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Prediction of the Outcomes, Prognosis, and Mortality of Gunshot Victims Based on Trauma Scoring Systems in a Trauma Center in South of Iran

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Abstract

Background: The current study aimed to successively assess the applicability of trauma scoring systems.
Objectives: To evaluate the outcomes, prognosis, and mortality in trauma patients.
Methods: The present study was conducted on all 221 injured patients referred to Shahid Rajaee Hospital from January 2014 to December 2020 with International Classification of Diseases-10th Revision (ICD-10) injury mechanism codes of W32.0-34.09, indicating a firearm injury. Univariate analysis and Chi-square test were employed to discover the individual relationship between each variable and the injury outcome. Logistic regression analysis was performed to control the confounder. Finally, the area under the Receiver Operating Characteristic (ROC) curve was used to compare the predictive efficiency of the injury severity scales.
Results: The mortality rate of the gunshot was 15 (6.78%). The cause of the gunshot was related to assaults in 73.68% of the surviving patients. Meanwhile, suicide attempt was the second cause of death in gunshot patients (16.67%). Most of the injuries that occurred among 20-24-year-old patients resulted from assaults. The odds of mortality in gunshot victims increased by 4.25 times (95% CI [1.99, 9.10]) for each additional unit Abbreviated injury scale (AIS). In the random forest model, the Trauma Injury Severity Score (TRISS) was the most important mortality predictor. The TRISS was the highest area under the ROC curve for death prediction among firearms gunshot patients.
Conclusion: Injury Severity Score (ISS) had the least, and TRISS had the most area under the curve. Therefore, TRISS was found to be the best predictor in determining the death or survival of firearms gunshot patients.

Keywords: Gunshot, Mortality, Scoring systems, Wounds

1. Background

Although civilian gunshot injuries are considerably more prevalent in the West (1), worldwide firearms mortality and morbidity are substantial, with an estimated number of 196,000-229,000 deaths in 2000 (2), and 251,000 firearm deaths in 2016 (3). Fortunately, strict gun ownership laws in Iran have resulted in a very low civilian firearm-related mortality (4), and the majority of firearm traumas originate from the Iran-Iraq war back in the 1980s (5). Nonetheless, considering the rising prevalence of suicide and unintentional gunshot injuries (6, 7), the importance of studying firearm injury may be revived again in this region.

Accurate prognosis of gunshot victims allows for the allocation of appropriate resources and discussions with clinical support teams (8). In addition, the results of previous studies have shown that using a method to assess the severity of injuries can be useful in managing the fate of patients. Several studies have compared different methods to assess the severity of injuries in traumatic patients (9, 10). Using methods to determine the severity of injuries and the extent of damage to patients can help determine critical conditions and prepare accurate medical-legal reports, especially in the case of patients with gunshots. Meanwhile, a hospital-based view of firearm-related injuries provides proper coverage over non-fatal and fatal injuries of various intents.

2. Objectives

Therefore, the present study aimed to determine the effectiveness and practicality of various types of injury severity scores, including Glasgow Coma Scale (GCS), Injury Severity Score (ISS), Revised Trauma Score (RTS), and Trauma Injury Severity Score (TRISS) in identifying the crucial status of the victims of weapons.

3. Methods

3.1. Study Design

This study was conducted at the Trauma Research Center affiliated with Shiraz University of Medical Sciences as a cross-sectional assessment of all firearm-related injuries referred to Shahid Rajaee (Emtiaz) Hospital regarding injury characteristics and hospitalization outcomes. Data from two hospital administrative databases (admission unit and medical records unit) were used as the primary data sources regarding injury characteristics and surgical

interventions for each patient.

Shahid Rajaee Emergency Center (Emtiaz) is one of the most equipped hospitals in Fars province, Iran. The total area of the hospital is 22,500 square meters with two separate buildings comprising six floors and 335 beds, including emergency rooms, wards, ICU, VIP, operating room, a specialized clinic, paraclinical units, labs, radiology, CT SCAN, physiotherapy, and administrative units. Moreover, this hospital is the largest trauma center in Fars province.

3.2. Patients and sampling method

The study was conducted on all injured patients referred to Shahid Rajaee Hospital from January 2014 to December 2020 with International Classification of Diseases-10th Revision (ICD-10) injury mechanism codes of W32.0-34.09, indicating a firearm injury. Patients with sequelae of previous firearm trauma (T79.9-T98.2) were excluded. Using continuous sampling, 221 cases were enrolled in the study.

3.3. Measurements and data collection

The data were manually retrieved from hard-copy medical records based on the patient's identification number in the hospital trauma registry. A data-gathering form was designed containing four parts. In the first part, demographics, including age, gender, previous medical disease history, admission and discharge date/time, and length of hospitalization were recorded. The second section dealt with the data regarding injury intent, firearm type, ballistic entrance site and depth of penetration, injured body regions and the associated internal organs, injury severity based on AIS, ISS, GCS, and TRISS scales (9), and physiological determinants upon admission (systolic/diastolic blood pressure, heart rate, respiratory rate, and presence of hemodynamic shock). In the third part, emergency department surgical interventions and the need for ICU admission or resuscitation were recorded. Finally, the outcome and possible complications associated with medical care during the hospitalization were recorded in the fourth part. After all, the data for each patient was coded and transferred to the SPSS software for statistical analysis.

3.4. Statistical analysis

The Statistical Package performed all descriptive and inferential statistical analyses for the Social Sciences software (SPSS, version 18). Continuous variables were checked for normality using the Shapiro-Wilk test. The normally distributed data was presented using mean and Standard Deviation (SD), while median and interquartile ranges were used in case of violation of the normality assumption. Categorical variables were presented using frequency and percentage. Student t-test was employed to compare normally distributed continuous variables.

The Chi-square test was used to compare categorical variables for bivariate analysis. A two-sided *P*-value of less than 0.05 was considered statistically significant. We also used logistic regression analysis to control the confounding variable. We also ran Random Forrest to express the importance of variables on firearm mortality using R software (version 3.5.0). The area under the Receiver Operating Characteristic (ROC) curve was used to evaluate the efficiency of each injury severity scale and to detect its sensitivity and specificity.

4. Results

4.1. Characteristics of the gunshot victims

There were 221 patients with injury-related gunshots, with a mortality rate of 15 (6.78%). The mean age of the surviving patients was 34.23 ± 3.73 years. Among these patients, 5.34% were female, and 94.66% were male. The cause of gunshot was related to assaults in 73.68% of the survived and 83.33% of the non-survived patients. Suicide attempt was the second cause of death among gunshot patients (16.67%). Moreover, the shotgun was the most common firearm among gunshot injuries (Table 1).

The results indicated that the highest frequency of injuries in the first bullets belonged to extremities among surviving patients (114 of 206). A single bullet injured about 50% of the patients. The results revealed no significant relationships between the number of bullets and the results of injuries. The most common interventions for the surviving patients included exploration and Irrigation and Debridement (I & D) / conservative management, laparotomy, thoracotomy, and Open Reduction and Internal Fixation (ORIF). However, 10 out of the 221 injured patients received no interventions because they did not survive. The severity of injuries, GCS, RTS, and TRISS of the non-survived patients were 21.5 ± 7.58, 5.57 ± 3.81, 4.32 ± 1.77, and 51 ± 30.46, respectively, which were significantly different from those of the survived patients.

The percentages of intent behind gunshot-related injuries in terms of age categories have been presented in Figure 1. Accordingly, the assault was the most common intent of injuries in all age groups. The highest percentage of intents was assaulted among 20-24-year-old injured patients. Furthermore, legal intervention (40%) was the second cause of injury among gunshot trauma patients aged under 19 years. Moreover, unintentional gunshot injuries were frequent among the 20-24 and over 45 age groups.

The distribution of injuries based on intents has been depicted in Figure 2. Accordingly, the most common injuries were head and neck, comprising about 40% of total injuries in suicide attempts. On the other hand, extremities, followed by the thorax,

Table 1. Characteristics of the survived and non-survived injured patients

Variables	Results of injury		*P*-value
	Survival (n=206)	Death (n=15)	
Age (mean ± SD*)	28.55±0.61	34.23±3.73	0.02
Sex			
Male	195 (94.66)	15(100)	0.35
Female	11 (5.34)	0	
Intent of injury			
Assaultive	152 (73.68)	12 (83.33)	
Unintentional	30 (14.74)	0	0.74
Suicide attempt	20 (9.47)	3 (16.67)	
Legal intervention	4 (2.11)	0	
Firearm class			
Shotgun	114 (71.88)	14 (90.91)	
Handgun	60 (27.34)	1 (9.09)	0.33
Machine gun	2 (0.78)	0	
Type of injuries in the first bullet			
Head and neck injuries	27 (13.11)	8 (55.33)	
Face injuries	2 (0.97)	0	
Thorax injuries	34 (16.50)	4 (26.67)	<0.001
Abdomen injuries	29 (14.08)	2 (13.33)	
Extremities	114 (55.34)	1 (6.67)	
Number of bullets			
One	122 (59.22)	8 (53.33)	
Two	54 (26.21)	5 (33.33)	0.83
Three	30 (14.56)	2 (13.33)	
Operation			
Exploration and I&D‡ /conservative management	54 (26.21)	0	
Laparotomy and thoracotomy	53 (25.73)	0	
ORIF¥	42 (20.39)	0	
Thoracotomy/thoracostomy tube	22 (10.68)	2 (13.33)	
Laparotomy /laparoscopy	20 (9.71)	1 (6.67)	
Vascular surgery	7 (3.4)	1 (6.67)	<0.001
Arthroscopy chondroplasty	3 (1.46)	0	
Amputation	2 (0.97)	0	
Craniotomy	2 (0.97)	1 (6.67)	
ORIF and thoracotomy	1 (0.49)	0	
CPR (death on arrival)	0	10 (66.67)	
ISS (mean ± SD)	8.14±7.62	21.5±7.58	<0.001
GCS (mean ± SD)	15.10±7.45	5.57±3.81	<0.001
RTS (mean ± SD)	7.70±0.45	4.32±1.77	<0.001
TRISS (mean ± SD)	98.29±4.32	51±30.46	<0.001

* Standard deviation of mean
‡ Irrigation and debridement
¥ Open reduction and internal fixation

were the main areas of injury in assaults and legal interventions.

4.2. Logistic regression and random forest of the firearm gunshot patients

Logistic regression was used to analyze the relationship between characteristics of gunshot victims and outcome status (Table 2). It was found that by holding other variables in the model constant, the odds of mortality in gunshot victims increased by 4.25 times (95% CI [1.99, 9.10]) for each additional unit AIS.

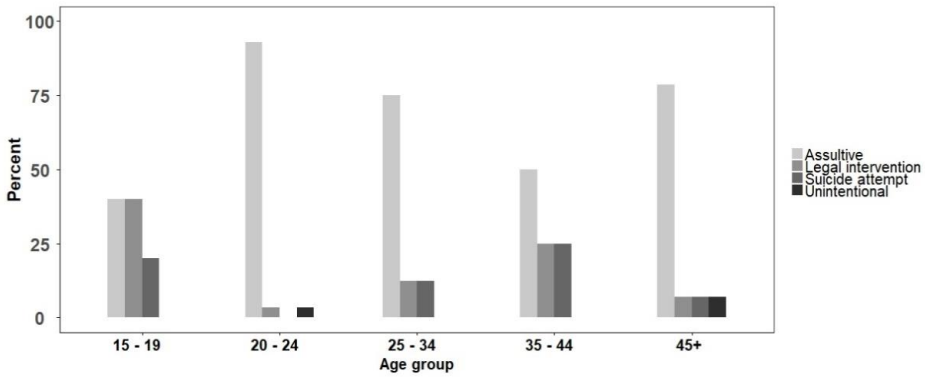

Figure 1. Intents of injuries stratified by age groups

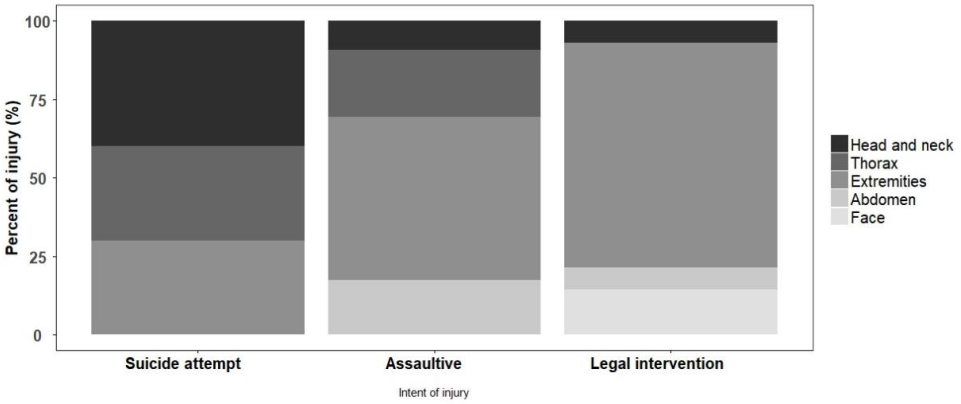

Figure 2. Injury type distribution based on the intent of the injury

The test classification accuracy of the random forest model was 93.21%. The three most important predictors of mortality were TRISS, GCS, and RTS (Figure 3).

4.3. Receiver Operating Characteristic (ROC) curve of trauma scoring systems of the firearm gunshot patients

The ROC curve model was performed to determine the sensitivity and specificity of each criterion, including ISS, GCS, RTS, and TRISS, regarding the outcome of injuries. As shown in Table 3, TRISS had the highest area under the ROC curve to predict death among firearms gunshot patients. After that, RTS (0.925) was the best criterion. Among the test variables, RTS had the best accuracy in death prediction. Additionally, TRISS was the best evaluator of correct stratification of the surviving patients.

According to Figure 4, ISS had the least, and TRISS had the most area under the curve. Therefore, TRISS was identified as the best predictor in determining the death or survival of firearm gunshot patients.

Table 2. Logistic regression of outcome status with characteristics of gunshot victims

Variable	Crude		Adjusted	
	OR (CI 95%)	P-value	OR (CI 95%)	P-value
Sex(male/female)	0.00 (0.00-.)	0.999	-	-
Age	1.044 (0.989-1.103)	0.120	-	-
Length of stay day	1.024 (.940-1.115)	.591	-	-
AIS	5.35 (2.48-11.56)	<0.001	4.25 (1.99, 9.10)	<0.001
ISS	.905 (.810-1.010)	0.074	-	-
GCS	0.532 (0.424-0.667)	0.025	-	-
RTS	0.191 (0.101-0.359)	.867	-	-
TRISS	0.869 (0.823-0.919)	0.665	-	-

Hosmer and Lemeshow Test: *P*-value=0.527

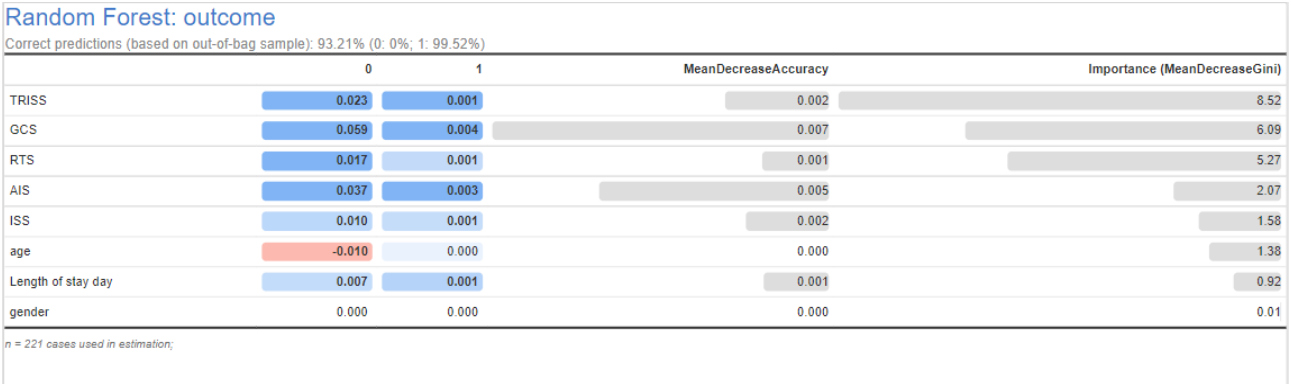

Figure 3. Random forest of outcome status with characteristics of gunshot victims

Table 3. Area under ROC curve, sensitivity, and specificity of ISS, GCS, RTS, and TRISS scores of the firearm gunshot patients

Test result variables	Area Under the Curve						
	Area	Std. error	*P*-value	Asymptotic 95% confidence interval		Sensitivity	Specificity
				Lower bound	Upper bound		
ISS	0.862	0.056	<0.001	0.752	0.973	80	67
GCS	0.881	0.081	<0.001	0.723	1.000	67.96	70
RTS	0.925	0.058	<0.001	0.810	1.000	80	71.69
TRISS	0.934	0.055	<0.001	0.827	1.000	82	70.01

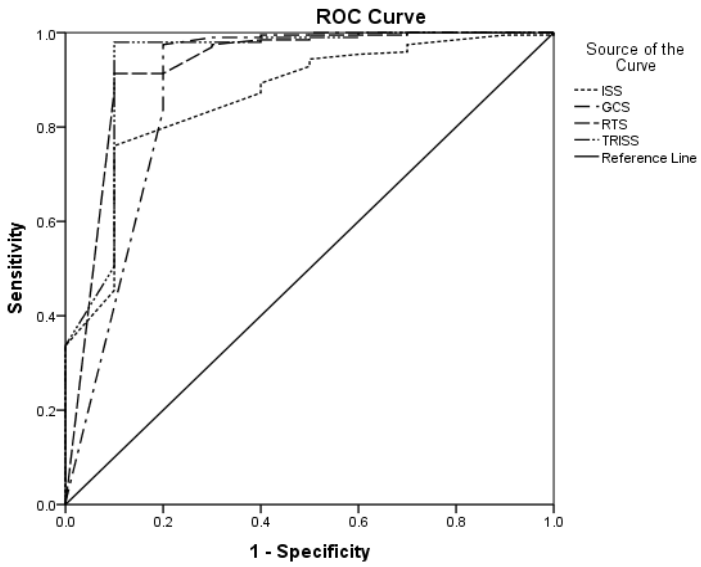

Figure 4. Sensitivity and specificity of ISS, GCS, RTS, and TRISS scores of firearm patients

5. Discussion

Much development and progress have been made in trauma care institutions in the last three decades. To reduce the complications and mortality associated with trauma, rapid triage and transfer of critically injured patients to a suitable center are important. Trauma scoring systems have been developed to assist in the proper transfer of patients. Our study aimed to evaluate whether trauma scoring systems (ISS, GCS, RTS, and TRISS) predict mortality in firearm gunshot patients.

The epidemiological studies on gunshot trauma indicated that most victims were young males who were hospitalized due to homicide. The present study also obtained similar results (1, 11, 12). However, the considerable point of the study was the increase in gunshot injuries related to legal interventions and homicide among the 15-19 and 20-24 age groups. In the current study, rifles and shotguns were the most prevalent firearms, while handguns were reported to be the most common firearms in other studies (13). This is quite justifiable because ownership of certain types of guns is legal in Iran, and permits are assigned to rifles for hunting purposes. In the present study, 10% of the patients sought release from the hospital instead of doctors' approval, while this rate was about half of the patients in a similar study in Nigeria (14).

In a similar study conducted in the United States (12), body organs (arms and legs) followed by chest, extremities, and abdomen were the most prevalent areas of gunshot injuries related to the first bullet. Because the type of firearms and pattern of injuries did not vary among patients, the cause of the incident might be associated with the location of the injury. For instance, the current study's findings revealed that most injuries occurred in heads and necks, which agrees with those of the study conducted among suicide patients in Turkey (15).

In the present study, 15 (6.79 %) patients died during their hospital stay, and 10 patients did not survive to reach the hospital. The in-hospital mortality rate was lower than a recent study performed in the United States (12). However, an accurate estimation of the mortality rate in Iran was not possible since the patients who died at the scene or within pre-hospital emergencies were not included in the study. The non-survived patients were all male and were injured mostly in the extremities, chest, and internal organs. There was a significant difference between the non-survived and survived patients regarding the severity of the injury, RTS, GCS, and TRISS.

This study indicated that the most prevalent causes of injuries were legal interventions and assaults in patients under 25 years old. Consequently, intervention and training to prevent gunshot injuries

in these ages will lead to fewer injuries. Moreover, careful treatment of people by the police force can reduce the number of injured patients in legal intervention and assault cases.

This study dealt with the epidemiological analysis of patients with gunshot injuries. According to the results, all gunshot victims were male, and their age distribution was greater than that of other trauma patients. Indeed, most gunshot cases were caused by homicide, and extremity injuries were the main cause of death among victims.

In this study, TRISS was found to be the best predictor of survival and death among gunshot trauma patients. It was able to correctly predict death in 82% of the patients with gunshot injuries. These results are consistent with those of the study conducted by Llullaku et al., which showed that TRISS enjoyed a higher accuracy in determining the status of trauma patients (16).

Previous studies focused on the epidemiological description of firearm injuries among fatal cases, and no comparison was made with the survived patients injured by bullet corrosion. Additionally, no study has been carried out to investigate the severity of gunshot injuries among hospitalized patients, while it is important to identify the severity of injuries to assess the severity of the disease. However, one of the limitations of this study was that the data associated with gunshot injuries was not specified for urban and suburban areas. Therefore, the rate of access to firearms was not specified in those regions. Moreover, data associated with people who were continuously exposed to gunshot injuries within these years were missing. Furthermore, ethnicity, race, and lifestyle are among the influential factors in gunshot injuries, which were not considered in this study.

6. Conclusion

The present study provides that TRISS could be a correct predictor of death in more than 82% of the patients. Hence, its evaluation in a pre-hospital emergency might be effective in how a patient is taken to the hospital.

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Footnotes

Conflicts of Interest: None.

Author contributions: MY: Contributed to the conception of the work, data collection, conducting the study, data analysis and interpretation of the study, revising the draft, approval of the final version of the manuscript, and agreed to all aspects of the work, ZM: Collection and entry of data collection and data entry manuscript writing and final approval of the manuscript, KJ: Translation and editing of the manuscript, MF: contributed in the conception of the work, conducting the study, revising the draft, approval of the final version of the manuscript, and agreed to all aspects of the work.

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References

1. Kalesan B, French C, Fagan JA, Fowler DL, Galea S. Firearm-related hospitalizations and in-hospital mortality in the United States, 2000–2010. *Am J Epidemiol*. 2014;**179**(3):303-12. doi: 10.1093/aje/kwt255 . [PubMed: 24148708].
2. Richmond TS, Cheney R, Schwab CW. The global burden of non-conflict related firearm mortality. *Inj Prev*. 2005; **11**(6):348-52. doi: 10.1136/ip.2005.008896. [PubMed: 16326769].
3. Naghavi M, Marczak LB, Kutz M, Shackelford KA, Arora M, Miller-Petrie M, et al. Global mortality from firearms, 1990-2016. *Jama*. 2018;**320**(8):792-814. doi: 10.1001/jama.2018.10060. [PubMed: 30167700].
4. Bangalore S, Messerli FH. Gun ownership and firearm-related deaths. *Am J Med*. 2013;**126**(10):873-6. doi: 10.1016/j.amjmed.2013.04.012 . [PubMed: 24054955].
5. Aarabi B. Surgical outcome in 435 patients who sustained missile head wounds during the Iran-Iraq war. *Neurosurgery*. 1990;**27**(5):692-5. [PubMed: 2259397].
6. Saberi-Zafaghandi M, Hajebi A, Eskandarieh S, Ahmadzad-Asl M. Epidemiology of suicide and attempted suicide derived from the health system database in the Islamic Republic of Iran: 2001-2007 *East Mediterr Health J*. 2012;**18**(8):836-42. doi: 10.26719/2012.18.8.836. [PubMed: 23057372].
7. Ali SA, Tahir SM, Makhdoom A, Shaikh AR, Siddique AJ. Aerial firing and stray bullet injuries: a rising tide. *Iran Red Crescent Med J*. 2015;**17**(4). doi: 10.5812/ircmj.17(4)2015.26179 . [PubMed: 26023345].
8. Kelly PD, Patel PD, Yengo-Kahn AM, Wolfson DI, Dawoud F, Ahluwalia R, et al. Incorporating conditional survival into prognostication for gunshot wounds to the head. *J Neurosurg*. 2021;**135**(5):1550-9. doi: 10.3171/2020.9.JNS202723 . [PubMed: 33690152].
9. Baker SP, o'Neill B, Haddon Jr W, Long WB. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. *J Trauma*. 1974;**14**(3):187-96. [PubMed: 4814394].
10. Singh J, Gupta G, Garg R, Gupta A. Evaluation of trauma and prediction of outcome using TRISS method. *J Emerg Trauma Shock*. 2011;**4**(4):446. doi: 10.4103/0974-2700.86626. [PubMed: 22090735].
11. Kohli A, Aggarwal NK. Firearm fatalities in Delhi, India. *Leg Med (Tokyo)*. 2006;**8**(5):264-8. doi: 10.1016/j.legalmed.2006.06.001. [PubMed: 16963304].
12. Tobon M, Ledgerwood AM, Lucas CE. The urban injury severity score (UISS) better predicts mortality following penetrating gunshot wounds (GSW). *Am J Surg*. 2019;**217**(3):573-6. doi: 10.1016/j.amjsurg.2018.09.013 . [PubMed: 30292327].
13. Fedakar R, Gündoğmuş ÜN, Türkmen N. Firearm-related deaths in two industrial cities of Turkey and their province. *Leg Med (Tokyo)*. 2007;**9**(1):14-21. doi: 10.1016/j.legalmed.2006.09.002. [PubMed: 17150397].

14. Solagberu BA. Epidemiology and outcome of gunshot injuries in a civilian population in West Africa. *European Journal of Trauma*. 2003;**29**(2):92-6. doi:10.1007/s00068-003-1285-5.
15. Balci Y, Canogullari G, Ulupinar E. Characterization of the gunshot suicides. *J Forensic Leg Med*. 2007;**14**(4):203-8. doi: 10.1016/j.jcfm.2006.06.025 . [PubMed: 17321192].
16. Llullaku SS, Hyseni NS, Bytyçi CI, Rexhepi SK. Evaluation of trauma care using TRISS method: the role of adjusted misclassification rate and adjusted w-statistic. *World J Emerg Surg*. 2009;**4**(1):1-6. doi: 10.1186/1749-7922-4-2 . [PubMed: 19146701].