age, Injury Severity Score (ISS), and Glasgow Coma Scale (GCS) were identified as independent predictors of 30-day mortality, highlighting the importance of early clinical assessment and severity-based management.

The trauma patient population in this region was predominantly elderly, with falls and transportation-related injuries as the leading mechanisms, consistent with global trends (World Health Organization, 2021). These findings underscore the need to further optimize trauma care processes and strengthen prevention strategies targeting common injury mechanisms. Continued system improvement and benchmarking are essential to enhance trauma care quality and reduce regional disparities in trauma care delivery (Goddard et al., 2024).

Author Contributions

Conceptualization: Xixi Li, Bo Yang; Methodology: Yao Liu, Bo Yang; Data Collection: Zhonglei Zhao, Tong Zhou, Yunxia Li; Analysis: Yao Liu; Writing – Original Draft: Xixi Li; Writing – Review & Editing: Yao Liu, Zhonglei Zhao, Tong Zhou, Yunxia Li, Bo Yang.

Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request, subject to institutional and ethical considerations.

Conflict of Interest

The authors declare that there are no financial or personal relationships with other people or organizations that could inappropriately influence (bias) the work presented in this research.

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