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Original Research

Under-Triage of Pediatric Agricultural Trauma: A 23-Year Rural Cohort Analysis

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Background: Pediatric agricultural injuries pose a significant challenge to trauma systems, particularly in settings where pediatric trauma expertise is limited. Under triage, failure to activate an appropriate trauma or medical response can delay escalation of care and adversely affect outcomes. Existing triage algorithms may not fully account for the injury patterns and physiologic presentation of pediatric farm-related trauma.

Objective: To evaluate the prevalence of under triage and associated clinical outcomes among pediatric agricultural trauma patients using the Cribari Matrix Method (CMM) and the Need for Trauma Intervention (NFTI) algorithm.

Methods: This retrospective cohort study examined 133 pediatric agricultural trauma patients admitted to a Level II pediatric trauma center between 2000 and 2023. Under triage was defined by CMM or NFTI criteria. Outcomes included injury severity, ICU admission, hospital length of stay, discharge disposition, and in-hospital mortality. Comparisons were performed using the Wilcoxon rank-sum and chi-square tests.

Results: Under triage occurred in 18% of cases. Under-triaged patients were younger (median 5.3 vs. 7.5 years) and had higher injury severity scores (median ISS 17 vs. 9; $P<0.01$), with more severe head (AIS 3.8 vs. 2.1) and abdominal injuries (AIS 3.2 vs. 1.5). Under-triaged patients were more often admitted directly to the ICU. Mortality among cases presenting to the trauma center was 3.7%.

Conclusions: A clinically meaningful proportion of pediatric agricultural trauma patients were under-triaged despite substantial injury severity. These findings highlight a discordance between injury burden and initial triage classification and underscore the need for triage protocols that adequately address pediatric farm-related injuries.

Keywords: Agricultural injury; Injury severity; Pediatric trauma; Rural health; Trauma systems; Under triage

Pediatric trauma triage remains a critical component of emergency care, especially in rural areas where access to pediatric trauma specialists and resources is limited. Among pediatric injury groups, agricultural trauma is a unique and often overlooked cause of illness and death. Agricultural injuries in children frequently involve high-energy mechanisms such as machinery entrapment, animal-related trauma, falls from heights, and farm vehicle accidents. Children in or visiting agricultural settings are often exposed to occupational hazards that surpass their developmental and physical abilities, increasing their risk of serious injury and death.[1,2]

International surveillance data consistently show agricultural environments remain among the most dangerous settings for children, despite long-standing injury-prevention and

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occupational-safety efforts. In Australia and Canada, national injury surveillance programs have documented ongoing pediatric farm injuries and fatalities over many decades, especially among younger children and teenagers exposed to machinery and livestock.[3,4] These efforts have mainly focused on surveillance and injury details rather than enforcement-driven safety regulations for children, and they do not seem to have significantly reduced injury risks at the population level.

Accurate trauma triage is crucial for providing timely access to definitive care for injured children. Under-triage, defined as failing to activate an appropriate trauma response for patients with serious injuries, has been linked to delays in surgical intervention, higher intensive care unit utilization, and longer hospital stays.[5–7] Pediatric patients are especially vulnerable to under-triage, because physiological responses to injury vary with age and may be less obvious than in adults. National and international studies have shown that commonly used trauma triage criteria often perform poorly in pediatric populations, particularly in cases involving blunt trauma, falls, and isolated head injuries.[8]

European registry-based studies from the United Kingdom and the Netherlands have reported pediatric under-triage rates exceeding 15%–20%, with younger age, low-energy mechanisms, and isolated head trauma identified as common risk factors.[9,10] Similar findings have been reported in analyses of the United States trauma system using the National Trauma Data Bank and the Trauma Quality Improvement Program, in which pediatric under-triage rates vary widely depending on trauma center level, activation criteria, and geographic location.[11–13] Under-triage rates are consistently higher in rural and lower-level trauma systems, where pediatric-specific experience and access to specialized resources may be limited.

Despite this increasing body of research, there is still a lack of data specifically addressing under-triage in pediatric agricultural trauma. Farm-related injuries are often underrepresented in national trauma benchmarking because of their relatively low frequency, rural location, and concentration within specific demographic groups. However, previous studies have shown that pediatric agricultural injuries tend to have higher injury severity, higher rates of intensive care unit admissions, and a greater risk of long-term functional impairment compared with non-agricultural pediatric trauma.[14–16]

In a recent United States propensity-matched analysis, children injured in farm-related incidents experienced significantly higher intensive care unit utilization and longer recovery times than children with non-farm injuries, even after adjustment for injury mechanism and injury severity score.[16] These findings suggest the agricultural context itself may confer additional risk that is not adequately captured by existing triage criteria.

Objective

This study aimed to fill a gap by examining how often pediatric agricultural trauma patients are under-triaged and their clinical outcomes at a rural trauma center over 23 years. Instead of assuming that existing triage systems correctly assess injury severity in children, we used two validated trauma benchmarking tools, the Cribari Matrix Method and the Need for Trauma Intervention algorithm, to check if severely injured children were properly identified during initial care.[17,18] By analyzing injury severity, intensive care unit use, and discharge results, this research seeks to help improve pediatric trauma triage practices in rural and agricultural areas.

Methods

Study Design and Data Source

This was a single-center, retrospective cohort study using data from the institutional trauma registry covering a 23-year period from January 1, 2000, to December 31, 2023. The study was conducted at a rural American College of Surgeons Verified Level II pediatric trauma center located in the upper north-central United States. It serves a primarily rural catchment area of more than 95 miles and handles approximately 1,200 trauma activations annually, including both adult and pediatric cases. Pediatric trauma patients account for approximately 10% of activations annually.

The study was deemed exempt from Institutional Review Board oversight under institutional policies governing retrospective analyses of existing trauma registry data collected for trauma system performance evaluation and quality improvement (IRB ID: RHO10124). Although the trauma registry contains protected health information, all analyses were performed on de-identified data within a secure institutional environment, and no data were extracted or shared outside the institution.

The trauma registry is maintained following the American College of Surgeons National Trauma Data Standard and supplies data to the National Trauma Data Bank. All data elements are collected from the electronic medical record by trained trauma registrars using standard American College of Surgeons definitions and abstraction rules. The registry data undergoes regular internal quality checks, including inter-rater reliability assessments and abstraction audits, as well as external validation through participation in the American College of Surgeons Trauma Quality Improvement Program.

Study Population and Eligibility Criteria

Pediatric patients were defined as those under 18 years-of-age. Patients were included if they were admitted to the trauma center between January 1, 2000, and December 31, 2023, and had an International Classification of Diseases-9 or International Classification of Diseases-10 external cause of injury location code indicating an agricultural or farm-related

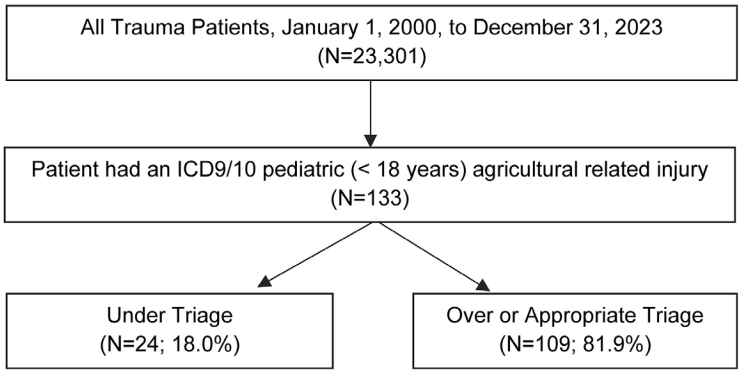

Figure 1. Participant Flow Diagram of Pediatric Agricultural Trauma Cases, 2000–2023.

Footnote: Pediatric agricultural trauma cases were identified using ICD-9-CM and ICD-10-CM external cause location codes indicating injury on a farm or agricultural property. Inclusion criteria were: ICD-9-CM code E849.1 (farm as place of occurrence), and ICD-10-CM codes Y92.7x (farm, ranch, or related non-institutional place as place of occurrence of the external cause). Patients were included if they were under 18 years of age and met trauma registry inclusion at the time of admission.

setting. Agricultural injury cases were identified using International Classification of Diseases, Ninth Revision and International Classification of Diseases, Tenth Revision external cause of injury location codes documented in the trauma registry. For encounters occurring prior to October 1, 2015, International Classification of Diseases, Ninth Revision external cause of injury codes indicating place of occurrence on a farm were used, including E849.1 (place of occurrence: farm). For encounters occurring on or after October 1, 2015, International Classification of Diseases, Tenth Revision external cause of injury location codes were applied, including Y92.7 (farm), and Y92.79 (other specified farm locations). Cases were initially identified through the electronic medical record and confirmed via trauma registry matching. Only admitted trauma patients are entered into the trauma registry per the American College of Surgeons inclusion criteria, and outpatient-treated patients were not included. See Figure 1 for case identification criteria.

Triage Classification

Patients were stratified into two groups: (1) under-triaged and (2) over or appropriately triaged**.** Under-triage status was determined using two validated trauma system benchmarking tools:

- The Cribari Matrix Method, which identifies under-triage based on injury severity score ≥16 in the absence of trauma team activation
- The Need for Trauma Intervention algorithm, which flags under-triage based on the need for one or more major trauma interventions, such as emergent surgery, transfusion within four hours, intensive care unit admission, mechanical ventilation, or in-hospital mortality

Patients were classified as under-triaged if they met under-triage criteria in either the Cribari Matrix Method or the Need for Trauma Intervention algorithm. Both tools are endorsed by national trauma quality programs and widely used for benchmarking triage accuracy.

Variables and Outcomes of Interest

Patient-level variables collected from the trauma registry included demographics (age, sex, insurance status, transfer status, method of transportation), prehospital and arrival physiology (Glasgow Coma Scale), injury characteristics (mechanism, Injury Severity Score, Abbreviated Injury Score by body region), and hospital course variables. Hospital outcomes encompassed emergency department length of stay, intensive care unit admission and intensive care unit length of stay, total hospital length of stay, discharge disposition, and in-hospital mortality. The method of transportation could include rendezvous, an enhanced dispatch protocol between an initial emergency medical contact and a handover to a typically higher-level emergency medical contact. Retraumatization was also calculated as a subsequent trauma center presentation during the study period, confirmed by unique patient identifiers and matched trauma records.

All variables were defined and categorized in accordance with the American College of Surgeons National Trauma Data Standard specifications, ensuring standardized data collection throughout the study period. Variables with incomplete documentation, especially certain prehospital elements, were analyzed descriptively with denominators reported where applicable.

Statistical Analysis

The analyses were descriptive and comparative. Continuous variables were summarized using means with standard deviations or medians with interquartile ranges, as appropriate. Group comparisons between under-triaged and appropriately triaged patients were performed using the Wilcoxon rank-sum test for continuous variables and Pearson's chi-square test for categorical variables. The analysis was designed to describe patterns of under-triage and compare associated injury severity and hospital course outcomes. Given the limited sample size and low event rate, no multivariable modeling or causal inference was attempted. A two-sided P value < 0.05 was considered statistically significant. Analyses were performed using R version 4.4.1 (R Core Team, 2023).

Results

Sample Description and Triage Distribution

A total of 23,301 trauma patients were recorded in the institutional registry from January 1, 2000, through December 31, 2023. Of these, 133 pediatric patients (<18 years) sustained injuries classified as agricultural-related based on ICD-9/10 external cause codes, representing 0.5% of all trauma encounters. Among this cohort, 24 patients (18.0%) were classified as under-triaged according to either the Cribari Matrix Method or the Need for Trauma Intervention algorithm.

The median age of the overall sample was 7 years (IQR: 4–13), and the majority were male (79.6%). The most common mechanism of injury was fall-related (30.8%), and nearly half of the patients (45.1%) were initially activated as an adult Level II trauma response. This is in line with national standards to categorize children who are ≥15 years of age under the adult trauma schema per National Trauma Data Bank and Trauma Quality Improvement Program conventions. Most children arrived via walk-in or private vehicle (43.6%), followed by rendezvous intercept (24.8%) and ground emergency medical services (26.3%) (Table 1).

The median Injury Severity Score was 9 (IQR: 6–13), and the mean arrival Glasgow Coma Scale score was 13.9 (SD: 3.1), indicating predominantly mild traumatic brain injuries (Table 2). The median hospital length of stay was 2 days (IQR: 1–3) with intensive care unit admission in 63.9% of cases (n=85) and a median intensive care unit stay of 2 days (IQR: 1–3) among patients admitted to either pediatric or adult intensive care unit settings, depending on patient age (Table 3). Most patients were discharged home without services (90.9%), and in-hospital mortality was low (3.8%).

Table 1. Demographic Characteristics of Pediatric Agricultural Trauma Patients by Triage Status (2000–2023)

	Total (N=133)	Under Triage (N=24; 18.0%)	Over or Appropriate Triage (N=109; 81.9%)	*P* value
Demographics				
Age (N=132, 99.2%; Median, IQR)	7 (4–13)	5 (3–9)	8 (4–13)	0.17
Male Sex (N, %)	106 (79.6%)	18 (75.0%)	88 (80.7%)	0.72
Insurance				
Amish/Mennonite (N, %)	6 (4.5%)	0 (0%)	6 (5.5%)	–
Medicaid (N, %)	17 (12.7%)	5 (20.8%)	12 (11.0%)	0.33
Private/Commercial (N, %)	27 (20.3%)	4 (16.7%)	23 (21.1%)	0.79
Self-Pay (N, %)	36 (27.1%)	6 (25.0%)	30 (27.5%)	0.96
Transferred In (Yes)	45 (33.8%)	7 (29.2%)	38 (34.9%)	0.31
Mode of Transportation				
Ground (N, %)	35 (26.3%)	7 (29.2%)	28 (25.7%)	0.81
Helicopter (N, %)	4 (3.0%)	0 (0%)	4 (3.7%)	–
Walk-In/Private Vehicle (N, %)	58 (43.6%)	10 (41.7%)	48 (44.0%)	1.00
Rendezvous (N, %)	33 (24.8%)	5 (20.8%)	28 (25.7%)	<0.01
Care Level of Initial EMS				
Advanced Life Support (N, %)	6 (4.5%)	0 (0%)	6 (5.5%)	–
Basic Intermediate (N, %)	15 (11.3%)	2 (8.3%)	13 (11.9%)	–
Basic Life Support (N, %)	1 (0.8%)	1 (4.2%)	0 (0%)	–
Critical Care Transport	3 (2.3%)	0 (0%)	3 (2.8%)	–
Blank	108 (81.2%)	21 (87.5%)	87 (79.8%)	–
Under Triage				
CMM (Under Triage)	19 (14.3%)	—	—	—
NFTI (Under Triage)	6 (4.5%)	—	—	—

Abbreviations: IQR = interquartile range; SD = standard deviation; EMS = emergency medical services; CMM = Cribari Matrix Method; NFTI = Need for Trauma Intervention.

Missing data: Age (n=1 missing); EMS care level (not documented in 81.2%).

Values are presented as n (%), median (IQR), or mean (SD) where appropriate.

Table 2. Injury Characteristics of Pediatric Agricultural Trauma Patients by Triage Status (2000–2023)

	Total (N=133)	Under Triage (N=24; 18.0%)	Over or Appropriate Triage (N=109; 81.9%)	*P* value
Retraumatization (Yes)	48 (36.0%)	7 (29.1%)	41 (37.6%)	0.58
Pre-Hospital				
Initial GCS (N=33, 24.8%; Mean, SD)	11.8 (4.7)	9.7 (5.3)	12.6 (4.4)	0.06
On Arrival				
GCS (N=108, 81.2%; Mean, SD)	13.9 (3.1)	14.6 (1.6)	13.7 (3.5)	0.31
Injury Severity Score (N=131, 98.4%; Median, IQR)	9 (4–13)	17 (15–18)	9 (6–12)	<0.01
AIS Body Regions Scores				
Head (N=44, 33.0%; Mean, SD)	2.4 (1.2)	3.8 (0.6)	2.1 (1.1)	<0.01
Thorax (N=34, 25.5%; Mean, SD)	2.2 (1.1)	2.3 (1.1)	2.1 (1.1)	0.65
Abdomen (N=34, 25.5%; Mean, SD)	2.0 (1.1)	3.2 (1.0)	1.5 (0.8)	<0.01
Activation				
Level I (N, %)	22 (16.5%)	0 (0%)	22 (20.1%)	–
Level II (N, %)	60 (45.1%)	14 (58.3%)	46 (42.2%)	0.22
Trauma Consult (N, %)	22 (16.5%)	5 (20.8%)	17 (15.6%)	0.74
Non-Trauma Service (N, %)	27 (20.3%)	5 (20.8%)	22 (20.2%)	1.00
Injury Type Blunt (N, %)	44 (33.0%)	5 (20.8%)	39 (35.8%)	0.27
Mechanism of Injury				
Agricultural Vehicle (N, %)	9 (6.8%)	3 (12.5%)	6 (5.5%)	0.43
Animal (N, %)	14 (10.5%)	5 (20.8%)	9 (8.3%)	0.15
Assault (N, %)	2 (1.5%)	1 (4.2%)	1 (0.9%)	0.80
ATV (N, %)	2 (1.5%)	0 (0%)	2 (1.8%)	–
Bicycle (N, %)	2 (1.5%)	0 (0%)	2 (1.8%)	–
Caught or Crushed (N, %)	7 (5.3%)	0 (0%)	7 (6.4%)	–
Fall (N, %)	41 (30.8%)	7 (29.2%)	34 (31.2%)	1.00
Machinery (N, %)	31 (23.3%)	4 (16.7%)	27 (24.8%)	0.54
Motorcycle (N, %)	2 (1.5%)	0 (0%)	2 (1.8%)	–
Pedestrian Struck (N, %)	2 (1.5%)	0 (0%)	2 (1.8%)	–
Snowmobile (N, %)	1 (0.8%)	0 (0%)	1 (0.9%)	–
Struck By (N, %)	8 (6.0%)	2 (8.3%)	6 (5.5%)	0.96
Toxic Inhalation (N, %)	1 (0.8%)	1 (4.2%)	0 (0%)	–

Abbreviations: GCS = Glasgow Coma Scale; IQR = interquartile range; SD = standard deviation; AIS = Abbreviated Injury Score.
Denominators are provided for variables with missing data.
Values are presented as n (%), median (IQR), or mean (SD) where appropriate.

Comparative Analysis by Triage Status

Under-triaged patients were younger than appropriately triaged peers (median age: 5 years [IQR: 3–9] vs. 8 years [IQR: 4–13], P=0.17), though this difference did not reach statistical significance. Under-triaged patients were less likely to have been transported via rendezvous intercept (20.8% vs. 25.7%, P<0.01), and more likely to present with higher acuity on several clinical measures.

Specifically, under-triaged patients had significantly higher injury severity score (median 17 [IQR: 15–18] vs. 9 [IQR: 6–12], P<0.01), more severe head injuries (Abbreviated Injury Score: 3.8 [SD: 0.6] vs. 2.1 [SD: 1.1], P<0.01), and more severe abdominal injuries (Abbreviated Injury Score: 3.2 [SD: 1.0] vs. 1.5 [SD: 0.8], P<0.01). Initial Glasgow Coma Scale scores were lower in the under-triage group (mean: 9.7 vs. 12.6), improving to 14.6 on arrival (Table 2).

Table 3. Morbidity and Mortality Characteristics of Pediatric Agricultural Trauma Patients by Triage Status (2000–2023)

	Total (N=133)	Under Triage (N=24; 18.0%)	Over or Appropriate Triage (N=109; 81.9%)	*P* value
ED Length of Stay (N=129, 96.9%; Mean, SD)	0.08 (0.04)	0.07 (0.04)	0.08 (0.05)	0.08
ICU Length of Stay in Days (N=85, 63.9%; Median, IQR)	2 (1–3)	3.1 (6.4)	1.8 (2.3)	0.30
Hospital Length of Stay in Days (N=133; Median, IQR)	2 (1–3)	2 (1–5)	2 (1–3)	0.31
ED Discharge Disposition				
Acute Care Facility (N, %)	2 (1.5%)	0 (0%)	2 (1.8%)	–
Floor (N, %)	5 (3.8%)	0 (0%)	5 (4.6%)	–
Adult Intensive Care Unit (N, %)	2 (1.5%)	0 (0%)	2 (1.8%)	–
Morgue (N, %)	4 (3.0%)	1 (4.2%)	3 (2.8%)	0.53
Operating Room (N, %)	33 (24.8%)	5 (20.8%)	28 (25.7%)	0.89
Pediatric Floor (N, %)	38 (28.6%)	2 (8.3%)	36 (33.0%)	0.03
Pediatric ICU (N, %)	44 (33.1%)	14 (58.3%)	30 (27.5%)	<0.01
Hospital Discharge Disposition				
Acute Care Facility (N, %)	4 (3.0%)	1 (4.2%)	3 (2.8%)	0.55
Home (N, %)	121 (90.9%)	20 (83.3%)	101 (92.6%)	0.22
Home with Services (N, %)	1 (0.8%)	1 (4.2%)	0 (0%)	–
Left AMA (N, %)	1 (0.8%)	1 (4.2%)	0 (0%)	–
Rehab (N, %)	1 (0.8%)	0 (0%)	1 (0.9%)	–
In-Hospital Mortality (Yes) (N, %)	5 (3.8%)	1 (4.2%)	4 (3.7%)	1.00

Abbreviations: IQR = interquartile range; SD = standard deviation; ICU = intensive care unit; OR = operating room; AMA = against medical advice. Denominators are provided for variables with missing data.

Values are presented as n (%), median (IQR), or mean (SD) where appropriate.

Under-triaged patients were significantly more likely to be admitted directly from the emergency department to the pediatric intensive care unit (58.3% vs. 27.5%, $P<0.01$) and less likely to be admitted to a general pediatric floor (8.3% vs. 33.0%, $P=0.03$). Despite these indicators of higher clinical severity, in-hospital mortality did not differ significantly between groups (4.2% vs. 3.7%, $P=1.00$) (Table 3). No multivariable models were constructed due to the small number of under-triaged patients and low event rates for key outcomes such as mortality. All findings reflect descriptive and bivariate statistical comparisons.

Discussion

In this 23-year single-center cohort of pediatric agricultural trauma patients, nearly one in five children met criteria for under-triage. Although the analysis was descriptive, under-triaged patients demonstrated substantially higher injury severity, including elevated injury severity scores and more severe head and abdominal injuries, compared with appropriately triaged peers. These findings reinforce prior evidence that anatomic injury patterns commonly seen in pediatric agricultural trauma may be underestimated during initial triage, particularly when external signs of injury are limited.

Under-triaged children were also significantly more likely to need direct admission to the pediatric intensive care unit. This pattern indicates delayed recognition of injury severity rather than delayed physiologic deterioration, as initial stabilization by emergency medical services seemed effective, with improvement in Glasgow Coma Scale scores from prehospital assessment to hospital arrival. Similar findings have been reported in pediatric trauma studies showing that under-triage more often leads to delayed escalation of care rather than immediate death.[5–7]

Mortality in this group was low and did not differ significantly by triage status. This aligns with existing pediatric trauma research and underscores the limitations of relying on in-hospital mortality alone as a measure of triage effectiveness.

Multiple surveillance and registry-based studies have demonstrated that a substantial proportion of fatal pediatric injuries, particularly in agricultural and rural settings, occur at the scene or prior to hospital arrival and are therefore not captured in hospital-based trauma registries.[2,4,6] Critically injured children may die before reaching definitive care, and survivors often face morbidity, which is better indicated by intensive care unit utilization, operative intervention, and extended hospital stays. Therefore, outcome measures beyond mortality are crucial when assessing pediatric triage accuracy.

Existing trauma triage criteria have well-documented limitations in pediatric populations, especially among younger children and those with blunt or isolated injuries.[8–10,12,13] In this study, under-triaged patients were more likely to be younger and to sustain severe head or abdominal injuries, patterns that have been repeatedly identified in both national and international analyses. While using adult trauma activation frameworks for older adolescents aligns with national trauma registry standards, it may also lead to misclassification when applied to agricultural injuries that resemble adult injury patterns but have different physiological effects in children.

Although the Cribari Matrix Method and the Need for Trauma Intervention algorithm are widely used for trauma system benchmarking, both tools were primarily developed for retrospective quality assessment rather than real-time clinical decision-making.[17,18] Their use in pediatric agricultural trauma reveals important limitations, especially the inability to consider contextual factors such as rural transport distances, variability in emergency medical services staffing, and limited pediatric exposure among rural responders. These limitations indicate that benchmarking tools alone are not enough to guide pediatric triage improvements.

Potential strategies to reduce pediatric under-triage in agricultural settings include refining age-specific physiologic thresholds, better characterizing agricultural mechanisms within triage criteria, and providing more pediatric-focused training for rural emergency medical services providers. Emerging evidence suggests that structured clinical judgment, supported by pediatric expertise through consultation or telemedicine, may outperform rigid algorithm-based triage in certain pediatric cases.[11–13] Such approaches could be especially useful in low-volume rural trauma systems, where exposure to pediatric agricultural injuries is rare but the outcomes can be severe.

This study highlights a significant mismatch between injury severity and initial triage classification in pediatric agricultural trauma. Future research should go beyond descriptive analysis to evaluate specific pediatric triage adjustments, incorporate more comprehensive prehospital data, and examine system-wide interventions aimed at better early recognition of severe injuries in rural and agricultural areas.

Limitations

This study has several limitations that should be considered. First, as a retrospective, single-center analysis, the findings may not apply to urban trauma centers, other geographic regions, or institutions with different trauma activation protocols. The data reflect the experience of a rural Level II pediatric trauma center serving a predominantly agricultural population, and the local emergency medical service structure and referral pathways may differ significantly from those in other systems.

The sample size of pediatric agricultural trauma cases was relatively small (N=133), and key outcomes, such as in-hospital mortality, were infrequent (3.8%), which limited statistical power for group comparisons and precluded multivariable modeling. Although retrospective cohort designs can contribute to causal reasoning when supported by appropriate analytic methods and sufficient event counts, the present study was not designed to support causal inference. The findings should therefore be interpreted as descriptive associations rather than evidence of causation.

Furthermore, this study used trauma registry data collected in accordance with the American College of Surgeons National Trauma Data Standard definitions. Although the registry undergoes both internal and external validation, the risk of misclassification, missing data, and coding inconsistencies still exists. In addition, important prehospital factors relevant to causal interpretation, including scene characteristics, emergency medical services decision-making, and transport constraints, were not available in the dataset and could not be evaluated.

We also recognize that the Cribari Matrix Method and the Need for Trauma Intervention algorithm, although widely employed in trauma quality improvement, were primarily developed for adult and mixed populations. Their use in pediatric agricultural trauma may not fully address developmental, mechanistic, or system-level factors unique to this subgroup. Finally, as with all retrospective observational studies, these data do not permit causal inference. Future research should include multicenter designs, enriched prehospital data, and prospective methods to better characterize system-level contributors to under triage and to evaluate the effectiveness of pediatric-specific triage enhancements in rural and agricultural contexts.

Conclusion

A clinically meaningful proportion of pediatric agricultural trauma patients were under-triaged despite having serious injuries, including high injury severity scores and increased rates of intensive care unit admission. This gap between injury severity and initial triage classification highlights limitations in current activation protocols, especially when used with children in rural and agricultural environments.

Due to the small sample size and low number of events, multivariable regression analyses were not carried out. Therefore, this study's findings are based on descriptive and bivariate analyses and should be viewed as associative rather than predictive. Nonetheless, the clinical patterns observed suggest a need for triage systems that better identify pediatric acuity. Future research should focus on developing and validating pediatric-specific triage improvements, including criteria sensitive to age and injury mechanism, to enhance early detection and response for this vulnerable group.

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