ORIGINAL ARTICLE

Evaluation of pediatric gunshot wounds and emergency department dynamics in high-volume incidents

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ABSTRACT

BACKGROUND: Pediatric gunshot injuries present significant challenges to emergency care, highlighting the need for precise strategies in the management of high-volume incidents. This study aims to assess pediatric gunshot injuries presenting to the emergency department in clusters and their outcomes, contributing to the development of a more detailed high-volume incidents classification based on patient numbers.

METHODS: A retrospective analysis was conducted at a level-one trauma center, focusing on pediatric gunshot admissions. Patients were segmented by admission type: single versus multiple simultaneous admissions from the same incident. Further analysis distinguished between incidents involving three or more victims and those with fewer victims to assess the impact on emergency care outcomes.

RESULTS: This study included 182 pediatric patients with gunshot injuries, with a median age of 16 years (IQR 13.75–17). Patients were analyzed using two grouping methods: the first divided patients into single admissions (n=103, 56.6%) and multi-victim presentations (n=79, 43.4%). In this comparison, multi-victim presentations had a lower rate of blood transfusions (RR: 0.58, 95% CI: 0.35–0.95) but similar mortality rates (RR: 0.88, 95% CI: 0.31–2.44). The second grouping method classified incidents with three or more victims (n=35, 19.2%) versus fewer victims (n=147, 80.8%). This analysis showed that incidents with three or more victims had a higher mortality rate (RR: 2.81, 95% CI: 1.08–7.31). The average ED stay was shorter for multi-victim presentations (54.1±22.5 minutes) compared to solo presentations (65.2±48.8 minutes).

CONCLUSION: Findings indicate that pediatric gunshot incidents with three or more simultaneous victims, regardless of triage category, significantly affect mortality and ED stay lengths in a center with a single trauma team. This highlights the necessity of defining MCIs based on such patient volumes to optimize emergency care responses and improve outcomes. Establishing objective, outcome-focused criteria for high-volume incidents classification is crucial for enhancing patient care and resource allocation in these critical situations.

Keywords: Pediatric Emergencies; Gunshot Wounds; High-Volume Incidents; Trauma Severity Indices; Emergency Department Utilization.

INTRODUCTION

The early identification of an incident is crucial for preparing strategic responses. While the number of patients arriving at the emergency department (ED) is essential for resource allocation, gunshot injury outcomes are influenced by multiple factors, including the type of firearm used and critical anatomical involvement.[1] Identifying an event as a mass casualty incident (MCI) and implementing specific strategies are essential for effectively managing the transition from the scene to EDs and ensuring a coordinated response.

Current literature lacks a consensus on objective criteria for defining MCIs, a gap evident in our investigations. MCI victims

Cite this article as: Aydogdu Umac G, Cetinkaya R, Ozel M, Balsak H, Yilmaz S. Evaluation of pediatric gunshot wounds and emergency department dynamics in high-volume incidents. Ulus Travma Acil Cerrahi Derg 2025;31:167-177.

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Ulus Travma Acil Cerrahi Derg 2025;31(2):167-177 DOI: 10.14744/tjtes.2025.35961

Submitted: 06.12.2024 Revised: 11.01.2025 Accepted: 17.01.2025 Published: 06.02.2025

typically sustain more severe injuries than those affected by other types of trauma, highlighting the distinct severity and impact within healthcare settings.[2] A key determinant of this disparity is the influx of patients to EDs in the immediate aftermath of an MCI.[3] While some institutions attempt to categorize MCIs based on casualty count, our findings suggest such criteria remain subjective and unvalidated by empirical research.[4] Defining thresholds for MCIs remains complex, influenced by multiple factors such as patient outcomes, resource utilization, and operational dynamics in the ED. This underscores the importance of injury volume as a pivotal factor in MCI response strategies. Consequently, the objective of this study is to evaluate the impact of patient volume from pediatric firearm injuries on mortality and emergency outcomes and to establish a threshold for MCI classification. Through a comparative analysis of single versus multiple simultaneous admissions, and further distinguishing between incidents with fewer than three and at least three victims, we aim to refine MCI criteria to enhance ED response and resource allocation.

MATERIALS AND METHODS

Study Design and Selection Criteria

This retrospective study was conducted at a tertiary care facility with a level-one trauma center designation, covering the period from January 1, 2020 to December 31, 2023. Ethical approval was obtained from the Şırnak University Ethics Committee (date: 04.02.2024, no: 97774), in accordance with the Declaration of Helsinki. Informed consent was waived due to the retrospective nature of the study.

The inclusion criteria consisted of individuals under the age of 18 who presented to the ED due to gunshot injuries. Exclusion criteria included patients referred for post-stabilization care without an initial ED assessment, those who required or received cardiopulmonary resuscitation (CPR) prior to their ED arrival, those with incomplete medical records, and patients or guardians who declined research participation

At the center where the study was conducted, pediatric patients with gunshot wounds initially present to the ED. Upon arrival, early triage is performed by an emergency physician, who assesses the patient and provides initial treatment. If surgical intervention is required, consultations are requested from relevant departments, including orthopedics, pediatric surgery, plastic surgery, and cardiovascular surgery. From this point, patient management proceeds as follows: if the patient continues to be managed in the ED, emergency physicians oversee their care. Patients requiring immediate surgery are transferred to the operating room for prompt intervention. Those without urgent surgical needs are admitted to surgical wards for further monitoring and treatment. In departments where consultations are requested by emergency physicians, a single physician on duty, both during the day and night, manages these cases.

In the center where the research was conducted, when an event is described as an MCI or a disaster, it is recommended to notify the Health Disaster and Coordination Center Unit, a unit of the Ministry of Health with national and international departments, within the ED and to manage the situation in accordance with the Disaster and Emergency Planning Guide for Health Institutions.[5]

Outcomes

The analysis was structured in two stages. First, incidents were categorized into two groups: cases involving a single admission and cases involving multiple simultaneous admissions due to the same gunshot event. This categorization allowed for the evaluation of how patient volume might influence outcomes such as mortality and other critical health metrics.

In the second stage, multiple simultaneous admissions were further examined by distinguishing incidents with three or more admissions from those with fewer. This deeper analysis aimed to determine whether a higher threshold of simultaneous admissions could provide a basis for defining an event as a mass casualty incident.

Data Collection

Data collection was conducted using the hospital's electronic medical records system, capturing comprehensive patient demographics, including age and gender, injury characteristics (such as anatomical location, including the head and neck, chest, abdomen, and extremities), and injury severity as assessed by the pediatric JumpStart triage system and the Pediatric Trauma Score. The Pediatric Trauma Score was utilized to provide a standardized assessment of injury severity, recognizing that while it serves as a general indicator, it does not fully account for the multifactorial nature of gunshot injury outcomes. This scoring system was selected to ensure consistency in assessing injury severity across different case scenarios while acknowledging its inherent limitations in capturing all nuances of gunshot injuries.

Clinical interventions documented within the ED included the administration of blood transfusions, the necessity and execution of intubation procedures, and the number and type of consultations provided by various medical specialties. The primary outcome measures were meticulously recorded, including the precise duration of each patient's stay in the ED (measured in minutes), the total length of hospital admission (measured in days), and in-hospital mortality status (recorded as a binary outcome). A standardized data extraction template was utilized to ensure uniform data capture, and the accuracy and completeness of the collected data were independently verified by a second research team member. All patient data were anonymized to protect confidentiality. The data collection process underwent periodic reviews to promptly identify and reconcile any discrepancies, thereby maintaining the dataset's robustness for subsequent analysis. Disagreements between the two primary reviewers occurred in eight cases; in each case, a third reviewer was consulted. A consensus was reached for all cases following further discussion.

Analysis

Statistical analyses were conducted using Statistical Package for the Social Sciences (SPSS) software (version 29, IBM Corp., Armonk, NY). Descriptive statistics were employed to summarize the data, with frequencies and percentages used for categorical variables. Continuous variables were presented as either medians with interquartile ranges (IQR, 25th-75th percentiles) or means±standard deviations (SD), depending on the data distribution. Continuous variables were dichotomized at their median values to facilitate the calculation of relative risk (RR) and associated 95% confidence intervals (CI).

Vital parameters, including systolic and diastolic blood pressure, pulse rate, respiratory rate, and oxygen saturation, were analyzed across the classification frameworks. Comparisons between groups (e.g., multi-victim versus single-victim presentations, three or more victims versus fewer than three victims) were conducted using medians and interquartile ranges, with differences assessed using Mann-Whitney U tests due to the non-normal distribution of these variables.

Relative risk calculations were performed by comparing the probability of each outcome occurring in the exposed group (multi-victim or three-or-more victim presentations) to the probability of the same outcome in the reference group (single-victim or fewer-than-three-victim presentations). For each categorical variable, RR and 95% CI were calculated to estimate the likelihood of a specific outcome across the different groups. In cases where continuous variables were dichotomized (such as age, Pediatric Trauma Score, number of consultations, ED stay duration, and hospital stay length), comparisons were made between the two resulting categories.

Univariate analyses were initially conducted to identify potential predictors of in-hospital mortality, with p-values reported to provide preliminary insights into significant differences between survivors and non-survivors. Variables with potential significance were further examined using multivariate logistic regression analysis to identify independent predictors of mortality while controlling for confounding factors. Odds ratios (OR) with 95% CIs were calculated for the multivariate analysis to provide effect size estimates for each variable. The performance of the logistic regression model was assessed using the Nagelkerke R-squared and Cox & Snell R-squared values to quantify the proportion of variance explained by the model. The Hosmer-Lemeshow test was applied to evaluate model fit, with a non-significant p-value indicating an adequate fit.

Receiver operating characteristic (ROC) curve analysis was conducted to evaluate the discriminatory ability of the classification frameworks used in this study. This analysis enabled comparisons between different thresholds to determine which framework provided better differentiation of in-hospital mortality. Statistical testing of the differences in ROC performance confirmed the superior discriminatory capacity of one classification framework over the other.

In accordance with current recommendations, p-values were not utilized for significance testing to minimize the risk of Type I error. Instead, 95% confidence intervals were reported to provide a measure of effect size and precision across comparisons.

RESULTS

This study included 182 pediatric patients with gunshot injuries, with a median age of 16 years (IQR 13.75-17). Gender distribution showed that 20.9% of the patients were female (n=38), while 79.1% were male (n=144). Analysis of injury sites revealed that extremities were the most frequently affected area (63.7%, n=116), followed by the head and neck (17.6%, n=32), chest (15.9%, n=29), and abdomen (12.6%, n=23). Vital parameters upon presentation showed a median systolic blood pressure of 111 mmHg (IQR 107-118), diastolic blood pressure of 76 mmHg (IQR 65-82), pulse rate of 101 beats per minute (bpm) (IQR 94-106), and oxygen saturation of 97% (IQR 95-98). According to Pediatric JumpStart triage, 16.5% of patients were classified as yellow (n=30), while 83.5% were classified as red (n=152). The median Pediatric Trauma Score (PTS) was 8 (IQR 6-9). Blood transfusions were administered to 30.2% of patients (n=55), and 15.4% (n=28) required intubation. The median number of consultations in the ED was 1 (IQR 1-2). Discharge outcomes indicated that 36.3% (n=66) were discharged directly from the ED, 21.4% (n=39) required intensive care unit (ICU) admission, and 30.2% (n=55) underwent surgery. The average ED stay was 60.4±39.9 minutes, with a median hospital stay of one day (IQR 0-4). The in-hospital mortality rate was 8.2% (n=15). Table 1 presents the demographic and clinical characteristics of pediatric patients with gunshot injuries.

Two classification frameworks were employed for analysis. The first categorized patients based on admission type: single admissions (n=103, 56.6%) and multi-victim presentations (n=79, 43.4%). The second framework further distinguished incidents involving three or more victims (n=35, 19.2%) from those with fewer than three victims (n=147, 80.8%).

As shown in Table 2, the distribution by age (<16 years) was similar between the single-victim presentation group (n=103) and the multi-victim presentation group (n=79) (RR: 1.14, 95% CI: 0.88-1.47). Gender ratios also did not differ significantly, with females comprising 24.1% of the multi-victim group and 18.4% of the single-victim presentation group (RR: 1.31, 95% CI: 0.75-2.30). Vital parameters were largely comparable between the groups, with median systolic blood pressure recorded as 113 mmHg (IQR 110-117) for the multi-victim group versus 112 mmHg (IQR 110-116) for the

Table 1. Demographic and clinical characteristics of pediatric patients with gunshot injuries

Parameters	Gunshot Injuries (n=182)
Demographic Information	
Age (years)	16 (13.75-17)
Female	38 (20.9%)
Male	144 (79.1%)
Vital Parameters	
Systolic Blood Pressure (mmHg)	111 (107-118)
Diastolic Blood Pressure (mmHg)	76 (65-82)
Pulse Rate (bpm)	101 (94-106)
Oxygen Saturation (%)	97 (95-98)
Injury Site	
Head and Neck	32 (17.6%)
Chest	29 (15.9%)
Abdomen	23 (12.6%)
Extremities	116 (63.7%)
JumpSTART Triage Category	
Yellow	30 (16.5%)
Red	152 (83.5%)
Trauma Score	
Pediatric Trauma Score	8 (6-9)
Presentation	
Single Admission	103 (56.6%)
Two Patients Injured	44 (24.2%)
Three or More Patients Injured	35 (19.2%)
In the ED	
Blood Transfusion	55 (30.2%)
Intubation	28 (15.4%)
Number of Consultations	1 (1-2)
Length of Stay	
ED Stay (minutes)	60.4±39.9
Hospital Stay (days)	1 (0-4)
Outcome	
Surgery	55 (30.2%)
Admission to ICU	39 (21.4%)
Discharged	66 (36.3%)
In-Hospital Mortality	15 (8.2%)

PTS: Pediatric Trauma Score; ICU: Intensive Care Unit; ED: Emergency Department.

single-victim presentation group (p=0.524). Similarly, diastolic blood pressure, pulse rate, and oxygen saturation did not show statistically significant differences between the groups (diastolic blood pressure [BP]: 76 mmHg vs. 78 mmHg, p=0.118; pulse rate: 99 bpm vs. 101 bpm, p=0.583; oxygen saturation: 96% vs. 96%, p=0.711). The frequency of injuries to the head and neck, chest, abdomen, and extremities was comparable across the groups (head/neck: RR: 1.01, 95% CI: 0.54-1.89; chest: RR: 0.80, 95% CI: 0.40-1.58; abdomen: RR: 1.01, 95% CI: 0.47-2.16; extremities: RR: 1.06, 95% CI: 0.85-1.32). JumpStart triage classification distributions were similar between groups, with yellow triage comprising 16.5% of both groups (RR: 1.00, 95% CI: 0.52-1.90). A notable difference emerged in blood transfusion rates, with the multi-victim group receiving fewer transfusions (21.5%) compared to the single-victim presentations group (36.9%), indicating a lower relative risk in the multi-victim group (RR: 0.58, 95% CI: 0.35-0.95). There were no significant differences in intubation rates (RR: 1.08, 95% CI: 0.48-2.43), ICU admissions (RR: 1.01, 95% CI: 0.56-1.80), or discharges directly from the ED (RR: 1.23, 95% CI: 0.84-1.80). ED stay was significantly shorter for the multi-victim group (54.1±22.5 minutes) compared to the single-victim presentation group (65.2±48.8 minutes), with a mean difference of 11.1 minutes (95% CI: 0.4-21.9). Hospital stay length and mortality rates were comparable (mortality RR: 0.88, 95% CI: 0.31-2.44).

In a further breakdown, Table 3 compares patients involved in incidents with three or more victims (n=35, 19.2%) to those with fewer than three victims (n=147, 80.8%). Age distribution did not vary significantly, with 62.9% of the three-or-more-victims group below the median age (RR: 1.14, 95% CI: 0.86-1.50). Gender distribution was also similar between groups, with 20% female representation in the three-or-more-victims group versus 21.1% in the fewer-victims group (RR: 0.95, 95% CI: 0.45-2.01). Vital parameters were largely comparable across the groups. The median systolic blood pressure was 113 mmHg (IQR 110-117) for the three-or-more-victims group and 113 mmHg (IQR 110-115) for the fewer-victims group (p=0.297). Similarly, no significant differences were observed in diastolic blood pressure (78 mmHg vs. 76 mmHg, p=0.304), pulse rate (100 bpm vs. 101 bpm, p=0.220), or oxygen saturation (96% vs. 96%, p=0.527). Injury sites showed comparable distributions across both groups (head/neck: RR: 1.29, 95% CI: 0.63-2.67; chest: RR: 0.49, 95% CI: 0.16-1.52; abdomen: RR: 1.48, 95% CI: 0.65-3.38; extremities: RR: 1.21, 95% CI: 0.96-1.54). In the JumpStart triage analysis, both groups exhibited similar proportions in the yellow category (RR: 1.05, 95% CI: 0.45-2.47). The three-or-more-victims group had fewer blood transfusions (17.1%) compared to the fewer-victims group (33.3%), indicating a lower relative risk (RR: 0.51, 95% CI: 0.25-1.04). Other ED interventions, such as intubation rates (RR: 0.92, 95% CI: 0.39-2.17) and the number of consultations, were not significantly different between groups. ED length of stay was longer for the three-or-more-victims group (62.3±43 minutes) compared to the fewer-victims group (52.3±21.5 minutes), with a mean difference of 10.05 minutes (95% CI: 0.01-20.09). The in-hospital mortality rate was significantly higher in the three-or-more-victims group (17.1%) compared to the fewer-victims group (6.1%) (RR: 2.81, 95% CI: 1.08-7.31), indicating

Table 2. Outcomes of pediatric gunshot injury admissions: comparison of single-victim and multi-victim incidents

Parameter	Multi-Victim Presentations (n=79)	Single-Victim Presentations (n=103)	RR (95% CI) or p
Demographic Information			
Age (years)	16 (12-17)	16 (14-18)	
<Median (16)	48 (60.8%)	55 (53.4%)	1.14 (0.88-1.47)
≥Median (16)	31 (39.2%)	48 (46.6%)	0.84 (0.58-1.21)
Female	19 (24.1%)	19 (18.4%)	1.31 (0.75-2.30)
Male	60 (75.9%)	84 (81.6%)	0.93 (0.82-1.06)
Vital Parameters			
Systolic Blood Pressure (mmHg)	113 (110-117)	112 (110-116)	0.524
Diastolic Blood Pressure (mmHg)	76 (64-81)	78 (69-83)	0.118
Pulse Rate (bpm)	99 (93-106)	101 (94-106)	0.583
Oxygen Saturation (%)	96 (95-98)	96 (95-98)	0.711
Injury Site			
Head and Neck	14 (17.7%)	18 (17.5%)	1.01 (0.54-1.89)
Chest	11 (13.9%)	18 (17.5%)	0.80 (0.40-1.58)
Abdomen	10 (12.7%)	13 (12.6%)	1.01 (0.47-2.16)
Extremities	52 (65.8%)	64 (62.1%)	1.06 (0.85-1.32)
JumpSTART Triage Category			
Yellow	13 (16.5%)	17 (16.5%)	1.00 (0.52-1.90)
Red	66 (83.5%)	86 (83.5%)	1.00 (0.92-1.08)
Trauma Score			
PTS	8 (5-9)	8 (6-9)	
<Median (8)	43 (54.4%)	64 (62.1%)	0.88 (0.67-1.14)
≥Median (8)	36 (45.6%)	39 (37.9%)	1.20 (0.86-1.66)
In the ED			
Blood Transfusion	17 (21.5%)	38 (36.9%)	0.58 (0.35-0.95)
Intubation	10 (12.7%)	12 (11.7%)	1.08 (0.48-2.43)
Number of Consultations	1 (1-2)	1 (1-2)	
≤Median (1)	45 (57%)	61 (59.2%)	0.96 (0.75-1.23)
>Median (1)	34 (43%)	52 (40.8%)	1.05 (0.81-1.36)
Outcome			
Discharged	32 (40.5%)	34 (33%)	1.23 (0.84-1.80)
Surgery	25 (31.6%)	30 (29.1%)	1.08 (0.68-1.70)
Admission to ICU	17 (21.5%)	22 (21.4%)	1.01 (0.56-1.80)
Length of Stay			
ED Stay (minutes)	54.1±22.5	65.2±48.8	
<Median (57)	43 (54.4%)	49 (47.6%)	1.14 (0.85-1.53)
≥Median (57)	36 (45.6%)	54 (52.4%)	0.87 (0.61-1.22)
Hospital Stay (days)	1 (0-4)	1 (0-4)	
≤Median (1)	42 (53.2%)	52 (50.5%)	1.05 (0.80-1.38)
>Median (1)	37 (46.8%)	51 (49.5%)	0.94 (0.65-1.36)
Mortality			
In-Hospital Mortality	6 (7.6%)	9 (8.7%)	0.88 (0.31-2.44)

PTS: Pediatric Trauma Score; ICU: Intensive Care Unit; ED: Emergency Department; RR: Relative Risk; bpm: Beats Per Minute; Note: All comparisons in this study are based on unadjusted 95% confidence intervals. P-values were not reported to align with current best practices for minimizing Type I error risk.

Table 3. Outcomes of pediatric gunshot injury admissions: comparison of incidents with three or more victims to those with fewer

Parameter	Three or More Victims (n=35)	Less Than Three Victims (n=147)	RR (95% CI) or p
Demographic Information			
Age (years)	16 (11-17)	16 (14-17)	
<Median (16)	22 (62.9%)	81 (55.1%)	1.14 (0.86-1.50)
≥Median (16)	13 (37.1%)	66 (44.9%)	0.83 (0.57-1.16)
Female	7 (20%)	31 (21.1%)	0.95 (0.45-2.01)
Male	28 (80%)	116 (78.9%)	1.01 (0.93-1.10)
Vital Parameters			
Systolic Blood Pressure (mmHg)	113 (110-117)	113 (110-115)	0.297
Diastolic Blood Pressure (mmHg)	78 (66-82)	76 (59-81)	0.304
Pulse Rate (bpm)	100 (93-106)	101 (96-108)	0.220
Oxygen Saturation (%)	96 (95-98)	96 (95-97)	0.527
Injury Site			
Head and Neck	7 (21.9%)	25 (17%)	1.29 (0.63-2.67)
Chest	3 (8.6%)	26 (17.7%)	0.49 (0.16-1.52)
Abdomen	6 (17.1%)	17 (11.6%)	1.48 (0.65-3.38)
Extremities	26 (74.3%)	90 (61.2%)	1.21 (0.96-1.54)
JumpSTART Triage Category			
Yellow	6 (17.1%)	24 (16.3%)	1.05 (0.45-2.47)
Red	29 (82.9%)	123 (83.7%)	0.99 (0.88-1.11)
Trauma Score			
PTS	7 (6-9)	8 (6-9)	
<Median (8)	21 (60%)	86 (58.5%)	1.03 (0.76-1.40)
≥Median (8)	14 (40%)	61 (41.5%)	0.96 (0.69-1.33)
In the ED			
Blood Transfusion	6 (17.1%)	49 (33.3%)	0.51 (0.25-1.04)
Intubation	5 (14.3%)	23 (15.6%)	0.92 (0.39-2.17)
Number of Consultations	1 (1-2)	1 (1-2)	0.95 (0.66-1.37)
≤Median (1)	21 (60%)	85 (57.8%)	1.04 (0.76-1.42)
>Median (1)	14 (40%)	62 (42.2%)	
Outcome			
Discharged	12 (34.3%)	54 (36.7%)	0.94 (0.54-1.64)
Surgery	12 (34.3%)	43 (29.3%)	1.17 (0.67-2.05)
Admission to ICU	12 (34.3%)	43 (29.3%)	1.17 (0.67-2.05)
Length of Stay			
ED Stay (minutes)	62.3±43	52.3±21.5	
<Median (57)	20 (57.1%)	72 (49%)	1.17 (0.79-1.73)
≥Median (57)	15 (42.9%)	75 (51%)	0.84 (0.58-1.22)
Hospital Stay (days)	1 (0-3.5)	1 (0-4)	
≤Median (1)	19 (54.3%)	75 (51%)	1.06 (0.76-1.48)
>Median (1)	16 (45.7%)	72 (49%)	0.93 (0.65-1.34)
Mortality			
In-Hospital Mortality	6 (17.1%)	9 (6.1%)	2.81 (1.08-7.31)

PTS: Pediatric Trauma Score; ICU: Intensive Care Unit; ED: Emergency Department; RR: Relative Risk; bpm: Beats Per Minute; Note: All comparisons in this study are based on unadjusted 95% confidence intervals. P-values were not reported to align with current best practices for minimizing Type I error risk.

a notable increase in risk associated with incidents involving multiple victims.

For the classification framework comparison, receiver operating characteristic curve analysis was conducted to evaluate the ability of different thresholds to discriminate in-hospital mortality (Fig. 1). The first analysis compared multi-victim presentations (n=79) versus single-victim presentations (n=103), yielding an area under the curve (AUC) of 0.481 (95% CI: 0.431-0.531). The second analysis compared three-or-more-victims incidents (n=35) versus fewer-than-three-victims incidents (n=147), yielding an AUC of 0.613 (95% CI: 0.563-0.663). These findings indicate that the threshold of three or more victims provides better discriminatory ability in predicting mortality compared to the classification based on multi-victim versus single-victim presentations. The difference in the area under the curve between the two receiver operating characteristic curves is 0.132. The statistical test yields a Z-score of 3.659, with a p-value of 0.00025, indicating that the difference is statistically significant.

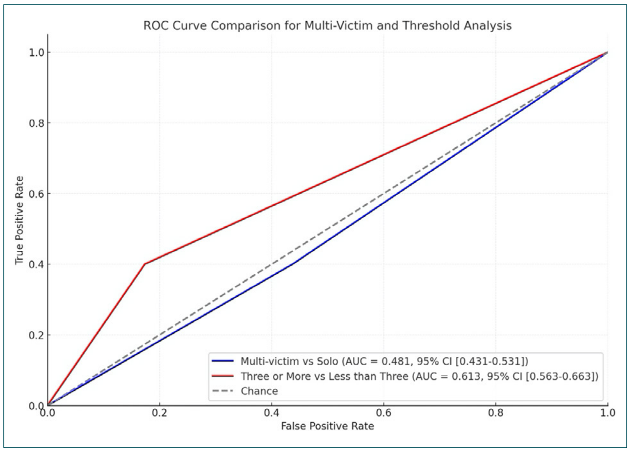

Figure 1. ROC plots of SII and PIV values for surgical treatment.

Table 4 presents the univariate and multivariate analyses of predictors of in-hospital mortality among pediatric patients with gunshot injuries. In the univariate analysis, significant differences between survivors and non-survivors were observed across multiple variables. Patients who succumbed to their injuries had markedly lower systolic and diastolic blood pressures (systolic blood pressure [SBP]: 83 mmHg [IQR 70-91] vs. 113 mmHg [IQR 101-127], p<0.001; diastolic blood pressure [DBP]: 56 mmHg [IQR 51-64] vs. 78 mmHg [IQR 69-82], p<0.001) and significantly elevated pulse rates (127 bpm [IQR 111-137] vs. 98 bpm [IQR 91-106], p<0.001). Injuries to the head and neck were much more frequent among non-survivors compared to survivors (60% vs. 13.8%, p<0.001), while injuries to the extremities were far less common in the non-survivor group (13.3% vs. 68.3%, p<0.001). Pediatric Trauma Scores were significantly higher among non-survi-

Table 4. Univariate and multivariate analysis of predictors of in-hospital mortality in pediatric gunshot injury patients

Parameter	Survivors (n=167)	Non-Survivors (n=15)	p	Multivariate OR (95% CI)	p
Age (years)	16 (13-17)	17 (15-17)	0.347		
Sex (female)	135 (80.8%)	9 (60%)	0.065		
Systolic BP (mmHg)	113 (101-127)	83 (70-91)	<0.001	0.873 (0.815-0.934)	<0.001
Diastolic BP (mmHg)	78 (69-82)	56 (51-64)	<0.001		
Pulse Rate (bpm)	98 (91-106)	127 (111-137)	<0.001		
Head and Neck Injuries	23 (13.8%)	9 (60%)	<0.001		
Chest Injuries	26 (15.6%)	3 (20%)	0.439		
Abdominal Injuries	19 (11.4%)	4 (26.7%)	0.102		
Extremity Injuries	114 (68.3%)	2 (13.3%)	<0.001		
JumpSTART Triage Category (yellow)	16 (9.6%)	14 (93.3%)	<0.001		
JumpSTART Triage Category (red)	151 (90.4%)	1 (6.7%)	<0.001		
Pediatric Trauma Score	4 (3-6)	8 (6-9)	<0.001	1.237 (1.156-1.412)	0.008
Blood Transfusion	44 (26.3%)	11 (73.3%)	<0.001	1.625 (1.234-17.556)	0.039
Intubation	15 (9%)	13 (86.7%)	<0.001		
Number of Consultations	1 (1-2)	1 (1-1)	0.086		
Length of ED Stay (minutes)	61 (36-78)	22 (21-42)	<0.001		
Length of Hospital Stay (days)	2 (0-4)	1 (0-1.25)	0.250		
Number of Presentations	1 (1-2)	3 (2-5)	0.130	1.464 (1.004-2.148)	0.045

OR: Odds Ratio; CI: Confidence Interval; BP: Blood Pressure; bpm: Beats Per Minute; ED: Emergency Department.

vors (8 [IQR 6-9] vs. 4 [IQR 3-6], p<0.001), consistent with the classification of more severe trauma. Blood transfusion (73.3% vs. 26.3%, p<0.001) and intubation rates (86.7% vs. 9%, p<0.001) were also substantially higher in the non-survivor group, indicating the severity of injuries among these patients. Interestingly, the length of ED stay was shorter among non-survivors (22 minutes [IQR 21-42] vs. 61 minutes [IQR 36-78], p<0.001), reflecting the urgency of their clinical deterioration. However, some variables did not show statistically significant differences in the univariate analysis, including chest injuries (20% vs. 15.6%, p=0.439), abdominal injuries (26.7% vs. 11.4%, p=0.102), and the number of consultations (median 1 [IQR 1-1] vs. 1 [IQR 1-2], p=0.086).

In the multivariate analysis, four variables emerged as independent predictors of in-hospital mortality. Systolic blood pressure remained a critical predictor, with an odds ratio of 0.873 (95% CI: 0.815-0.934, p<0.001), indicating that a 1 mmHg decrease in SBP was associated with a 12.7% increase in the odds of mortality. Higher PTS values were independently associated with an increased risk of mortality (OR: 1.237, 95% CI: 1.156-1.412, p=0.008). The requirement for blood transfusion also independently predicted mortality (OR: 1.625, 95% CI: 1.234-17.556, p=0.039). Lastly, the number of simultaneous presentations was a significant predictor (OR: 1.464, 95% CI: 1.004-2.148, p=0.045). The logistic regression model demonstrated strong predictive validity, with a Nagelkerke R-squared value of 0.730, indicating that the model explained 73% of the variance in mortality. The Hosmer-Lemeshow goodness-of-fit test yielded a p-value of 0.614, confirming the adequacy of the model's fit to the data.

DISCUSSION

Identifying an event as an MCI depends on two critical aspects: the casualty count and the adequacy of the response to patient needs. A disproportionate number of patients relative to available response resources indicates the event's MCI status. Current clinical guidelines provide comprehensive management strategies for MCI-related patient care but lack an objective, evidence-based framework for applying these procedures.[6] For EDs to shift effectively from routine operations to MCI protocols, reliance on objective data is essential for both leadership and operational staff. Guidelines recommend rapid communication of the incident scale and early determination of casualty numbers to mobilize hospital emergency preparedness, alongside coordination with regional support teams.[6] The evaluation of potential MCIs currently employs a subjective, decision-based approach by incident commanders, highlighting the need for a more standardized criterion. This study proposes the development of an objective, indicator-based framework applicable in both trauma and non-trauma emergency settings, emphasizing the necessity of quantitative metrics to enhance care quality across all settings.[7] Focusing on the prerequisites for care centers, including the availability of a dedicated trauma team and specialized pediatric emergency care, this research aims to introduce a universally applicable, evidence-based definition of MCIs. It examines the threshold at which the simultaneous arrival of three or more pediatric emergency cases to an ED, following a single incident, significantly affects mortality outcomes, thereby establishing a concrete criterion for MCI identification. Research indicates that most MCIs occur outside of standard hospital operating hours, complicating the optimization of workforce resources, logistical support, and supplies due to fluctuating capacity needs.[2] This suggests that managing MCIs requires a minimalist approach, necessitating preparedness with limited teams ready to respond to the injured. This study was conducted under constrained conditions, with only a single on-call trauma team available in the required specialties, to ensure feasibility in more resource-rich centers. It proposes classifying an event as an MCI based on the arrival of three or more pediatric emergency cases to the ED, reinforcing this criterion with its significant impact on patient mortality.

In this study, we examined the impact of managing multiple pediatric emergencies, specifically cases involving two or more and three or more simultaneous arrivals, compared to individual case scenarios, with the objective of refining MCI classification criteria. Our analysis of pediatric admissions revealed a distinct contrast: groups with two or more patients experienced significantly longer ED stays and had a greater need for blood transfusions compared to individual admissions. However, this divergence was not reflected in mortality rates or other measured outcomes. Interestingly, the absence of mortality in the two-victim admissions group highlights the inherent variability of gunshot injury outcomes. This variability aligns with the complex nature of gunshot injuries, which are influenced by multiple factors beyond patient volume, underscoring the need for a nuanced approach in MCI classification. This variability is shaped not only by the number of patients but also by factors such as firearm type, bullet trajectory, critical anatomical involvement, and pre-existing conditions. These considerations emphasize the exploratory nature of this study, suggesting that patient volume should be assessed alongside other variables to refine MCI classification thresholds. Notably, when focusing on instances with three or more concurrent admissions, classified as MCIs, we observed significant differences not only in length of stay (LOS) and blood transfusion requirements but also in mortality rates, highlighting a critical threshold for increased care demands. Research on ED waiting times has demonstrated that a prolonged LOS in the ED is independently associated with an increased risk of in-hospital mortality in critically ill patients, even among those without time-sensitive conditions requiring ICU admission, such as severe sepsis or septic shock.[8,9] The impact of MCIs on these durations has been previously documented. In our study, we observed that when the number of gunshot wound patients presenting to the ED was one or two, the approach to patient management differed significantly compared to scenarios involving three or more patients. While managing one or two patients resulted in prolonged ED LOS, handling three or more patients led to resource constraints and specialist shortages. We interpreted this complex variation in ED management based on the number of casualties in MCIs.

Another critical factor is that each surgical department responsible for the close monitoring of these patients has one dedicated trauma team. When the number of casualties is two, emergency medicine specialists assist the trauma teams in patient monitoring, leading to extended ED stays. However, when the casualty count reaches three or more, trauma teams and resources become limited, and specialist time constraints become even more pronounced.

Current guidelines for MCI management advocate for a meticulously organized medical team structure, tailored to efficiently address diverse requirements. This structure includes the deployment of essential trauma teams for immediate response, a dedicated minimum healthcare team to provide continuous support until patients can be transferred to specialized care and the assignment of additional duties as determined by personnel availability. Through this study, which employs a unified team approach for pediatric emergencies, our objective is to propose a more streamlined and universally applicable strategy for EDs that encounter three or more pediatric emergencies simultaneously, given their significant impact on mortality rates. This recommendation highlights the critical need for an integrated response strategy, emphasizing early intervention and specialist consultation for this highly vulnerable patient group. Ensuring the applicability of this approach extends beyond major trauma centers to a broader healthcare spectrum is essential.

Our investigation into the demographics of pediatric gunshot wound incidents confirms consistency with existing literature, incorporating all patients under 18 years of age due to age-related ambiguities in gunshot wound management and MCI classification.[10] Contrasting with Maya et al.'s[11] ICU study, our research recorded a mortality rate of 8.2% for individual admissions, a slight decrease to 7.6% for two or more admissions, but a marked increase to 17.1% for three or more admissions from similar incidents. This stark increase in ED admissions underscores the heightened severity associated with MCIs compared to single gunshot wound cases.[2] The JumpSTART triage system further corroborated the severity of these cases, with a majority classified as red triage for severe conditions, and this severity level remained consistent across different patient numbers. While retrospective triage poses a limitation, it ensures accurate severity assessment.[12] The pediatric trauma scores also aligned with findings from other gunshot wound studies, indicating that severity assessments are reliable, regardless of admission quantity.[13]

In MCIs, the need for blood transfusions underscores the challenge of providing timely and balanced resuscitation to minimize preventable hemorrhagic deaths. Evidence indicates that meeting these demands poses a struggle for many healthcare facilities, a challenge corroborated by our research.[14] Challenges such as the unpredictability of casualty numbers, the ongoing risks of the incident, and chaotic conditions within the ED further complicate the ability to respond effectively. Notably, a study by Soffer et al.[15] revealed that in MCIs caused by terrorist attacks, only 5% of patients required massive transfusions, yet they accounted for half of the total units of packed red blood cells (PRBCs) used. This disproportionate use of resources highlights a potentially higher demand within our pediatric study population. This observation emphasizes the urgent need for dedicated research into pediatric-specific MCI decision-making algorithms to ensure that the youngest and most vulnerable patients receive the care they need in times of crisis.

Activation of transfusion protocols in the aftermath of trauma incidents is crucially time-sensitive and typically requires immediate action.[16] This necessity places a critical emphasis on the time patients, particularly those affected by MCIs, spend in the ED, as well as on the medical interventions they receive. In our examination of pediatric gunshot wound victims' ED stays, a notable pattern emerged. Single admissions tended to have longer ED stays compared to groups of two or more. However, this trend reversed dramatically for groups of three or more, where stay lengths increased even more significantly. According to the Advanced Trauma Life Support (ATLS) 10th edition, a swift transfer to surgery following initial ED stabilization is advised for trauma patients requiring surgical intervention to minimize ED stay.[17] However, the complexities of MCIs, including the logistics of arranging surgery, ICU availability, and necessary staff, inherently extend these durations.[3] Our findings indicate that the length of ED stays in MCIs is largely influenced by the efficiency of transferring patients to appropriate care units. Specifically, pediatric gunshot wound cases involving three or more admissions saw significant increases in ED stay, aligning with existing research on pediatric gunshot wound incidents within MCIs. Effective resource management is pivotal in MCI scenarios, where extended ED stays could limit the availability of critical resources for other incoming patients, contradicting MCI management objectives.[1] Our research found that pediatric gunshot wound incidents resulting in three or more admissions notably prolonged ED waiting times, underscoring the need for improved MCI response strategies.

Conclusively, while specialized guidelines suggest distinct approaches for handling MCIs compared to regular ED operations, the absence of objective criteria for identifying MCIs persists. Our investigation focuses on pediatric patients—a demographic especially at risk during disasters and MCIs—centering on the prevalent public health issue of gunshot wound injuries. Analyzing the response capabilities of EDs in both trauma centers and hospitals without trauma designation, it is evident that mortality among injured children escalates when three or more are admitted from such events. This finding leads us to propose that instances involving three or more pediatric gunshot wound victims should be recognized as MCIs, offering an objective, outcome-focused method for categorization.

Limitations

The study's design and scope introduce certain limitations that merit consideration. First, this is a single-site study conducted at a level-one trauma center, which may not fully capture the diversity of emergency care settings or patient populations, potentially limiting the generalizability of the findings to other healthcare environments. Additionally, while we observed a difference in the number of transfusions administered based on the number of pediatric gunshot wound victims, the underlying reasons for this trend remain unclear and warrant further investigation. The decision to exclude patients who required or received CPR prior to their ED arrival was made to streamline the cohort. However, this exclusion may have inadvertently omitted a subset of patients with the most severe outcomes, potentially affecting the overall interpretation of mortality and resource utilization rates. This decision aligns with the rationale of many commonly used triage algorithms for resource management in MCIs, such as the Simple Triage and Rapid Treatment (START) and Sort, Assess, Lifesaving Interventions, Treatment/Transport (SALT) systems, which assign a "black triage" category to patients requiring CPR. While electronic medical records provide a robust basis for data collection, there is always a risk of encountering incomplete or inconsistent documentation, which could influence the accuracy of the analysis. Furthermore, focusing exclusively on pediatric patients under the age of 18 offers critical insights into this vulnerable group but does not address the outcomes and challenges faced by adult gunshot wound victims.

CONCLUSION

This study provides evidence that when three or more pediatric patients with gunshot injuries present simultaneously to an ED, there is an associated increase in mortality and extended ED stays compared to fewer concurrent admissions. While gunshot injury outcomes are shaped by multifactorial influences, our findings suggest that this threshold may serve as a practical marker for identifying mass casualty incidents, where patient surges significantly impact resource allocation and care delivery.

Ethics Committee Approval: This study was approved by the Şırnak University Ethics Committee (Date: 02.04.2024, Decision No: 97774).

Peer-review: Externally and Internally peer reviewed.

Authorship Contributions: Concept: G.A.U., M.O., R.C., S.Y.; Design: G.A.U., M.O., R.C., S.Y.; Supervision: H.B.; Resource: G.A.U., M.O., R.C., S.Y.; Materials G.A.U., M.O., R.C., S.Y.; Data collection and/or processing: M.O., R.C., H.B.; Analysis and/or interpretation: G.A.U., S.Y.; Literature review: G.A.U., M.O., R.C., H.B., S.Y.; Writing: G.A.U, M.O., R.C., S.Y.; Critical review: G.A.U., M.O., R.C., S.Y.

Conflict of Interest: None declared.

Financial Disclosure: The author declared that this study has received no financial support.

Data Sharing Statement: The entire deidentified dataset, data dictionary and analytic code for this investigation are available upon request, from the date of article publication by contacting Sarper YILMAZ, Assoc. Prof., at sarperyilmaz08@gmail.com.

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ORİJİNAL ÇALIŞMA - ÖZ

Çoklu yaralanmalı olaylarda çocukluk çağı ateşli silah yaralanmalarının ve acil servis dinamiklerinin değerlendirilmesi

AMAÇ: Çoklu yaralanmalı olaylar ile sonuçlanan pediatrik ateşli silah yaralanmaları, acil bakımda önemli zorluklar oluşturmaktadır. Bu nedenle, bu hastaların acil servis (AS) yönetiminde kullanılacak stratejilerin hassas bir şekilde belirlenmesi gerekmektedir. Bu çalışmanın amacı, hasta sayısına dayalı daha ayrıntılı bir pediatrik çoklu yaralanmalı olay sınıflandırması geliştirilmesine katkı sağlamak için AS'ye başvuran pediatrik ateşli silah yaralanmalarını ve sonuçlarını değerlendirmektir.

GEREÇ VE YÖNTEM: Birinci basamak travma merkezinde retrospektif bir analiz gerçekleştirilmiş ve pediatrik ateşli silah yaralanmaları nedeniyle yapılan başvurular incelenmiştir. Hastalar, tek ve aynı olaydan çoklu sayıda başvuru olarak gruplandırılmıştır. Ayrıca, üç veya daha fazla hastayı içeren olaylarla daha az hastayı içeren olaylar arasında ayrım yapılarak acil bakım sonuçlarına etkisi değerlendirilmiştir.

BULGULAR: Bu çalışmaya medyan yaşı 16 (IQR 13.75–17) olan 182 pediatrik ateşli silah yaralanması hastası dahil edilmiştir. Hastalar, iki gruplama yöntemi kullanılarak analiz edilmiştir: Birinci yöntem, hastaları tekli başvuru (n=103, %56,6) ve aynı olaydan çoklu sayıda yaralı başvuru (n=79, %43,4) olarak ayırmıştır. Bu karşılaştırmada, aynı olaydan çoklu sayıda pediatrik yaralı başvurularında kan transfüzyonu oranı daha düşük bulunmuştur (RR: 0.58, %95 GA: 0.35–0.95), ancak ölüm oranları benzer kalmıştır (RR: 0.88, %95 GA: 0.31–2.44). İkinci gruplama yöntemi ise aynı olay nedeniyle üç veya daha fazla yaralı içeren olaylar (n=35, %19,2) ile daha az sayıda yaralı içeren olaylar (n=147, %80,8) arasında ayrım yapmıştır. Aynı olay sonrasında üç veya daha fazla yaralı içeren olaylarda ölüm oranı daha yüksek bulunmuştur (RR: 2.81, %95 GA: 1.08–7.31). Aynı olaydan çoklu yaralı başvurularında AS kalış süresi (54.1±22.5 dakika) tekli başvurulara göre (65.2±48.8 dakika) daha kısa bulunmuştur.

SONUÇ: Bulgular, üç veya daha fazla eşzamanlı yaralı olan pediatrik ateşli silah yaralanmalarının, triyaj kategorisinden bağımsız olarak, tek bir travma ekibi bulunan merkezlerde ölüm ve AS'de kalış sürelerini önemli ölçüde etkilediğini göstermektedir. Bu durum, acil bakımın optimize edilmesi ve hasta sonuçlarının iyileştirilmesi için çoklu yaralanmalı olayların bu tür hasta sayılarına dayalı olarak tanımlanmasının gerekliliğini düşündürmektedir. Bu kritik durumlarda hasta bakımı ve kaynak tahsisini geliştirmek için objektif ve sonuç odaklı kriterlerin belirlenmesi büyük önem taşımaktadır.

Anahtar sözcükler: Pediatrik Aciller, Ateşli Silah Yaralanmaları, Çoklu Yaralanmalı Olaylar, Travma Şiddet İndeksleri, Acil Servis Kullanımı

Ulus Travma Acil Cerrahi Derg 2025;31(2):167-177 DOI: 10.14744/tjtes.2025.35961