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ORIGINAL RESEARCH

A Twelve-Year Retrospective Analysis of a Journey Towards Rural Level I Trauma Center Verification

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Purpose: This study describes the transformation of a rural trauma center in the Upper Mountain West, which expanded from 280 to 305 beds between 2011 and 2022, and from an American College of Surgeons (ACS) verified Level II to Level I facility, serving a four-state region.

Patients and Methods: A retrospective analysis of all 8947 trauma activations from 2011–2022 was conducted using the institution's trauma registry. A structured gap analysis assessed alignment with ACS Level I principles.

Results: The gap analysis identified four priority areas for growth and development of our trauma program to become an ACS Level I Trauma Center: patient volumes, absence of a Surgical Intensive Care Unit (SICU), lack of a surgical residency program, and limited trauma research infrastructure. Targeted interventions led to the establishment of a dedicated SICU, initiation of PGY-4 surgical rotations, and the development of trauma-focused research capacity. By 2023, the number of severely injured patients (Injury Severity Score (ISS) ≥16) exceeded ACS thresholds despite total admissions remaining below 1200. Between 2011 and 2022, 8947 trauma patients were treated. Mean patient age increased from 42.6 to 51.8 years (p <0.0001), with geriatric cases rising from 19.8% to 37.1% and female patients from 33.3% to 41.2%. Overall injury severity decreased (mean ISS 10.4 to 9.7; p <0.0001), but ICU patient acuity rose (ISS 15.9 to 17.9; p <0.0001). Mortality remained stable (3.3–4.0%). ICU admissions declined from 33.1% to 22.6%, while length of stay and patient acuity increased (49.6% and 4.7%, respectively). Interfacility transfer rates decreased from 2.8% to 1.1% (p=0.0372), reflecting improved system capacity.

Conclusion: Strategic investments in infrastructure, workforce development, education, and research enabled this rural trauma center to achieve Level I criteria while adapting to changing patient demographics and clinical demands. These implementation strategies may inform similar resource-constrained rural trauma systems pursuing ACS Level I verification.

Plain Language Summary: People living in rural areas often face long travel distances to receive advanced trauma care after serious injuries. This can delay treatment and may affect outcomes. In many rural states, access to the highest level of trauma care is limited, making it important for regional hospitals to expand their capabilities.

This study describes how a rural trauma center in the Upper Mountain West region of the United States improved its trauma program and achieved American College of Surgeons (ACS) Level I trauma center verification. Researchers reviewed data from 8947 trauma patients treated between 2011 and 2022 and evaluated the hospital's readiness for Level I verification.

The assessment identified four major areas needing improvement: the number of severely injured patients treated, the lack of a dedicated Surgical Intensive Care Unit (SICU), the absence of a surgical residency training program, and limited trauma research capacity. In response, the hospital established a dedicated SICU, introduced surgical resident training rotations, and expanded trauma research support.

Over the study period, trauma patients became older, with the proportion of patients aged 65 years and older nearly doubling. Although the overall severity of injuries decreased slightly, patients admitted to intensive care had more severe injuries and required longer hospital stays. The number of patients transferred to other hospitals for higher-level care declined, suggesting that more patients could be treated locally.

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These findings show that targeted investments in infrastructure, workforce development, education, and research can help rural trauma centers achieve higher levels of trauma care while adapting to changing patient needs. The strategies described in this study may help guide other rural hospitals seeking to strengthen trauma services and improve access to advanced trauma care close to home.

Keywords: trauma centers, level I, level II, rural trauma center, gap analysis

Introduction

Trauma centers across the United States form a vital network of comprehensive care designed to meet the needs of patients with traumatic injuries.[1] These centers achieve designations ranging from Level I to Level IV, with Level I indicating the highest standard of trauma care. Designation is based on a facility's ability to provide specific resources and services tailored to the needs of its region and population. In 1987, the American College of Surgeons (ACS) established a verification process to evaluate trauma centers based on their compliance with criteria corresponding to each level of designation.[2] Level I trauma centers are distinguished by their ability to deliver the full continuum of care, from initial resuscitation through rehabilitation, and often serve as regional referral centers.[1]

Geospatial analyses have consistently shown that trauma centers are concentrated in densely populated areas.[3] As a result, patients in sparsely populated states such as Alaska, Montana, Wyoming, and the Dakotas frequently face substantial geographic barriers to accessing trauma care. In these rural regions, definitive trauma care may be located hundreds of miles away, and delays in access are linked to worse clinical outcomes.[4] These challenges are further compounded by environmental and infrastructural factors, such as mountainous terrain, severe weather, and hazardous road conditions, which can impede or prevent timely ground or air transport.[3,5]

Expanding trauma systems in ways that are responsive to local resources and population needs is also crucial, particularly in rural states.[6] In Montana, for example, elderly residents over age 65 and American Indian/Native American populations have reduced access to not only the highest level, but any level of trauma care.[7] Although much of the US population resides within one hour of trauma care, approximately 30 million individuals remain outside this critical access window.[8] Furthermore, patients injured in areas with higher median age, lower per capita income, or greater distance from Level I or II centers have the highest odds of death.[9]

Comparative studies have demonstrated that Level I trauma centers offer improved long-term outcomes, including lower morbidity and mortality, compared to Level II centers.[10–12] These findings highlight the critical importance of ensuring access to the highest levels of trauma care, particularly for patients with complex or severe injuries. Yet, according to Shekhar and Lewis,[13] the three least populated states, Alaska, Montana, and Wyoming, lacked an in-state Level I trauma center. As a result, patients were often transferred out of state to distant Level I trauma centers, typically accessible only via fixed-wing aircraft, with transport times that can exceed two hours. These extended delays can worsen clinical outcomes and place additional emotional and logistical burdens on patients and their families.[14,15]

While outcomes associated with Level I trauma centers have been extensively studied, little literature describes the operational and organizational processes required for rural trauma centers to achieve Level I verification. Most published reports focus on urban academic centers, leaving limited evidence regarding implementation strategies in geographically isolated regions with workforce shortages and lower patient volumes.

During the study period, the trauma population served by this institution was predominantly composed of patients with blunt injuries, reflecting the injury patterns typical of many rural trauma systems.[16] Because injury mechanisms influence resource utilization, critical care requirements, and trauma system planning, understanding how centers serving largely blunt-trauma populations achieve Level I readiness may provide valuable insights for other geographically isolated regions.

Against this backdrop, a rural Level II trauma center in Montana undertook a phased initiative to pursue American College of Surgeons (ACS) Level I trauma verification. Key milestones included surpassing the Injury Severity Score (ISS) volume threshold, establishing a dedicated surgically directed Intensive Care Unit (SICU), launching a surgical residency track, and developing trauma-focused research infrastructure. These efforts occurred alongside evolving patient demographics, including increasing volumes of geriatric trauma, rising intensive care unit (ICU) acuity, and changing transfer patterns.

This study evaluates the organizational, workforce, infrastructure, and clinical system changes associated with a rural trauma center's transition toward ACS Level I verification. By providing a longitudinal perspective on trauma system development in a resource-constrained rural setting, the findings may offer practical implementation strategies for other rural trauma centers seeking to enhance trauma care delivery and achieve higher levels of trauma system maturity.

Materials and Methods

Study Design and Oversight

This was a single-center, retrospective study spanning twelve years prior to American College of Surgeons (ACS) Level I trauma verification. Institutional approval was obtained from the Billings Clinic Institutional Review Board (Privacy and Exemption Committee; Project #24.003). Which determined the study to be exempt under 45 CFR 46.102(l) because only deidentified data was used, the requirement for informed consent was waived. The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki.

Setting and Population

This study was conducted at a rural trauma center located in the Upper Mountain West region, which expanded from 280 beds in 2011 to 305 beds in 2022, and served as a regional referral facility for four states throughout the study period. At the time of the study, the facility was an ACS-verified Level II trauma center. Following implementation of these initiatives and successful external review, the institution achieved ACS Level I trauma center verification in 2023.

Deidentified patient data was obtained from the institution's trauma registry. The trauma registry included all trauma activations meeting institutional registry inclusion criteria, including blunt, penetrating, and burn injuries. A total of 8947 trauma patients from 2011–2022 were included in this study.

Strategic Planning and Implementation Timeline

Initiatives to pursue Level I designation formally began in 2019 through roundtable discussions with key stakeholders. These discussions assessed the current capabilities of the Level II trauma center and led to a structured needs assessment.

Patient volume, particularly the number of cases with ISS $\geq$16, was identified as a preliminary criterion for Level I eligibility. A retrospective review of trauma volumes from 2011–2022 was conducted, with particular focus on the 2019–2022 period to assess recent trends.

As projections suggested that ACS Level I volume thresholds could be met by 2025, a comprehensive gap analysis was performed using the Golden et al (2017) framework.[17] The analysis mapped existing trauma program resources against ACS Resources for Optimal Care of the Injured Patient standards. The process identified four domains requiring development prior to verification, specifically four key areas for improvement (Table 1): (a) patient volumes; (b) a dedicated SICU; (c) a surgical residency training program; and (d) trauma-focused research.

To address these gaps, the trauma program implemented Rolling Action Item Log (RAIL) plans to define objectives, assign responsibilities, and monitor progress toward ACS Level I readiness.

Trauma Program Development Initiatives

In addition to infrastructure development, the trauma program implemented several organizational and clinical process improvements during the study period. These included expansion of trauma performance improvement activities, standardized trauma activation criteria, multidisciplinary trauma review processes, enhanced critical care coverage, and ongoing refinement of transfer and triage protocols. Although the present analysis was not designed to evaluate the independent effects of these initiatives, they likely contributed to overall maturation of the trauma program and improved system readiness for ACS Level I verification.

Table 1 Rural Level I Development Framework: A Gap Analysis of High-Priority Facility Level I Criteria

Identified Level I Gaps	Original State	Target State	Action plan	Outcome Status by Verification
Patient Volumes	Patient volumes were below ACS requirements for a Level I Trauma Center.	"Severely Injured" patients (ISS greater than or equal to 16) will exceed ACS minimums within the given time frame.	(a) Assure all trauma patients are being captured in the registry; implement additional peer-review audits to ensure the ISS is being appropriately captured. (b) Increase outreach to other facilities to educate what is locally available. (c) Assess population and tourism growth.	Met
Surgical ICU	Existing organizational alignment did not distinguish SICU.	SICU structural hierarchy, as defined by the ACS, specific to a rural hospital setting.	(a) Engage stakeholders (Trauma and ICU team members) to create a framework for a definitive SICU. (b) Increase critical care surgeon staffing.	Met
Residency	No existing general surgical residency track.	Established surgical residency track with plans for ongoing and expanded enrollment.	(a) Establish academic relationships with universities interested in offering surgical residency in a rural setting. (b) Add at least one surgical resident PGY4 in rotation.	Met
Research	Trauma system lacked resources dedicated to research.	A minimum of one focused research scientist for project coordination and one nursing resource committed to trauma research.	(a) Generate buy-in from both facility physicians and nurses. (b) Immediately begin research projects, introduce focused research personnel to further increase footprint and output. (c) Focus sparse resources upon those niche areas which can be published.	Met

Abbreviations: ACS, American College of Surgeons; ICU, Intensive Care Unit; ISS, Injury Severity Score; SICU, Surgical Intensive Care Unit; PGY4, Postgraduate Year 4.

Measures

Demographic and clinical data collected included age, sex, and initial ISS, derived from patient charts and trauma flowsheets. Outcomes of interest included in-hospital mortality and length of stay.

Transfer distances were calculated using road mileage to reflect realistic travel barriers, accounting for impassable geographic features.

Statistical Analysis

All analyses were performed using R Studio 4.4.2 (R Foundation for Statistical Computing, Vienna, Austria). Demographic variables were presented by time intervals, stratified into four-time intervals: 2011–2013, 2014–2016, 2017–2019, and 2020–2022. Categorical variables were summarized using percentages, whereas means and 95% confidence intervals were used to summarize continuous variables (means consisting of less than five had variance expressed as ± standard deviation). For categorical variables, proportions were compared using chi-square goodness of fit with correction relative to the 2020–2022 period. One way ANOVA tests were used to compare quantitative variables with a post-hoc Dunnett's multiple comparison test relative to 2020–2022 period. All p values less than 0.05 were considered statistically significant.

Results

Gap Analysis and Implementation Outcomes

A structured gap analysis (Table 1) identified four priority domains: (a) patient volumes, (b) a dedicated Surgical Intensive Care Unit (SICU), (c) a surgical residency program, and (d) trauma-focused research. Each area showed critical deficiencies, prompting targeted interventions.

Patient Volume

Initially, the facility did not meet ACS Level I volume thresholds, specifically 1200 trauma admissions or 240 severely injured patients (ISS ≥16), annually. Interventions involved regional outreach and registry improvements aligned with projected population and tourism growth. By 2023, while total admissions remained below 1200, the facility surpassed the 240 severely injured patient benchmark.

Surgical Intensive Care Unit (SICU)

Previously, trauma and emergent general surgery patients were co-managed without a dedicated SICU. In 2020, a dedicated SICU service was established, staffed by board-certified surgical critical care providers. Initially, night coverage involved Medical ICU (MICU) teams under surgical critical care oversight, later replaced by full SICU staffing with an additional critical care surgeon. Further restructuring included repurposing MICU rooms to support this transition.

Residency Program

The facility lacked a surgical residency program at baseline. A phased development plan established an on-site graduate medical education (GME) team, secured academic partnerships, and completed accreditation steps. In 2021, Postgraduate Year 4 (PGY-4) residents began rotations, and across the next two years six residents participated. Partner institutions have since shown interest in expanding their participation.

Research Infrastructure

Trauma research capacity was originally limited, with minimal staffing and support. Initial efforts included launching focused projects and hiring a research coordinator and a dedicated research nurse. The strategy emphasized high-yield topics to support ACS compliance, with continued success reliant upon physician and nursing engagement.

Demographic Trends

Between 2011 and 2022, 8947 trauma patients were treated, and subsequently divided into four intervals: 2011–2013 (n=1590), 2014–2016 (n=1764), 2017–2019 (n=2155), and 2020–2022 (n=3438) (Table 2).

Patient Demographics

The trauma population aged significantly over time, with mean age rising from 42.6 to 51.8 years ($p<0.0001$). Pediatric cases (≤17 years) declined from 11.8% to 8.6%, while geriatric cases (≥65 years) nearly doubled from 19.8% to 37.1% ($p<0.0001$). Adult cases (18–64 years) decreased proportionally. Female patient cases increased from 33.3% to 41.2% ($p<0.0001$). Racial distribution remained stable, with White patients comprising ~78% throughout the study ($p=0.4692$).

Substance Use

Ethanol use increased from 18.0% to 22.8% ($p<0.0001$), while the average blood alcohol concentration (BAC) among positive patients declined from 208.6 to 168.4 mg/dL ($p<0.0001$).

Clinical Characteristics and Outcomes

Mechanism of Injury

Blunt trauma remained the predominant mechanism of injury throughout the study period, accounting for more than 90% of all admissions without significant temporal change ($p=0.5098$). Penetrating injuries and burns represented only a small proportion of cases but demonstrated modest variation over time (Table 3).

Table 2 Trauma Patient Demographics Across Twelve Years

Mean, [95% Confidence Intervals]	2011–2013	2014–2016	2017–2019	2020–2022	*p* value
N	1590	1764	2155	3438	N/A
Age	42.59[a] [41.5, 43.7]	44.68[a] [43.6, 45.7]	49.57[a] [48.6, 50.6]	51.83 [51.0, 52.7]	<0.0001
Pediatrics (≤17 years old), n (%)	186 (11.8%)[b]	191 (10.8%)[b]	196 (9.1%)[b]	295 (8.6%)	<0.0001
Adults (18–64 years old), n (%)	1092 (68.7%)[b]	1182 (67.0%)[b]	1267 (58.8%)[b]	1867 (54.3%)	<0.0001
Geriatric (≥65 Years old), n (%)	312 (19.8%)[b]	391 (22.2%)[b]	692 (32.1%)[b]	1276 (37.1%)	<0.0001
Sex Female, n (%)	529 (33.3%)[b]	589 (33.4%)[b]	731 (33.9%)[b]	1416 (41.2%)	<0.0001
Injury Severity Score (ISS)	10.40[a] [9.9, 10.9]	11.12[a] [10.7, 11.5]	10.62[a] [10.3, 11.0]	9.72 [9.4, 10.0]	<0.0001
Hospital Length of Stay, Days	4.49[a] [4.2, 4.8]	4.86 [4.6, 5.2]	4.55[a] [4.2, 4.9]	5.11 [4.8, 5.4]	0.0086
Ethanol Use, n (%)	285 (18.0%)[b]	279 (15.8%)[b]	477 (22.2%)[b]	782 (22.8%)	<0.0001
Blood Alcohol Concentration, mg/dL	208.6[a] [197.2, 220.0]	184.6 [171.9, 197.3]	169.4 [158.2, 180.7]	168.4 [159.7, 177.1]	<0.0001
Race					
White, n (%)	1235 (77.7%)	1392 (78.9%)	1717 (79.7%)	2728 (79.3%)	0.4692
American Indian/Native American, n (%)	253 (15.9%)	273 (15.5%)	327 (15.2%)	522 (15.2%)	0.9122
Other, n (%)	102 (6.4%)	99 (5.6%)	111 (5.2%)	188 (5.5%)	0.4014

Notes: Statistical comparisons were made using one-way ANOVA with Dunnett's post-hoc test versus 2020–2022 (significant if $p < 0.05$, bold [a]), and chi-square goodness of fit with correction relative to 2020–2022 for categorical variables (significant if $p < 0.05$, bold [b]).
Abbreviations: N/A, not applicable; N, population sample size; n, category-specific sample size.

Table 3 Trauma Patient Clinical Trends Across Twelve Years

Mean, [95% Confidence Intervals]	2011–2013	2014–2016	2017–2019	2020–2022	*p* value
Mechanism of Injury					
Blunt Force, n (%)	1455 (91.5%)	1616 (91.6%)	1950 (90.5%)	3119 (90.7%)	0.5098
Penetrating, n (%)	116 (7.3%)	123 (7.0%)	124 (5.8%)	251 (7.3%)	0.1285
Burn, n (%)	11 (0.7%)	18 (1.0%)	18 (0.8%)	15 (0.4%)	0.0831
Other, n (%)	2 (0.1%)[b]	3 (0.2%)[b]	28 (1.3%)[b]	36 (1.0%)	0.0005
Unknown/ Not Classified, n (%)	6 (0.4%)[b]	4 (0.2%)[b]	35 (1.6%)[b]	17 (0.5%)	0.0005
Intensive Care Unit (ICU)					
ICU Patients, n (%)	527 (33.1%)[b]	698 (39.6%)[b]	883 (41.0%)[b]	778 (22.6%)	<0.0001
ICU LOS, Days	3.51[a] [3.1, 6.7]	3.92[a] [3.6, 4.3]	3.87[a] [3.6, 4.1]	5.25 [4.7, 5.8]	<0.0001
ICU ISS	17.1 [16.2, 33.3]	15.9[a] [15.2, 16.5]	15.5[a] [14.8, 16.0]	17.9 [17.2, 18.6]	<0.0001
Interfacility Transfer Patients					
n (%)	649 (40.8%)[b]	830 (47.1%)[b]	927 (43.0%)[b]	1351 (39.3%)	<0.0001
Injury to Tertiary Facility Distance, Miles	162.7 [155.3, 170.1]	171.0 [164.4, 177.7]	165.0 [159.1, 170.9]	164.9 [159.8, 170.0]	0.3346
Means of Transport					
Fixed Wing, n (%)	293 (45.1%)[b]	377 (45.4%)[b]	372 (40.1%)[b]	531 (39.3%)	0.0075

(*Continued*)

Table 3 (Continued).

Mean, [95% Confidence Intervals]	2011–2013	2014–2016	2017–2019	2020–2022	*p* value
Rotor Wing, n (%)	63 (9.7%)[b]	139 (16.7%)[b]	164 (17.7%)	204 (15.1%)	<0.0001
Ground Ambulance, n (%)	287 (44.2%)[b]	295 (35.5%)[b]	368 (39.7%)[b]	585 (43.3%)	<0.0001
Other, n (%)	6 (0.9%)	19 (2.3%)	23 (2.5%)	31 (2.3%)	0.1445
Mortality					
Mortality, n (%)	59 (3.7%)	58 (3.3%)	73 (3.39%)	137 (3.98%)	0.5355
Mortality ISS	35.1[a] [29.7, 40.3]	29.4[a] [25.6, 33.2]	24.8 [22.0, 27.6]	22.5 [20.0, 25.1]	<0.0001

Notes: Statistical comparisons were made using one-way ANOVA with Dunnett's post-hoc test versus 2020–2022 (significant if $p < 0.05$, bold [a]), and chi-square goodness of fit with correction relative to 2020–2022 for categorical variables (significant if $p < 0.05$, bold [b]).
Abbreviations: N/A, not applicable; N, population sample size; n, category-specific sample size.

Injury Severity and Outcomes

Mean ISS peaked at 11.12 in 2014–2016, then declined to 9.7 by 2020–2022 ($p<0.0001$). Hospital mortality remained stable throughout the study period (3.3–4.0%, $p=0.5355$). However, the ISS among patients who died declined significantly from 35.1 to 22.5 ($p<0.0001$), coinciding with a significant increase in the elderly trauma population. Hospital length of stay increased from 4.49 to 5.11 days ($p=0.0086$).

ICU admissions peaked at 41.0% in 2017–2019 before declining to 22.6% ($p<0.0001$). ICU length of stay rose to 5.25 days, with ICU patient ISS increasing to 17.9, indicating higher acuity in those admitted.

Transfers and Transport

Interfacility transfer rates peaked at 47.1% in 2014–2016 but fell to 39.3% by 2020–2022 ($p<0.0001$). Transfer distance remained stable (~163-171 miles, $p=0.3346$).

Rotor wing transport increased from 9.7% to 15.1% ($p<0.0001$), while fixed wing use declined from 45.1% to 39.3% ($p=0.0075$). Ground transport showed minor fluctuations, decreasing slightly overall ($p<0.0001$). Other modes of transport remained minimal and stable ($p=0.1445$).

Transfers-Out

Annual transfers-out for higher or more appropriate care, remained stable (~10-13 per year; $p=0.5381$), but the proportion relative to total patients fell significantly from 2.8% to 1.1% ($p=0.0372$), with the sharpest decline between 2017–2019 and 2020–2022 (Figure 1 and Table 4). Despite the fluctuation in raw transfer numbers, transfers out represented a decreasing proportion of total patient volume across all intervals.

Discussion

To our knowledge, this is among the first longitudinal descriptions of organizational, workforce, research, and critical care infrastructure changes associated with ACS Level I verification in a rural trauma center serving a multistate frontier region. This study highlights the strategic transformation of a rural trauma center pursuing ACS-Committee on Trauma (COT) Level I designation.[2] Through structured gap analysis and targeted improvements, measurable progress was achieved in domains specifically identified through an ACS Level I readiness assessment, and the institution subsequently achieved ACS Level I verification in 2023.

Meeting Volume Criteria in a Rural Setting

Though initially below ACS thresholds, the center met the severely injured patient (ISS) ≥16) benchmark by 2023. This was supported by improved ISS data accuracy, registry audits, and regional outreach. Growth in population and tourism[18]

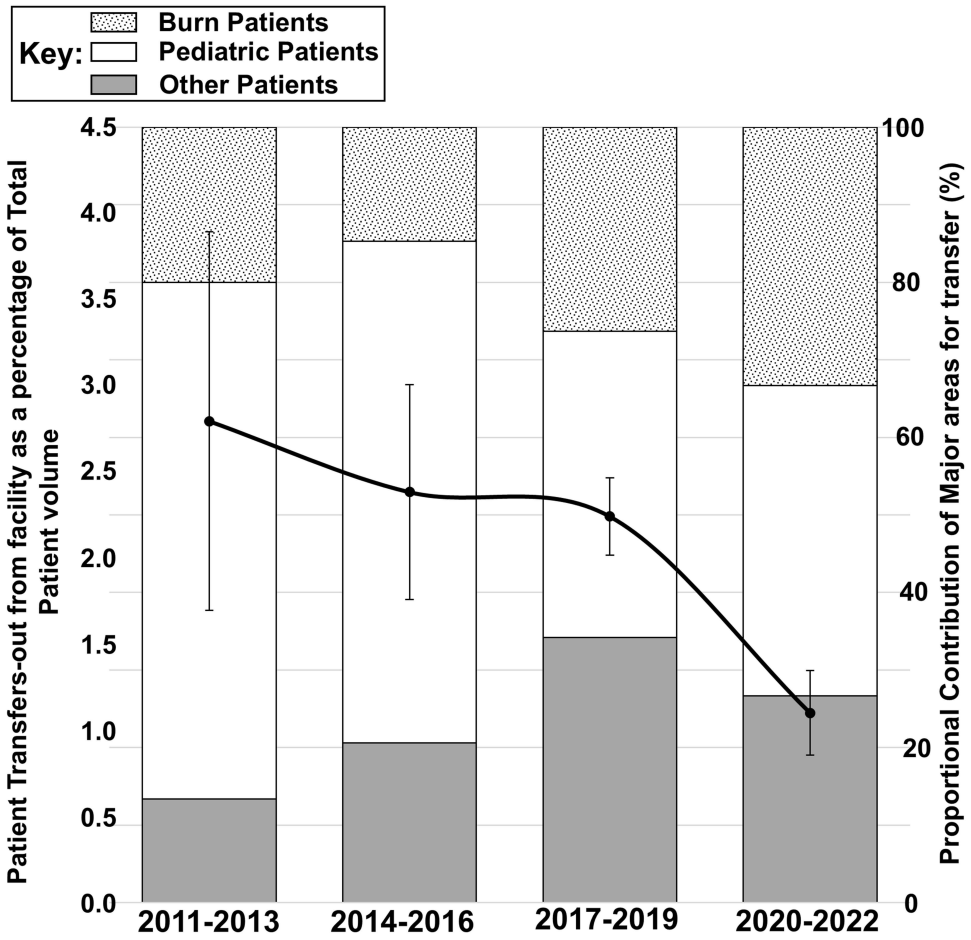

Figure 1 Trauma Patient Transfers Out from the Facility for Higher-level Care and Proportion of Total Trauma Admissions, 2011–2022. Annual percentage of trauma patients transferred out of the facility relative to total trauma admissions and the proportional contribution of the major referral reasons. Error bars are standard deviation.

likely contributed, highlighting that rural centers can align with community trends to meet volume targets without artificial inflation. A declining proportion of transfers-out further indicates enhanced local capacity for high-acuity care.

Development of a Dedicated Surgical ICU

Creation of a dedicated surgeon-directed SICU represented a major organizational change intended to meet ACS standards and expand local critical care capability.[19] Transitioning from MICU night coverage to consistent trauma-led staffing, supported by an additional surgical intensivist, improved management of complex cases. The observed increase in ICU LOS and injury severity demonstrates an increase in complexity, and the restructuring is consistent with findings linking dedicated SICUs to improved outcomes and reduced transfers out from the facility.[20,21]

Table 4 Trauma Patient Transfers Out from the Facility for Higher-Level Care and Proportion of Total Trauma Admissions Across Twelve Years

Mean, (± Standard Deviation)	2011–2013	2014–2016	2017–2019	2020–2022	*p* value
Mean Patient Transfers-out per Annum	10.0 (±3.56)	11.3 (±3.30)	12.7 (±0.47)	10.0 (±2.45)	*0.5381*
% Patient Transfers-out/ Total Patients	2.8% (±1.09)	2.4% (±0.62)	2.2% [a] (±0.22)	1.1% (±0.25)	0.0372

Notes: Statistical comparisons were performed using Welch's one-way ANOVA with Dunnett's T3 post hoc testing, using the 2020–2022 interval as the reference. Statistical significance was defined as $p < 0.05$ (significant comparisons indicated in bold [a]).
Abbreviation: ±, plus or minus.

Building a Rural Academic Pipeline

Launching a surgical residency track marked a major advance, integrating PGY-4 residents into trauma care and laying groundwork for program expansion. GME leadership and academic partnerships enabled this transition. Prior studies have shown that resident involvement can enhance clinical outcomes[22] and support long-term recruitment in underserved areas.[23] In our residency track, although the program duration was limited, 66.7% of graduates are currently practicing as general surgeons, and 33.3% are localized to rural states. These findings suggest that rural centers can successfully develop and sustain training programs through phased implementation and also strong institutional support.

Laying the Foundation for Trauma Research

Establishing a trauma research program remains a challenge, especially in rural settings where infrastructure is limited. Embedding researchers within rural communities and fostering relationships with both patients and healthcare providers has demonstrated long-term benefits.[24] Early project initiation and strategic recruitment of research staff have laid a foundation for sustained scholarly output, in line with ACS Level I expectations. Continued clinician and nursing engagement will be essential to maintain momentum,[25] particularly given the workload-academic balance, issues common in rural systems.[26] However, rural trauma care is an under-researched field, making it an ideal area of focus for the institution to develop expertise and produce publications.

Collectively, these initiatives addressed the principal organizational deficiencies identified during the initial ACS readiness GAP assessment and culminated in successful ACS Level I verification following external review in 2023.

Shifting Demographics and Injury Patterns

The trauma population served by this facility has aged significantly over the past decade, mirroring national trends.[27] Geriatric patients now account for over one-third of trauma admissions, necessitating tailored clinical pathways for injury prevention, ICU management, and rehabilitation.[28] Simultaneously, pediatric trauma declined, suggesting a need to reassess pediatric-specific readiness in a center increasingly focused on adult and elderly populations. The rise in ethanol prevalence, despite declining mean BAC levels, may indicate a broader public health concern around alcohol use and injury risk, albeit at a lower severity.

While mean ISS and mortality-associated ISS declined, mortality rates remained stable This apparent paradox may reflect increased mortality in less severely injured elderly patients, improved triage, earlier interventions,[29] or shifts in case mix[30] rather than changes in trauma severity alone. Notably, ICU admission rates decreased in recent years, yet those admitted had significantly higher acuity, as evidenced by rising ISS and ICU length of stay. This suggests more targeted ICU utilization, consistent with maturing trauma systems.[29]

Clinical Implications of Injury Patterns

Throughout the study period, blunt trauma consistently accounted for more than 90% of injuries, reflecting the epidemiology of trauma in rural and frontier regions. Unlike many urban Level I trauma centers, where penetrating trauma represents a larger proportion of major injuries, the institution primarily manages injuries resulting from motor vehicle collisions, falls, agricultural accidents, and recreational trauma. This injury profile has important implications for trauma system development because blunt trauma frequently requires prolonged multidisciplinary management, advanced imaging, orthopedic and neurosurgical expertise, critical care, and rehabilitation rather than immediate operative hemorrhage control. Accordingly, the predominance of blunt trauma likely shaped the resources required for Level I readiness, supporting investments in surgeon-directed critical care, multidisciplinary ICU services, specialty coverage, and coordinated rehabilitation pathways.

The progressive aging of the trauma population likely contributed to the observed decline in mortality-associated ISS. Elderly patients often experience substantial morbidity and mortality following injuries that would be considered moderate in younger adults because of frailty, anticoagulant use, and multiple comorbidities.[27]

Burn injuries represented only a small proportion of trauma activations and therefore had minimal influence on overall trauma system planning. Nevertheless, inclusion of burn patients within the registry reflects the comprehensive regional role of the institution and underscores the importance of maintaining transfer relationships with specialized burn

centers when appropriate. Consequently, trauma centers serving rural populations should anticipate increasing demand for geriatric-specific trauma pathways, multidisciplinary rehabilitation, and critical care expertise.

These findings suggest that rural Level I trauma readiness extends beyond meeting ACS verification criteria and must also incorporate clinical resources tailored to the predominant injury mechanisms and demographic characteristics of the population served.

Evolving Transport and Transfer Patterns

Transport modalities evolved substantially, with increased rotor wing utilization and declining fixed-wing use. These patterns reflect improved prehospital coordination, weather-related access patterns, and/or cost considerations. The consistent distance between injury and definitive care over time affirms the regional role of the facility within a large rural catchment area.

The reduction in transfers-out may reflect increasing institutional readiness and expanding local treatment capacity, although this observational study cannot determine whether the decline resulted directly from Level I preparation activities or other concurrent organizational changes. As trauma centers mature, reduced reliance on tertiary referrals has been associated with higher system efficiency and reduced time to definitive care.[31]

Implications for Other Rural Trauma Centers

The findings of this study have important implications for rural trauma centers seeking to expand capabilities and pursue higher levels of trauma verification. Achieving Level I trauma center requirements in rural settings appears feasible through deliberate system development, robust trauma registry practices, and strategic alignment with regional population and referral trends. Investments in dedicated, surgeon-directed critical care infrastructure may enhance a center's ability to manage increasingly complex trauma patients locally, reducing reliance on tertiary referrals and improving access to definitive care. Similarly, development of rural graduate medical education programs may provide a sustainable workforce strategy by strengthening recruitment pipelines and promoting retention of surgeons in underserved regions. Establishing trauma research capacity, through incremental investments in personnel and infrastructure, can support verification requirements while generating evidence relevant to rural populations that remain underrepresented in trauma research. Furthermore, reductions in transfers-out and evolving transport patterns suggest that strengthening regional coordination and transfer networks may improve system efficiency and local treatment capacity across large geographic catchment areas.

These findings should be interpreted within the broader context of substantial advances in trauma care that occurred nationally during the study period.[32] Improvements in trauma resuscitation,[33] critical care, imaging technology, prehospital triage,[34] geriatric trauma management,[35] and regional trauma system development likely influenced patient outcomes independent of institutional efforts toward Level I verification. Consequently, observed changes in patient characteristics, transfer patterns, ICU utilization, and clinical outcomes cannot be attributed solely to local initiatives. Rather, this study describes how a rural trauma center adapted to and leveraged evolving best practices while pursuing system maturation. Collectively, the findings suggest that rural trauma centers can successfully advance toward higher levels of trauma system maturity through phased, data-driven investments in clinical infrastructure, workforce development, research capacity, and regional partnerships, while simultaneously incorporating broader innovations in trauma care delivery.

Strengths

This study has several notable strengths. First, it provides a longitudinal 12-year evaluation of trauma system development preceding ACS Level I verification, allowing assessment of organizational and clinical trends over an extended period. Second, the study examines a rural trauma center serving a large multistate frontier region, a setting that is underrepresented in trauma literature. Third, the analysis incorporates multiple domains of trauma center maturation, including workforce development, critical care infrastructure, research capacity, patient demographics, and transfer patterns, providing a comprehensive view of Level I readiness. Finally, the use of a prospectively maintained trauma

registry allowed evaluation of nearly 9000 trauma patients and facilitated objective assessment of changes occurring during the center's progression toward ACS Level I verification.

Future Studies

Future multicenter studies are needed to evaluate whether the developmental framework described in this study can be successfully replicated in other rural and frontier trauma centers. Comparative investigations examining centers that achieve Level I verification versus those that do not, may help identify the most influential organizational, workforce, and infrastructure factors associated with successful advancement. In addition, cost-effectiveness analyses are needed to better understand the financial investment required for rural trauma system maturation.

Limitations

Several limitations must be acknowledged. First, this is a single-center retrospective analysis, limiting generalizability. Second, ISS calculations and registry data are inherently subject to variation, despite audit safeguards. Third, some metrics of trauma center readiness, such as timeliness of subspecialty response, quality of multidisciplinary care, and educational outcomes, were not captured in this dataset. Fourth, we were unable to account for secular changes in trauma care practices occurring nationally during the study period, and therefore causal attribution of observed trends to Level I preparation activities alone cannot be established. Lastly, while progress toward Level I designation is evident, the long-term sustainability of these gains remains to be evaluated. Because this was an observational single-center study without a contemporaneous comparison group, causality cannot be inferred. Multiple institutional developments occurred concurrently, including hospital expansion, workforce growth, critical care restructuring, educational program development, and trauma system maturation. Consequently, it is not possible to determine the relative contribution of ACS Level I preparation activities versus other organizational changes to the observed trends. The findings should therefore be interpreted as associations occurring during the center's transition rather than direct effects of designation-related initiatives.

Conclusion

The observed changes in patient demographics, transfer patterns, ICU utilization, and institutional capabilities occurred concurrently with the center's progression toward ACS Level I verification and illustrate the complexity of trauma system development in rural settings. Major organizational developments included surpassing the ISS volume threshold, establishing a dedicated SICU service, launching a surgical residency track, and initiating trauma research infrastructure. These developments occurred alongside important clinical changes within the trauma population, including a growing proportion of geriatric patients, persistent predominance of blunt trauma, increasing injury severity among ICU patients, and evolving transport and transfer patterns. Together, these findings demonstrate that successful trauma system maturation in rural settings requires both organizational development and adaptation to changing clinical demands. This study provides a longitudinal perspective on a rural trauma center advancing its system despite aging populations and limited resources, while offering a replicable roadmap for other rural institutions seeking to enhance trauma care within the challenges of rural healthcare.

Disclosure

All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. All the authors declare that there is no conflict of interest in this work.

References

1. Southern AP, Celik DH. EMS, trauma center designation. In: *StatPearls*. StatPearls Publishing. Copyright © 2023, StatPearls Publishing LLC; 2023.
2. American College of Surgeons. *Resources for Optimal Care of the Injured Patient*. Vol. 6. American College of Surgeons; 2014.
3. Brown JB, Rosengart MR, Billiar TR, Peitzman AB, Sperry JL. Geographic distribution of trauma centers and injury-related mortality in the United States. *J Trauma Acute Care Surg*. 2016;80(1):42–9; discussion49–50. doi:10.1097/ta.0000000000000902
4. Jarman MP, Castillo RC, Carlini AR, Kodadek LM, Haider AH. Rural risk: geographic disparities in trauma mortality. *Surgery*. 2016;160 (6):1551–1559. doi:10.1016/j.surg.2016.06.020

5. Fleet R, Lauzier F, Tounkara FK, et al. Profile of trauma mortality and trauma care resources at rural emergency departments and urban trauma centres in Quebec: a population-based, retrospective cohort study. *BMJ Open*. 2019;9(6):e028512. doi:10.1136/bmjopen-2018-028512
6. Morgan JM, Calleja P. Emergency trauma care in rural and remote settings: challenges and patient outcomes. *Int Emerg Nurs*. 2020;51:100880. doi:10.1016/j.ienj.2020.100880
7. Stamey HM, Meyers KR, Fordham JT, Young KJ, Ott RL, Spilman SK. Access to trauma care in a rural state: a descriptive geographic and demographic analysis. *J Emerg Med*. 2024;66(1):e20–e26. doi:10.1016/j.jemermed.2023.08.011
8. Carr BG, Bowman AJ, Wolff CS, et al. Disparities in access to trauma care in the United States: a population-based analysis. *Injury*. 2017;48 (2):332–338. doi:10.1016/j.injury.2017.01.008
9. Jarman MP, Curriero FC, Haut ER, Pollack Porter K, Castillo RC. Associations of distance to trauma care, community income, and neighborhood median age with rates of injury mortality. *JAMA Surgery*. 2018;153(6):535–543. doi:10.1001/jamasurg.2017.6133
10. McConnell KJ, Newgard CD, Mullins RJ, Arthur M, Hedges JR. Mortality benefit of transfer to level I versus level II trauma centers for head-injured patients. *Health Serv Res*. 2005;40(2):435–457. doi:10.1111/j.1475-6773.2005.00366.x
11. Sewalt CA, Gravesteijn BY, Nieboer D, Steyerberg EW, Den Hartog D, Van Klaveren D. Identifying trauma patients with benefit from direct transportation to Level-1 trauma centers. *BMC Emerg Med*. 2021;21(1):93. doi:10.1186/s12873-021-00487-3
12. Van Ditshuizen JC, Van Den Driessche CRL, Sewalt CA, Van Lieshout EMM, Verhofstad MHJ, Den Hartog D. The association between level of trauma care and clinical outcome measures: a systematic review and meta-analysis. *J Trauma Acute Care Surg*. 2020;89(4):801–812. doi:10.1097/ta.0000000000002850
13. Shekhar AC, Lewis BA. State-level variability in the number of level 1 trauma centers per capita in the United States. *Ann Emerg Med*. 2023;82 (4):530–531. doi:10.1016/j.annemergmed.2023.05.006
14. Burns M, Bally J, Burles M, Peacock S. Critically ill patients: family experiences of interfacility transfers from rural to urban centers and impact on family relationships. *J Fam Nurs*. 2023;29(1):74–88. doi:10.1177/10748407221124254
15. Kulnik ST, Wulf AK, Brunker C. Experiences of long-distance visitors to intensive care units at a regional major trauma centre in the United Kingdom: a cross-sectional survey. *Intensive Crit Care Nurs*. 2019;55:102754. doi:10.1016/j.iccn.2019.102754
16. Lipsky AM, Karsteadt LL, Gausche-Hill M, et al. A comparison of rural versus urban trauma care. *J Emerg Trauma Shock*. 2014;7(1):41–46. doi:10.4103/0974-2700.125639
17. Golden SH, Hager D, Gould LJ, Mathioudakis N, Pronovost PJ. A gap analysis needs assessment tool to drive a care delivery and research agenda for integration of care and sharing of best practices across a health system. *Jt Comm J Qual Patient Saf*. 2017;43(1):18–28. doi:10.1016/j.jcjq.2016.10.004
18. Bureau of Business & Economic Research. 2023 montana economic report - analysis and assessment of montana's economic performance. report. *Mont Bus Q*. 2022;60:60.
19. Savel RH, Cohen W, Borgia D, Simon RJ. The intensive care unit perspective of becoming a level i trauma center: challenges of strategy, leadership, and operations management. *J Emerg Trauma Shock*. 2018;11(1):65–70. doi:10.4103/jets.Jets_9_17
20. Wagner J, Iwashyna TJ, Kahn JM. Reasons underlying interhospital transfers to an academic medical intensive care unit. *J Crit Care*. 2013;28 (2):202–208. doi:10.1016/j.jcrc.2012.07.027
21. Yoon HJ. The effect of nurse staffing on patient outcomes in acute care hospitals in Korea. *Int J Environ Res Public Health*. 2022;19(23):15566. doi:10.3390/ijerph192315566
22. Bacchus R, Levy D, Hickey C, Arrillaga A, Raio C. General surgery residents improve efficiency but not hospital length of stay in trauma care. *Cureus*. 2024;16(1):e52499. doi:10.7759/cureus.52499
23. MacQueen IT, Maggard-Gibbons M, Capra G, et al. Recruiting rural healthcare providers today: a systematic review of training program success and determinants of geographic choices. *J Gen Int Med*. 2018;33(2):191–199. doi:10.1007/s11606-017-4210-z
24. Wong Shee A, Quilliam C, Corboy D, et al. What shapes research and research capacity building in rural health services? Context matters. *Aust J Rural Health*. 2022;30(3):410–421. doi:10.1111/ajr.12852
25. Schmidt D, Webster E, Lyle D. Mechanisms to build research capacity in the rural health workplace: a realist synthesis. *Front Med*. 2025;12:1584904. doi:10.3389/fmed.2025.1584904
26. Miskimins R, Pati S, Schreiber M. Barriers to clinical research in trauma. *Transfusion*. 2019;59(S1):846–853. doi:10.1111/trf.15097
27. Southern AP, Lopez RA, Patel PJ, Jwayyed S. Assessment and management of traumatic injuries in older adults. In: *StatPearls*. StatPearls Publishing; 2024.
28. Lundy ME, Zhang B, Ditillo M. Management of the geriatric trauma patient. *Surg Clin North Am*. 2024;104(2):423–436. doi:10.1016/j.suc.2023.09.010
29. Alharbi RJ, Shrestha S, Lewis V, Miller C. The effectiveness of trauma care systems at different stages of development in reducing mortality: a systematic review and meta-analysis. *World J Emerg Surg*. 2021;16(1):38. doi:10.1186/s13017-021-00381-0
30. Glance LG, Osler T, Shinozaki T. Effect of varying the case mix on the standardized mortality ratio and W statistic: a simulation study. *Chest*. 2000;117(4):1112–1117. doi:10.1378/chest.117.4.1112
31. Peitzman AB, Courcoulas AP, Stinson C, Udekwu AO, Billiar TR, Harbrecht BG. Trauma center maturation: quantification of process and outcome. *Ann Surg*. 1999;230(1):87–94. doi:10.1097/00000658-199907000-00013
32. Schmitt J, Gurney J, Aries P, Danguy Des Deserts M. Advances in trauma care to save lives from traumatic injury: a narrative review. *J Trauma Acute Care Surg*. 2023;95(2):285–292. doi:10.1097/ta.0000000000003960
33. Lulic I, Mesquita C, Lulic D, et al. Strengthening trauma resuscitation education and training in low-resource settings: a call for global inclusion. *Resusc Plus*. 2025;23:100935. doi:10.1016/j.resplu.2025.100935
34. Lokerman RD, van Rein EAJ, Waalwijk JF, et al. Accuracy of prehospital triage of adult patients with traumatic injuries following implementation of a trauma triage intervention. *JAMA Netw Open*. 2023;6(4):e236805. doi:10.1001/jamanetworkopen.2023.6805
35. Ringen AH, Gaski IA, Rustad H, Skaga NO, Gaarder C, Naess PA. Improvement in geriatric trauma outcomes in an evolving trauma system. *Trauma Surg Acute Care Open*. 2019;4(1):e000282. doi:10.1136/tsaco-2018-000282