MARMARA
MEDICAL JOURNAL

Original Article

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Epidemiological characteristics and predictors of surgical intervention in forensic sharp and penetrating injuries

Mustafa ALTUN[1], Mehmet Birkan KORGAN[1], Emre KUDU[2], Mustafa AYTEMIZ[2], Gizem BOZKURT[2], Furkan YAKIN[1], Sinan KARACABEY[2], Erkman SANRI[2]

[1] Department of Emergency Medicine, Marmara University Pendik Training and Research Hospital, Istanbul, Turkiye
[2] Department of Emergency Medicine, School of Medicine, Marmara University, Istanbul, Turkiye
Corresponding Author: Mustafa ALTUN
E-mail: mustaffaltun@gmail.com

Submitted: 18.08.2025 **Accepted:** 25.12.2025

ABSTRACT

Objective: This study aimed to analyze the epidemiological and clinical characteristics of forensic sharp and penetrating injuries and to identify independent predictors of surgical intervention in a tertiary trauma center.

Patients and Methods: This retrospective cohort study included all patients presenting with forensic-reported sharp and penetrating injuries to a level 1 trauma center between January 1 and December 31, 2024. Demographic characteristics, injury mechanisms, anatomical injury locations, vital signs, imaging use, and clinical outcomes were extracted from electronic health records. The primary outcome was the need for surgical intervention. Univariate and multivariate logistic regression analyses were performed to identify independent predictors of surgery.

Results: A total of 1,076 patients were included, of whom 123 (11.4%) required surgical intervention. The cohort was predominantly male (85.8%) with a median age of 30 years. Upper extremity trauma was the most common anatomical site (73.8%), particularly in self-inflicted cases. Hemodynamic instability at presentation was strongly associated with surgery (OR 10.70). Increasing age was independently associated with surgical intervention, with each additional year increasing the odds by approximately 3%. Male sex (OR 3.45) and foreign nationality (OR 3.69) were also independent predictors. Injuries involving the head, maxillofacial, or neck region were associated with a lower likelihood of surgical management (OR 0.18).

Conclusion: In this large, single-center cohort of forensic sharp and penetrating injuries, older age, male sex, foreign nationality, and hemodynamic instability at presentation emerged as key early predictors of surgical intervention, while head, maxillofacial, and neck injuries were less likely to require operative management. These findings underscore the value of early clinical assessment and region-specific trauma data in supporting timely surgical decision-making, injury-prevention strategies, and local trauma system planning.

Keywords: Sharp trauma, Penetrating injury, Surgical intervention, Predictors, Forensic cases

1. INTRODUCTION

Penetrating injuries caused by sharp objects represent a significant public health concern, contributing substantially to the global burden of trauma care [1,2]. These injuries encompass a wide range of scenarios, including stab wounds, self-inflicted wrist lacerations, and occupational accidents [3,4]. The consequences are not limited to fatal outcomes; survivors often experience lasting physical and psychological sequelae [3,5]. These may include functional limitations due to musculoskeletal or neurovascular damage, increased risk of infection, and long-term conditions such as post-traumatic stress disorder [6,7]. The complexity of these injuries underscores the critical need for prompt diagnosis, effective stabilization, and appropriate triage in emergency settings [8,9].

In both Türkiye and worldwide, the widespread presence of sharp objects in daily life, rising trends in interpersonal violence and self-harm, and insufficient workplace safety measures

How to cite this article: Altun M, Korgan BM, Kudu E, et al. Epidemiological characteristics and predictors of surgical intervention in forensic sharp and penetrating injuries. Marmara Med J 2026;39(2): 116-122. doi: 10.5472/marumj.1951357

This manuscript was presented as an oral presentation at the 2025 National Emergency Medicine Congress, June 12-14, 2025, Kyrenia, Cyprus, and was published in abstract form in the congress proceedings.

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ISSN: 1309-9469

http://doi.org/10.5472/marumj.1951357
Marmara Med J 2026;39(2): 116-122

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impose an increasing burden on clinical and forensic systems [5]. Previous studies in Türkiye have reported similar patterns, with a predominance of young males exposed to stab wounds due to assaults and occupational accidents, often focusing more on interpersonal violence and less on self-inflicted injuries [4,5]. Despite the growing incidence, there remains a paucity of region-specific epidemiological and clinical data, which hinders the development of effective trauma management strategies. Regional trauma reports from high-volume tertiary centers provide context-specific insights into injury patterns, mechanisms, and resource utilization that may not be fully captured in national datasets. Such descriptive studies help identify local trends in penetrating trauma, support injury-prevention strategies, optimize emergency medical services and emergency department (ED) workflows, and inform hospital-level and regional trauma system planning, particularly in settings where trauma registries are limited or still developing [10].

This study aimed to describe the epidemiological and clinical characteristics of forensic sharp and penetrating injuries in a tertiary trauma center and to identify independent predictors of surgical intervention in this cohort.

2. PATIENTS and METHODS

Study design and settings

This study is a single-center, retrospective cohort study conducted at Marmara University Hospital, a level 1 trauma center equipped with advanced diagnostic and surgical facilities. The study protocol was approved by the Marmara University Clinical Research Ethics Committee (protocol number: 09.2025.25-0389). The study was conducted following the principles of the Declaration of Helsinki, and the reporting adhered to the STROBE guidelines for observational studies.

Study Participants

All patients admitted to Marmara University Pendik Training and Research Hospital with forensic-reported sharp and penetrating injuries between January 1 and December 31, 2024, were retrospectively analyzed. Patients with missing critical data (e.g., unspecified clinical outcome status) were excluded from the study. Additionally, needlestick injuries reported for healthcare personnel, documented for occupational accident procedures, and not requiring trauma treatment, were excluded. Firearm-related injuries were also excluded to focus specifically on injuries caused by sharp and penetrating objects such as knives, glass, or other cutting implements. Each ED presentation was considered an independent case. Recurrent presentations by the same patient were included as separate cases if they represented distinct injury events.

Variables and data sources

Data were collected from the electronic health records and patient files of Marmara University Pendik Training and Research Hospital. Patients were screened based on records categorized as occupational accidents, forensic cases, and traffic accidents in the ED. For each patient, demographic information (age and gender) and the mechanism of injury were recorded. The mechanism of injury was categorized as self-inflicted (intentional or unintentional) or caused by others (inflicted by an acquaintance or an unknown individual), based on patient reports and forensic documentation. Clinical variables included the anatomical location of the injury (head/neck, chest, abdomen, upper extremity, lower extremity), use of imaging modalities (computed tomography (CT) or X-ray), consultation requirements, and the need for blood transfusion or surgical intervention during treatment. Injuries involving more than one anatomical region were classified as multiregional trauma. Patients with multiregional injuries were included in each relevant anatomical injury category, and the multiregional trauma variable was used to indicate the presence of injuries affecting multiple body regions. Vital signs at admission were recorded according to internationally accepted standards, as outlined in the Advanced Trauma Life Support (ATLS) 11th edition. (systolic blood pressure < 90 mmHg, heart rate > 100 beats/min, respiratory rate (>29 breaths/min) or peripheral oxygen saturation (SpO_2) < 94%), and patients were classified as having stable or unstable vital signs [11]. Furthermore, the length of hospital stay and clinical outcomes (discharge, admission, or in-hospital mortality) were documented.

Outcomes

The primary outcome of the study is the need for surgical intervention. Surgical intervention was defined as any invasive procedure performed for the management of penetrating injuries during the index hospital admission. "Surgical intervention" encompassed both operating-room procedures and ED/bedside procedures (e.g., tube thoracostomy, extensor tendon repair), unless otherwise specified. Secondary outcomes include the mechanism of injury (self-inflicted vs. injured by others), length of hospital stay, and clinical outcome (discharge, ward, Intensive Care Unit (ICU), or death in the ED).

Statistical analysis

Statistical analyses were conducted using JAMOVI 2.6.26 software. The distribution of continuous variables was examined visually through histograms. Categorical data were reported as frequencies and percentages. Numerical variables with normal distribution were expressed as mean ± standard deviation, while those with non-normal distribution were presented as median and interquartile range. Differences between groups were assessed using the Chi-square test for categorical variables and, for continuous variables, either the independent samples t-test or the Mann-Whitney U test based on their distribution. Univariate logistic regression analysis was performed to identify predictors of the need for surgical intervention. Variables included in the multivariate model were selected based on clinical relevance and a univariate analysis threshold of $p < 0.1$, to minimize the exclusion of potentially significant predictors. Multicollinearity among independent variables included in the multivariate logistic regression model was assessed using

http://doi.org/10.5472/marumj.1951357
Marmara Med J 2026;39(2): 116-122

variance inflation factors (VIFs). A VIF value greater than 5 was considered indicative of significant multicollinearity, and variables exceeding this threshold were carefully evaluated prior to model inclusion [12].

3. RESULTS

Overall cohort and patient flow

A total of 1,364 forensic sharp and penetrating injury cases were initially identified at Marmara University Pendik Training and Research Hospital between January 1 and December 31, 2024. Of these, 126 patients with needlestick injuries reported for healthcare personnel, documented for occupational accident procedures, and not requiring trauma treatment, were excluded. Additionally, 119 patients with firearm-related injuries were excluded to focus specifically on injuries caused by sharp and penetrating objects. Furthermore, 43 patients who were discharged against medical advice or transferred to another facility were also excluded. Consequently, a total of 1,076 patients with sharp and penetrating injuries were analyzed during the study period. Of these, 123 patients (11.4%) required surgical intervention, while 953 patients (88.6%) were managed without surgery. Surgical procedures were most frequently associated with upper extremity trauma, followed by thoracic and abdominal/pelvic injuries. The distribution of interventions by anatomical regions and patient flow throughout the study cohort is presented in detail in Figure I. (Of 123 surgical patients, some required multiple procedures, leading to a higher overall count of interventions).

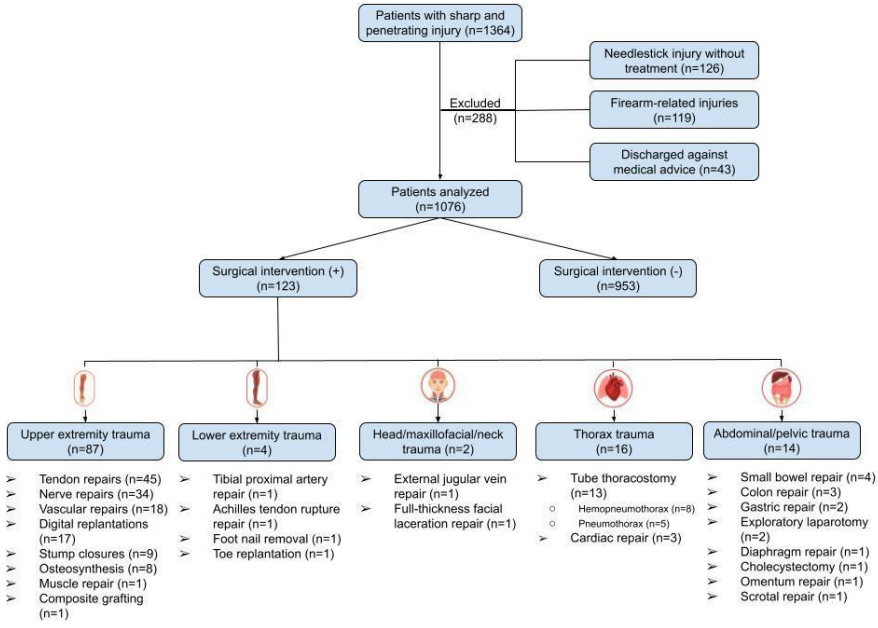


Figure I. *Flowchart of patient selection and distribution of surgical interventions by anatomical regions and procedures*

Note: Some patients required interventions in multiple anatomical regions or multiple procedures, resulting in a higher total count of interventions than the number of surgical patients (n=123).

Clinical characteristics by surgical intervention

Of the included patients, 923 patients were male (85.8%), with a median age of 30.0 (23.0-42.0) years. Among the patients, 945 (87.8%) were discharged from the ED, while 131 (12.2%) were admitted to the hospital. Of those admitted, 122 were admitted to wards, and nine were monitored in the intensive care unit. One patient (0.09%) died in the hospital, with this mortality occurring in the ICU.

The primary outcome, the need for surgical intervention, was identified in 123 patients (11.4%). Patients requiring surgery had a higher median age of 36.0 years (IQR: 27.0–47.5) compared to 29.0 years (IQR: 22.0–41.0) in non-surgical cases ($p < 0.001$). Surgical intervention was more frequent in males (12.7% vs. 3.9% in females, $p = 0.002$) and in foreign nationals (25.0% vs. 11.1% in Turkish citizens, $p = 0.035$). Injury mechanisms revealed that 832 patients (77.3%) sustained self-inflicted injuries, while 244 (22.7%) were injured by others, with no significant difference in surgical requirements between the groups ($p = 0.104$). Clinical assessments showed that hemodynamic unstable patients had markedly higher surgical needs (80.0% vs. 11.1% in stable patients, $p < 0.001$). Similarly, among 22 patients who required

http://doi.org/10.5472/marumj.1951357
Marmara Med J 2026;39(2): 116-122

blood transfusion, 86.4% underwent surgery compared to 9.9% of those not transfused (p < 0.001). Imaging modalities were also strongly associated with operative management. X-ray was performed in 89.4% of surgical patients compared to 61.7% of non-surgical cases (p < 0.001), while CT was used in 43.9% and 20.0%, respectively (p < 0.001). Notable differences were also observed across clinical outcomes, including discharge, hospitalization, and intensive care (p = 0.001). Length of stay was another differentiating factor. A total of 146 patients (13.6%) had a hospital stay longer than 8 hours, and 109 (10.1%) stayed longer than 24 hours. Of these, 73.3% and 79.8%, respectively, required surgery (both p < 0.001). Among patients undergoing surgery, the median length of stay was 66 hours (IQR: 32–118). All surgical patients with a hospital stay shorter than 8 or 24 hours had hand surgery-related injuries. Detailed comparisons of demographic, clinical, and outcome characteristics between surgical and non-surgical patients are presented in Table I.

Table I. *Demographic, clinical, and outcome characteristics by surgical intervention requirement*

Variable, n (%)	No Surgical Intervention (n=953)	Surgical Intervention (n=123)	p value
Age (years), median (IQR)	29.0 (22.0-41.0)	37.0 (27.0-47.5)	< 0.001
Gender			0.002
Male	806 (84.6%)	117 (95.1%)	
Female	147 (15.4%)	6 (4.9%)	
Nationality			0.035
Turkish Citizen	935 (98.1%)	117 (95.1%)	
Foreign National	18 (1.9%)	6 (4.9%)	
Injury Mechanism			0.104
Self-inflicted	744 (78.1%)	88 (71.5%)	
Injured by others	209 (21.9%)	35 (28.5%)	
Injured by Others			0.705
By acquaintance	50 (23.9%)	10 (28.6%)	
By unknown individual	159 (76.1%)	25 (71.4%)	
Self-inflicted Injury Type			0.460
Intentional	17 (2.3 %)	3 (3.4%)	
Unintentional	727 (97.7%)	85 (96.6%)	
Vital Signs			<0.001
Stable	952 (99.9%)	119 (96.7%)	
Unstable	1 (0.1%)	4 (3.3%)	
Blood Transfusion	3 (0.3%)	19 (15.4%)	<0.001
X-ray Performed	588 (61.7%)	110 (89.4%)	<0.001
CT Performed	191 (20.0%)	54 (43.9%)	<0.001
Clinical Outcome			0.001
Discharged from ED	929 (97.5%)	16 (13.0%)	
Admitted to ward	24 (2.5%)	98 (79.7%)	
Admitted to ICU	0 (0.0%)	9 (7.3%)	
Hospital Stay >8 Hours	39 (4.1%)	107 (87.0%)	<0.001
Hospital Stay >24 Hours	8 (0.8%)	101 (82.1%)	<0.001

IQR: Interquartile range, CT: Computed tomography, ED: Emergency Department, ICU: Intensive Care Unit

Anatomical distribution and multiregional trauma

The need for surgical intervention was evaluated according to the anatomical location of trauma and the presence of multiregional involvement. Among the 1076 patients, 794 (73.8%) had upper extremity trauma, 180 (16.7%) had lower extremity trauma, 90 (8.4%) had head/maxillofacial/neck trauma, 71 (6.6%) had thoracic trauma, 99 (9.2%) had abdominal/pelvic trauma, and 10 (0.9%) had spinal trauma. In addition, 113 patients (10.7%) presented with multiregional trauma. Thoracic trauma (p = 0.002) and multiregional trauma (p = 0.027) were significantly associated with a higher likelihood of requiring surgical intervention. In contrast, head/maxillofacial/neck trauma (p = 0.004) and lower extremity trauma (p < 0.001) were significantly associated with a lower likelihood of surgical intervention. No significant associations were observed for upper extremity (p = 0.412), abdominal/pelvic (p = 0.376), or spinal trauma (p = 0.254). Detailed comparisons of surgical intervention requirements by anatomical region and multiregional trauma are summarized in Table II.

Table II. *Surgical intervention requirements by anatomical region and multiregional trauma*

Variable, n (%)	No Surgical Intervention (n=953)	Surgical Intervention (n=123)	p value
Upper Extremity Trauma	707 (74.2%)	87 (70.7%)	0.412
Lower Extremity Trauma	176 (18.5%)	4 (3.3%)	<0.001
Head/Maxillofacial/Neck Trauma	88 (9.2%)	2 (1.6%)	0.004
Thorax Trauma	55 (5.8%)	16 (13.0%)	0.002
Abdominal/Pelvic Trauma	85 (8.9%)	14 (11.4%)	0.376
Spinal Trauma	10 (1.0%)	0 (0.0%)	0.254
Multiregional Trauma	93 (9.8%)	20 (16.3%)	0.027

Stratified analyses by injury mechanism

Surgical intervention was required in 88 (10.6%) of 832 self-inflicted cases and in 35 (14.3%) of 244 cases injured by others, with no statistically significant difference between the two groups (p = 0.243). Patients with self-inflicted injuries were significantly older than those injured by others (median age 31.5 vs. 26.0 years, p < 0.001). Within both injury mechanisms, patients who required surgical intervention were significantly older than those managed non-operatively. In the self-inflicted group, surgical patients had a higher median age than non-surgical patients (40.5 vs. 31.0 years, p < 0.001). Similarly, among patients injured by others, those requiring surgery were older than those not requiring surgery (33.0 vs. 26.0 years, p = 0.011).

Among patients requiring surgical intervention, marked differences were observed in the anatomical distribution of injuries according to injury mechanism (Table III). In the self-inflicted group, upper extremity injuries were by far the most common, occurring in 79 patients (89.8%), whereas this pattern was significantly less frequent among patients injured by others. In contrast, among patients injured by others, thoracic

http://doi.org/10.5472/marumj.1951357
Marmara Med J 2026;39(2): 116-122

injuries (14 patients, 40.0%) and abdominal/pelvic injuries (12 patients, 34.3%) were the most frequently observed surgical injury sites, both occurring significantly more often than in self-inflicted cases. Multiregional trauma was also substantially more common in patients injured by others (19 patients, 54.3%) compared with self-inflicted injuries (1 patient, 1.1%; $p < 0.001$).

Table III. *Age and anatomical distribution of surgically treated injuries according to injury mechanism*

Variable	Self-inflicted (n=88)	Injured by others (n=35)	p value
Age, median (IQR)	31.5 (24.0–43.0)	26.0 (19.0–35.3)	<0.001
Anatomical region			
Upper extremity	79 (89.8%)	8 (22.9%)	<0.001
Lower extremity	3 (3.4%)	1 (2.9%)	0.876
Head / maxillofacial / neck	2 (2.2%)	0 (0.0%)	0.369
Thoracic	2 (2.3%)	14 (40.0%)	<0.001
Abdominal/ pelvic	2 (2.3%)	12 (34.3%)	<0.001

IQR: Interquartile range

As shown in Table I, among the self-inflicted group, 20 patients intentionally injured themselves, with 3 (15.0%) requiring surgery, compared to 812 unintentional cases, of whom 85 (10.5%) required surgery ($p = 0.460$). Among patients injured by others, 60 cases were inflicted by an acquaintance (16.6% required surgery), while 184 were inflicted by an unknown individual (13.6% required surgery), with no significant difference between these subgroups ($p = 0.705$).

Multivariate predictors of surgical intervention

Multivariate logistic regression analysis identified several independent predictors of surgical intervention, as presented in Table IV. Increasing age, male sex, foreign nationality, and hemodynamic instability (unstable vital signs) were associated with a higher likelihood of requiring surgery. In contrast, injuries involving the head, maxillofacial, or neck region were associated with a substantially lower likelihood of surgical treatment. Increasing age was modestly but significantly associated with a higher likelihood of requiring surgery, with each additional year raising the odds by approximately 3%. Hemodynamic instability emerged as the most influential predictor, increasing the odds of surgical intervention by nearly 11-fold, although the wide confidence interval suggests variability in this estimate. Male sex and foreign nationality were each associated with an approximately 3.5-fold higher probability of surgical intervention. Thoracic and lower-extremity injuries were not independently associated with the need for surgery in the adjusted model. Overall, these findings indicate that demographic characteristics, injury location, and initial physiological status are key determinants of surgical intervention in patients with forensic sharp and penetrating injuries.

Table IV. *Multivariate Logistic Regression Analysis of predictors for surgical intervention*

Predictor	OR	95% CI	p value
Age (per year increase)	1.03	1.01–1.04	<0.001
Male vs. female	3.45	1.48-8.06	0.004
Foreign vs. Turkish nationality	3.69	1.39-9.79	0.009
Head / Maxillofacial / Neck trauma	0.18	0.05-0.66	0.010
Thorax trauma	1.34	0.64-2.79	0.438
Lower Extremity Trauma	0.68	0.38-1.24	0.212
Hemodynamic instability (unstable vital signs)	10.70	1.39-82.55	0.023

OR: Odds ratio, CL: Confidence level

4. DISCUSSION

This study provides a comprehensive regional trauma report of forensic sharp and penetrating injuries managed over a one-year period at a high-volume, level 1 tertiary trauma center. By simultaneously examining both self-inflicted and assault-related injuries within a single cohort, the present analysis offers a more complete depiction of penetrating trauma patterns encountered in routine emergency practice. In addition, the explicit evaluation of early predictors of surgical intervention adds clinically relevant insight into factors that may support timely decision-making during initial assessment. Together, these findings highlight the value of high-volume regional trauma data for informing clinical care, injury-prevention strategies, and local trauma system planning, particularly in settings where comprehensive trauma registries remain limited. The predominance of young adult males (median age 30 years; 85.8% male) aligns with prior research indicating that this demographic bears the highest burden of penetrating trauma due to occupational exposure and violent mechanisms of injury [1,4,13]. The association between older age and surgical intervention supports literature suggesting that older patients may sustain more severe injuries due to reduced physiological reserve or complex injury patterns, necessitating operative management [14]. Specifically, patients with self-inflicted injuries had a higher median age compared to those injured by others, possibly due to risk-taking behaviors or exposure to interpersonal violence, consistent with findings in diverse settings [15]. Within both injury mechanism groups, older patients were more likely to require surgery, suggesting that advanced age may contribute to increased injury severity or comorbidities [14]. Injury patterns in this study also parallel prior observations: upper extremity trauma was the most frequent site overall, particularly in self-inflicted injuries, whereas thorax, abdominal/pelvic, and multiregional trauma were more strongly associated with assaults [16].

In the multivariate model focusing on early predictors available at initial clinical assessment, increasing age, male sex, foreign nationality, and hemodynamic instability emerged as independent predictors of surgical intervention. In contrast, injuries involving the head, maxillofacial region, or neck were independently associated with a lower likelihood of

http://doi.org/10.5472/marumj.1951357
Marmara Med J 2026;39(2): 116-122

surgical intervention. This likely reflects the predominance of superficial soft-tissue injuries in these anatomical regions within the present cohort, many of which can be managed conservatively without operative treatment. Hemodynamic instability at presentation was the strongest predictor of surgical intervention in this cohort, underscoring the critical role of early physiological assessment in identifying patients who may require urgent operative management. This finding aligns with established trauma principles, where abnormal vital signs serve as key indicators of occult hemorrhage or severe internal injury and guide rapid decision-making in both prehospital and ED settings [11,17]. Older age has been consistently associated with increased injury severity and reduced physiological reserve, which may contribute to a higher likelihood of operative management in penetrating trauma [14]. Male sex and foreign nationality were each associated with an approximately three – to four-fold increased probability of requiring surgical intervention. The association with male sex may reflect a higher prevalence of assault-related and occupational penetrating injuries among men [1,4,15], whereas the effect observed for foreign nationality is more likely related to occupational hazards, delayed presentation, and potential barriers to timely access to health care, as suggested in previous studies [18-20]. Thorax trauma was significantly associated with surgical intervention in the univariate analysis, but did not remain an independent predictor after adjustment. This finding contrasts with previous literature, where thoracic penetrating trauma is often linked to high morbidity and mortality, particularly in the presence of major vascular or pulmonary injury [21]. In-hospital mortality was very low (0.09%), consistent with the predominance of noncritical injuries in the study cohort and potentially reflecting the level 1 trauma center's rapid care capabilities [22].

This study has several limitations that should be acknowledged. First, its single-center, retrospective design may limit generalizability, as trauma patterns, patient characteristics, and management practices can vary across regions and health-care systems. The retrospective nature of the study also introduces the potential for selection bias, particularly due to the exclusion of cases with incomplete records, as well as information bias related to variability between forensic documentation and ED clinical records. Second, several potentially relevant variables were not available in the dataset, including psychosocial characteristics, injury-to-admission time, and detailed prehospital information. The absence of these factors limited the ability to fully adjust for all possible confounders and to explore their influence on early surgical decision-making. In addition, the relatively small proportion of foreign nationals in the cohort may limit the robustness of conclusions related to nationality and warrants cautious interpretation. Finally, although multivariate analyses were designed to focus on early predictors available at initial assessment, unmeasured clinical factors and institutional practice patterns may still have influenced surgical decision-making. Therefore, the findings should be interpreted in the context of these limitations, and future multicenter prospective studies are needed to validate and extend these results.

In conclusion, older age, male sex, foreign nationality, and hemodynamic instability at presentation emerged as key early predictors of surgical intervention, while head, maxillofacial, and neck injuries were less likely to require operative management. These findings highlight the value of early clinical assessment and region-specific trauma data in supporting timely surgical decision-making, injury-prevention strategies, and local trauma system planning.

Compliance with Ethical Standards:

Ethical approval: Marmara University Clinical Research Ethics Committee approved the study protocol (protocol number: 09.2025.0389; May 23, 2025).This work was conducted ethically by following per under Helsinki World Medical Association Declaration.

Funding Information: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of Interest: None.

Authors' contribution: MA: Conceptualization, data curation, formal analysis, investigation, methodology, project administration, software, visualization, and writing – original draft (lead), MBK and EK: Data curation, investigation, methodology, software, and writing – original draft (supporting), MAY, GB, and FY: Data curation, investigation, and writing – original draft (supporting), SK and ES: Supervision, validation, writing – review and editing. All authors read and approved the final submitted version of the manuscript.

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