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Logistic Regression Modeling for Evaluation of Factors Affecting Trauma Outcome in a Level I Trauma Center in Shiraz

Mahnaz Yadollahi,[1] Mehrdad Anvar,[1,*] Haleh Ghaem,[2] Shahram Bolandparvaz,[3] Shahram Paydar,[3] and Fateme Izianloo[3]

[1]Trauma Research Center, Shahid Rajaee Trauma Hospital, Shiraz University of Medical Sciences, Shiraz, IR Iran
[2]Department of Epidemiology, Research Center for Health Sciences, School of Health, Shiraz University of Medical Sciences, Shiraz, IR Iran
[3]Trauma Research Center, Shahid Rajaee Trauma Hospital, Shiraz University of Medical Sciences, Shiraz, IR Iran

[*]*Corresponding author*: Mehrdad Anvar, Trauma Research Center, Shahid Rajaee Trauma Hospital, Shiraz University of Medical Sciences, Shiraz, IR Iran. Tel: +98-7136254206, Fax: +98-7136254206, E-mail: anvarmm@sums.ac.ir

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Abstract

Background: Since injury-related mortality is preventable, identifying factors that inversely affect trauma outcome are important initial steps towards reducing injury burden.

Objectives: This study aims to determine independent risk factors of early/late in-hospital mortality among adult trauma victims with equal injury characteristics and severity at Shahid Rajaee (Emtiaz) Hospital during 2013 and 2014.

Patients and Methods: A cross-sectional study of adult trauma patients (age $\geq$ 15 years) sustaining injury through traffic accidents, violence, and unintentional incidents was conducted. Information was retrieved from three hospital administrative databases. Data on demographics, injury mechanisms, injured body regions, injury descriptions, outcomes of hospitalization, and development of nosocomial infections were recorded. Injury severity score was calculated by cross walking from international classification of diseases (ICD-10) injury diagnosis codes to abbreviated injury scale (AIS-98) severity codes. Two multiple logistic regression models were employed to reflect the partial effect of each covariate on early (within 48 hours) and late (beyond 48 hours) deaths.

Results: There were 47,295 hospitalized patients (male/female ratio: 2.7:1.0) with a median age of 30 years (interquartile range 23 - 44 years). A crude mortality rate of 1% (454 cases) was observed and 52% of deaths occurred within 48 hours of hospital arrival. One percent developed a nosocomial infection in the course of admission. After adjusting for covariates, sustaining a thoracic injury (OR 8.5, 95% CI [4.7 - 15.2]), ISS over 16 (OR 6.4, 95% CI [3.6 - 11.4]) and age over 65 years (OR 5.1, 95% CI [3.0 - 8.8]) were the most important independent risk factors of early trauma death. Presence of a hospital-acquired infection (OR 12.7, 95% CI [8.9 - 18.1]), age over 65 years (OR 7.4 95% CI [4.5 - 12.1]), and ISS of more than 16 (OR 14.6, 95% CI [6.2 - 34.3]) were independent predictors of late death.

Conclusions: Age, injury severity, injured body region, and hospital-acquired infections are important determinants of trauma outcome in our center. Timely recognition of factors affecting trauma mortality is crucial for monitoring changes of trauma quality of care. Our findings suggest the need to allocate resources for trauma prevention along with a potential focus on reducing in-hospital complications.

Keywords: In-hospital Mortality, Risk Factors, Injury Severity Score, Logistic Models, Nosocomial Infection

1. Background

Iran, as a middle-income developing country with a population of 73 million, faces a high incidence of injury-related mortality and morbidity (1-3). Although mortality from road traffic accidents has dropped since 2006 in Iran, nearly 18,000 in-hospital injury related deaths were recorded during the years 2005 - 2008 (4, 5). Meanwhile, outcomes after trauma have received increasing attention, given the numerous deaths, emergency department admissions, physician visits, and hospitalizations involved. Even after surviving an injury, a large number of victims are faced with temporary or permanent disabilities (6).

None of the existing studies in Iran has outlined the potential risk factors of death following trauma by considering mortality time distribution. The Forensic Medicine organization has claimed the main role in trauma surveillance and trauma mortality, mainly focusing on fatal road traffic accidents (7-9). It is known that the quality, reliability, and coverage of data vary between surveillance systems (10, 11), and therefore, hospital administrative databases may be considered as potential sources of valuable information while studying prognostic aspects of injuries.

In recent years, the Shahid Rajaee trauma center (Emtiaz) has become a major referral center for adult trauma in Fars. Since injury-related mortality is preventable, identifying factors that inversely affect trauma outcome and establishing preventive strategies based on the obtained estimates are important initial steps towards reducing injury burden (12).

2. Objectives

This study aims to determine the independent risk factors of in-hospital death among adult trauma victims with equal injury characteristics and severity who were referred to Shahid Rajaee (Emtiaz) hospital during 2013 and 2014.

3. Patients and Methods

This study was conducted at Shiraz trauma research center, which is affiliated to the Shiraz University of Medical Sciences as a cross-sectional study of adult trauma patients who were referred to Shahid Rajaee hospital (a Level I trauma referral center) during 2013 and 2014. We aimed to determine independent factors affecting the likelihood of death among adult trauma victims with equal injury characteristics and severity. The main source of information was the hospital administrative records of Shahid Rajaee hospital, which is a governmental trauma referral center in Shiraz city (13). Shiraz is the capital of Fars Province and is located in Southwest Iran. It has a generally hot semi-arid climate and a population of 1.7 million Muslim residents (65% of its adult population is younger than 45 years, and the sex ratio is 1.02:1.00).

3.1. Study Population

The sampling method involved the enumeration (census) of all hospitalized patients in the emergency departments or other hospital wards of Shahid Rajaee hospital during the study period. Inclusion criteria were as follows: all trauma patients older than 15 years injured in traffic-related incidents (car, motorcycle, and pedestrian accidents), falls, violence-related incidents, firearm injuries, and people struck by or against objects (47979 cases). Patients with the following characteristics were excluded: individuals admitted for surgical procedures other than emergency trauma intervention; patients with complications of previous trauma surgeries (infection); and people injured through burns, foreign body aspirations, suicide attempts, and sports injuries (684 cases). A total number of 47,295 observations from January 2013 to December 2014 met the inclusion/exclusion criteria, which underwent statistical analysis after data validation.

3.2. Measurements and Data Collection

Whenever a patient is referred to Shahid Rajaee hospital, a unique eight-digit code under the title "(SERIAL CODE)" is generated by the hospital admission unit. Upon admission, information regarding baseline demographics such as identifications, serial code, age, gender, admission date and time, and injury mechanism are routinely electronically recorded by the admission unit employees 24/7 (24 hours a day/7 days a week). After a patient is discharged, the hard-copied records are transferred to the medical records unit, where trained staff members routinely extract information regarding external causes of the injury, injury diagnosis, surgical interventions, and outcome of hospitalization. Information is then coded using the international classification of diseases (ICD)-10 coding system and entered into an electronic database. In this study, upon initiation of data validation, the trauma registry is accessed at Shiraz trauma research center, and the information retrieved from three hospital databases were merged (based on serial codes) to generate one combination that included all records from January 1, 2013, to the December 31, 2014.

3.3. Injury Description, Injury Severity Score, and Injured Body Regions (Abbreviated Injury Scale [AIS] and ISS)

An algorithm was designed to convert each ICD-10 rubric (injury diagnosis code) to its relevant AIS-98 score where possible. The algorithm was developed using the Microsoft Excel program text functions, which entails transforming text strings into numbers. In the ICD-10 lexicon, each injury was described by a code ranging from S.00 to T79.7 and a code description. We excluded the ICD-10 diagnostic codes related to foreign bodies (T15.0 - T19.9), burns, and corrosion injuries (T20.0 - T32.9), environmental exposures (T33.0 - T35.7, T66 - T75.8), and poisonings (T36.0 - T65.9). Complications of medical care and late effects of injury (T80 - T98) were also excluded, leaving a total number of 47295 patients to be included for ISS calculation.

In consultation with a member of the Trauma research center, each injury-related ICD-10 code was assigned to an appropriate AIS-98 severity code (number) where possible. Conservatively, we transformed the ICD-10 codes to the lowest AIS-98 severity score. In cases where the ICD-10 codes could not be transformed to an accurate AIS severity score, that particular injury was not used in calculating the ISS. Specifically, in cases where the ICD-10 described injuries to multiple, unidentified, or unspecified body regions, a 99 (missing) code was used (e.g., S09.7 multiple injuries of head). We also assigned each ICD-10 injury code to 1 of 6 ISS body regions with the same procedure. Injured body regions for each patient corresponded to the most severely ISS injured body region based on the AIS severity scale.

3.4. Length of Stay (LOS), Hospital-Acquired Infections (HAI), and Mortality Timing

The hospitalization period and interval between admission and death were calculated based on subtraction of discharge/death date from admission date for each individual. The resulting variable measured hospitalization period on a one-day scale (24 hours). Deaths were stratified into two categories: early (within 48 hours of admission) and late (beyond 48 hours of admission). Patients were considered to have acquired nosocomial infections if one or more positive cultures were obtained from blood, respiratory secretions, urinary system, surgical incision site, or cerebrospinal fluid. Individuals with a positive culture and LOS of less than 48 hours were not assumed to have a nosocomial infection. Since information regarding infectious complications was registered in a different database, the injury characteristics' data were merged with the HAI database.

3.5. Statistical Analysis

Data was properly recoded using Microsoft's Excel program and transferred to the Statistical Package for Social Sciences software (SPSS Inc., Chicago, IL, USA, version 18), and all analyses were performed using this package. Normality was checked using the one sample Kolmogorov-Smirnov test for continuous variables. Categorical variables were summarized using frequency (%), while median (interquartile range) was used in case of non-normally distributed continuous variables. Patients were not normally distributed regarding age and ISS. Mann-Whitney U test was used in cases where normality assumption was violated and the Chi-square test was used to compare categorical variables for bivariate analysis. Two multiple logistic regression models were employed to reflect the partial effect of each covariate on early/late death. Covariates were age, gender, injury mechanism, injured body regions, ISS, and HAIs. We only considered nosocomial infection as a predictor of late mortality, since we assumed that patients who were either discharged or died within 48 hours would not have had time to have developed HAIs. In order to provide a detailed comparison between age groups regarding mortality risk, age was entered as a categorical predictor in both models. A two-sided P value < 0.05 was considered statistically significant.

4. Results

4.1. Descriptive Statistics

There were a total of 47,295 injured adult patients with a median age of 30 years (interquartile range 23 - 44 years), of whom 73.1% were male and the remaining 26.9% were female (M/F = 2.7:1). The majority of patients were originally from Shiraz (96.3%), while 3.7% were transferred from other cities within Fars Province. Table 1 shows the demographic characteristics of the studied population.

4.2. Outcomes (Mortality)

There were 454 recorded injury-related deaths during the study period. The decedents were significantly older than those who survived traumatic injuries (49 ± 22 years vs. 35 ± 16 years respectively, $P < 0.001$). Across age categories, case fatality rate increased significantly from 0.6% in the young age group (15 - 44 years old) to 3.9% for those older than 65 years (χ^2 (2) = 383, $P < 0.001$). Mortality rate was significantly higher among males compared to females (1.0% vs. 0.8% respectively) (χ^2 (1) = 383, $P < 0.05$). Gunshots followed by pedestrian accidents were the most lethal injury mechanisms, accounting for 2.6% and 1.8% mortality rates respectively (χ^2 (6) = 86, $P < 0.001$). Among the most severely injured body regions, head injuries accounted for the highest mortality rate (2.6%), compared to a value of 0.5% for facial injuries (χ^2 (4) = 130, $p < 0.001$). Injuries were significantly more severe among the decedents compared to survivors, as reflected by a higher median (IQR) ISS [4 (1 - 9) vs. 9 (9 - 16) respectively, $P < 0.001$]. Although 52% of the mortalities occurred within 48 hours of admission, the Mann-Whitney U test revealed that non-survivors had a significantly higher median length of hospitalization as compared to survivors [2 (0 - 12) days vs. 0 (0 - 1) days respectively, $P < 0.001$] (Table 1). Considering a mortality rate of 15% among those with HAIs, mortality was significantly associated with acquiring a nosocomial infection (χ^2 (1) = 1030, $P < 0.001$).

4.3. Regression Analysis

Regression analysis was performed on patients with complete information on all variables (n = 21638, 45.8% of total). Since a considerable number of deaths were recorded during the initial 48 hours of admission (236/454), we divided mortalities into early (within 48 hours of admission) and late (beyond 48 hours) categories. Partial effects of age, gender, injury mechanism, injured body region, ISS, and nosocomial infection on mortality were investigated through the application of two binary logistic regression models to the data.

With a Nagelkerke R^2 of 0.153, the final model described 15% of the variation in early mortality. The model adequately fit the data as reflected by the Hosmer-Lemeshow test [χ^2 (8) = 6.7, P = 0.57]. After adjusting for covariates, sustaining a thoracic injury (OR 8.50, 95% CI [4.73 - 15.2]), ISS over 16 (OR 6.41, 95% CI [3.58 - 11.4]), and age over 65 years

Table 1. Demographic Characteristics of the Injured Patients by Outcome[a]

	Outcome			P Value
	Survivors No. (Row %)	Non-Survivors No. (Row %)	Total No. (Column %)	
Age				< 0.001
15 - 44	35291 (99.4)	203 (0.6)	35494 (75.0)	
45 - 64	8302 (98.6)	119 (1.4)	8421 (17.8)	
> 65	3248 (96.1)	132 (3.9)	3380 (7.1)	
Gender				0.011
Female	12619 (99.2)	98 (0.8)	12717 (26.9)	
Male	34222 (99.0)	356 (1.0)	34578 (73.1)	
Injury Mechanism				< 0.001
Car Accident	18395 (98.8)	218 (1.2)	18613 (39.6)	
Motorcycle Accident	7807 (99.1)	70 (0.9)	7877 (16.7)	
Fall	8752 (99.0)	85 (1.0)	8837 (18.8)	
Assault Injuries	5458 (99.8)	9 (0.2)	5467 (11.6)	
Pedestrian Accident	2918 (98.2)	53 (1.8)	2971 (6.3)	
Struck by Objects	2949 (99.7)	10 (0.3)	2959 (6.3)	
Firearm Injuries	326 (97.6)	8 (2.4)	334 (0.7)	
Body Region				< 0.001
Head and Neck	7233 (97.4)	193 (2.6)	7426 (33.9)	
Face	917 (99.5)	5 (0.5)	922 (4.2)	
Thorax	2024 (97.8)	45 (2.2)	2069 (9.4)	
Abdomen	1906 (98.3)	32 (1.7)	1938 (8.8)	
Extremities	9513 (99.4)	54 (0.6)	9567 (43.6)	
ISS Continuous [Median (IQR)]	4 (1 - 9)	9 (9 - 16)	-	< 0.001
ISS Categorized				< 0.001
1 - 3	7366 (99.7)	23 (0.3)	7389 (33.8)	
4 - 8	4863 (99.4)	29 (0.6)	4892 (22.4)	
9 - 15	6388 (98.0)	129 (2.0)	6517 (29.8)	
16 - 24	1991 (94.4)	117 (5.6)	2108 (9.6)	
≥ 25	902 (96.6)	32 (3.4)	934 (4.2)	
HAI				< 0.001
No	46409 (99.2)	379 (0.8)	46788 (98.9)	
Yes	432 (85.2)	75 (14.8)	507 (1.1)	

Abbreviation: HAI, hospital-acquired infection.
[a]Values are No. (%) unless otherwise stated

(OR 5.11, 95% CI [2.97 - 8.79]) were the most important independent risk factors of early trauma death (Table 2). Gender did not significantly affect early death (OR 0.96, 95% CI [0.65 - 1.42], P = 0.82). Overall, 26% of the variation in late mortality was described by the final model produced (Nagelkerke $R^2 = 0.262$). The Hosmer-Lemeshow goodness of fit test revealed a satisfying level of fitness [χ^2 (8) = 9.6, P = 0.30]. Presence of a HAI (OR 12.7, 95% CI [8.95 - 18.1]), age over 65 years (OR 5.11, 95% CI [2.97 - 8.79]), and ISS more than 16 (OR 14.6, 95% CI [6.23 - 34.3]) were independent predictors of late death after adjusting for confounders. Although significant, gender was not a potent predictor of late death (OR 1.84, 95% CI [1.24 - 2.74], P = 0.002).

5. Discussion

To the best of our knowledge, this is the first study in the Fars province that reports risk factors of early and late in-hospital injury related deaths. The cut point regarding the definition of early/late in-hospital death varies across different studies (14). Herein, we stratified deaths into those occurring within 48 hours of admission (early) and those occurring beyond this period (late), since we were interested in examining the contribution of HAIs to in-hospital mortality. Since deaths occurring immediately at the scene are transferred directly to a mortuary in Shiraz, our observations do not represent all the fatalities resulting from injuries. A number of previously published reports by forensic medicine organizations, mainly focusing on traffic-related deaths, have stated that 60% - 75% of deaths occur within 24 hours of trauma in Shiraz, although none of them examined risk factors with respect to mortality timing (7-9). In Shiraz, trauma information on each incident is scattered between three different databases of three different organizations (police departments, hospitals, and forensic medicine organizations). No attempts have been made to systematically unify these databases; until this is done, epidemiologic studies of trauma will be scarce and scattered, with less meaningful conclusions in the Fars province region.

There were 454 registered mortalities during the study period, resulting in a 1% crude mortality rate. Unadjusted for covariates, men had significantly higher odds of death compared to women. This is in accordance with the findings of two large national studies in Iran conducted by Rasouli et al. (15) and Bhalla et al. (16). Comparison of our findings with another population-based report from 2001 (17) reveals an unchanged male predominance over the recent decade regarding trauma mortality. Gender was not a significant predictor to be considered in early death, since mortality was more a function of injured body region, age, and ISS. For late in-hospital deaths, however, males were 1.84 times more likely to die after adjusting for confounders. This is in agreement with the findings of large studies of the American national trauma data bank (18), but a plausible explanation for the phenomenon is available from the set of variables studied here. We hypothesize that the effect of gender on late mortality may be confounded by a higher prevalence of preexisting medical conditions among men (19). Further, women are shown to better tolerate severe injuries, considering the immune-enhancing effects of estrogen and estradiol (20, 21). In addition, profound injuries usually result in immediate death at the scene or early in-hospital death (22), and therefore, the effect of preexisting medical conditions is pronounced for those surviving the first 48 hours following trauma.

The odds of early death began to rise significantly for patients aged 55 and above. Slightly different patterns were observed for late in-hospital death, which was in favor of people older than 45 years being independently associated with increased mortality risk. Increased age is universally accepted to inversely affect trauma outcome and, specifically, survival. Multiple studies have determined that the elderly (> 65 years old) tend to die more often than younger individuals do (23-25). This may be explained by lower physiologic reserve in older age, which itself is caused by a higher prevalence of preexisting medical conditions hampering the response to injury (26). Since, the elderly are often hospitalized for longer periods, hospital-acquired infectious complications could be another explanation for increased odds of mortality in this age group.

Gunshot injuries followed by pedestrian injuries and car accidents were the most lethal injury mechanisms, as indicated by the highest crude mortality rates. Roudsari et al. (27) previously declared that pedestrian injuries had the highest mortality rate among road traffic accidents. Possible explanations are relatively high injury severity sustained in pedestrian and gunshot injuries (28-30). Since there are few cases of firearm-related deaths in our society, such injuries are not important public health problems and are not discussed here. Our findings favored injured body region, age, and ISS's effects on early mortality far more than the effect of injury mechanisms.

For late death, pedestrian injuries accounted for the highest odds of mortality, which was 6.5 times of those injured in assaults. Many studies have concluded injury mechanisms (specifically pedestrian injuries) to be independently associated with increased mortality and functional impairment at hospital discharge in various age groups even after adjusting for gender, race, injury severity, and physiologic determinants (30-32). The kinetic energy for a moving object or a projectile is a function of its squared velocity, which may be the highest for pedestrians being hit by fast-moving vehicles. Improving urban infrastructure (building overhead pedestrian bridges) may not individually improve this outcome, because a considerable number of people intentionally cross streets, freeways, and highways even in the presence of an overhead bridge. Important preventive strategies for reducing pedestrian injuries should be outlined in our society. Increasing public awareness and carrying out traffic education are long-term preventive efforts that may prove to be promising. Finally, we were unable to locate any studies addressing the contribution of injury mechanisms to mortal-

Table 2. Logistic Regression Risk Factors of In-hospital Death Considering Death Timing

Risk Factors	Early Death			Late Death		
	Wald	P Value	OR (95% CI)[a]	Wald	P Value	OR (95% CI)[a]
Age	69.461	< 0.001	-	92.5	< 0.001	-
15 - 24	-	-	1	-	-	1
25 - 34	0	0.88	0.95 (0.55 - 1.67)	0.07	0.78	1.07 (0.63 - 1.82)
35 - 44	0.2	0.68	0.85 (0.41 - 1.77)	1.97	0.16	1.51 (0.84 - 2.70)
45 - 54	0.8	0.33	1.35 (0.70 - 2.61)	7.42	0.006	2.16 (1.24 - 3.77)
55 - 64	26.7	< 0.001	4.21 (2.44 - 7.27)	8.22	0.004	2.46 (1.33 - 4.57)
Over 65	34.8	< 0.001	5.11 (2.97 - 8.79)	63.19	< 0.001	7.43 (4.53 - 12.1)
Gender			-			-
Female	-	-	1	-	-	1
Male	0.0	0.86	0.96 (0.65 - 1.42)	9.34	0.002	1.84 (1.24 - 2.74)
Injury Mechanism	21.9	0.001	-	11.24	0.08	-
Assault Injuries	-	-	1	-	-	1
Car Accident	3.7	0.055	2.30 (0.98 - 5.39)	5.99	0.01	5.85 (1.42 - 24.1)
Motorcycle Accident	1.5	0.23	1.77 (0.70 - 4.45)	3.16	0.07	3.72 (0.87-15.9)
Fall	0.0	0.99	0.99 (0.38 - 2.56)	5	0.02	5.17 (1.22 - 21.8)
Firearm Injuries	6.5	0.01	6.26 (1.52 - 25.7)	1.31	0.25	4.16 (0.36 - 48.0)
Pedestrian Accidents	3.7	0.054	2.57 (0.98 - 6.74)	6.21	0.01	6.48 (1.48 - 28.2)
Struck by Objects	0.5	0.48	0.55 (0.11 - 2.79)	1.53	0.21	2.95 (0.53 - 16.3)
Injured Body Region	53.2	< 0.001	-	34.59	< 0.001	-
Extremities	-	-	1	-	-	1
Head and Neck	26.6	< 0.001	5.04 (2.72 - 9.34)	33.24	< 0.001	4.50 (2.70 - 7.51)
Face	1.2	0.28	2.24 (0.51 - 9.79)	2.90	0.09	2.85 (0.85 - 9.54)
Thorax	51.3	< 0.001	8.50 (4.73 - 15.2)	10.94	< 0.001	2.81 (1.52 - 5.20)
Abdomen	14.3	< 0.001	3.80 (1.90 - 7.58)	7.89	< 0.001	2.34 (1.29 - 4.23)
ISS	58.1	< 0.001	-	46.61	< 0.001	-
1 - 3	-	-	1	-	-	1
4 - 8	0.1	0.81	1.11 (0.46 - 2.67)	15.87	< 0.001	6.76 (2.64 - 17.3)
9 - 15	30.6	< 0.001	5.21 (2.90 - 9.36)	35.7	< 0.001	14.2 (5.94 - 33.9)
16 - 75	39.4	< 0.001	6.41 (3.58 - 11.4)	38.02	< 0.001	14.6 (6.23 - 34.3)
HAI	-	-	-			(-)
No	-	-	-	-	-	1
Yes	-	-	-	199.64	< 0.001	12.7 (8.95 - 18.1)

[a] Odds ratio (95% confidence interval).

ity in the context of early and late stratification. The overall predominating pattern of mortality resulting from traffic accidents has decreased in Iran (33), but huge differences exist when compared with the developed word. The western world has successfully reduced mortality rates from motor vehicle crashes and is expecting the fall-related mortality to exceed both MVT and firearm mortality rates (25).

In this study, exact causes of death were not studied based on autopsy reports, although head and chest injuries were significantly associated with increased risk of death. Adjusted odds of early death for thoracic injuries were 8.5 times higher than those for extremity injuries.

Since the majority of immediate deaths are caused by severe head injuries (34, 35), we hypothesize that patients with severe thoracic trauma will survive long enough to reach hospital, but the extent of the injuries will cause death within 48 hours. Other studies have stated that thoracic injuries are associated with death in the first 24 - 48 hours of admission (36, 37), which may be caused by extensive injury of the vital organs in the chest cavity.

A phenomenon that has been extensively studied around the world is that non-survivors have a significantly higher ISS compared to those who survived the trauma, which implies the contribution of ISS to mortality. It is worth mentioning in this study that patients with ISS $\geq$ 25 had a relatively lower crude mortality rate compared to patients with ISS of 16 - 24 (3.4 % vs. 5.6%). This finding is not surprising, however, because injury-related mortality has been shown to vary considerably even in patients with very close ISS (38). We reported a median ISS of 9 (IQR 9 - 16) for non-survivors, which may be an underestimation of injury severity since injury related mortality is expected to occur for relatively higher ISS values. There are two possible explanations for this: First, we employed a conservative method of translating ICD-10 codes to AIS 98 severity codes, which resulted in underestimation of ISS. Each 1-unit change in AIS codes may result in up to 25-unit changes in ISS, and this is more evident in severe or multiple injuries. Since algorithm mapping has been shown to function properly in determining ISS across large populations, another explanation exists that involves the questionable quality of injury diagnosis coding in our trauma registry. Trauma registrars have frequently used ICD codes, which refer to unspecified injuries or injuries to multiple body regions without further specifications. This may have resulted in missing ISS values for 124 (27.3%) of a total of 454 registered fatalities. Improving the quality of trauma coding through continuous education of trauma physicians and the recording staff is a rational method of increasing trauma surveillance quality, which in turn facilitates the process of trauma research.

ICD-10 derived ISS was a potent predictor of both early and late in-hospital mortality, but it was more prominent for early deaths. It is implied that prevention of injuries and, specifically, severe injuries is likely to affect trauma mortality, considering the rather small effect of salvaged lives even in the case of flawless clinical care. Moreover, ICD-10-derived ISS could easily be used to monitor changes among large populations regarding injury severity over time. Addressing the severity of injuries through data-derived scores has several advantages: they are based on vast data experience and they require less specialized injury coding, therefore reducing costs (39).

Another important finding of this study was that HAI increased the odds of late death by 12.7 times. It was the most important risk factor for late death, and we estimate the true effect to be far greater, since we could not include all of the patients with HAI in this study. Multiple previously published studies have declared sepsis and multiple organ failure to be the most important cause of late in-hospital deaths (14). In addition, HAI is considered to be associated with increased LOS and financial costs (40). Advancements in pre-hospital and in-hospital quality of care and prevention of septic complications in prolonged hospitalizations have led to a steady decrease in late hospital deaths over time. The trimodal distribution of deaths, therefore, has changed to bimodal distribution in the western world (36, 41) and even in high-income neighboring countries (42). In Iran, however, late in-hospital death caused by septic complications remains a considerable concern. This is a potential area for further research in highlighting important risk factors and developing preventive strategies.

5.1. Conclusions

Sustaining a thoracic injury, age > 65, and ISS above 16 are the most important independent risk factors for early mortality, while late mortality is independently affected by developing HAIs, age > 65 years, and ISS above 16. Timely recognition of the factors affecting trauma mortality is crucial for improving survival in the acute care setting. Our findings suggest the need to allocate resources for trauma prevention and promote research on improving the care of acutely injured patients, with potential focus on reducing in-hospital complications.

5.2. Limitations, Strengths, and Future Directions

We did not provide data on physiologic parameters and preexisting medical conditions, which are important determinants of outcome. Additionally, the fatalities reported here are not representative of all trauma-related deaths in Shiraz, and the quality of injury description and severity may be improved. However, nonfatal injuries were widely covered in this study. ISS was calculated and reported on a large scale using administrative data, based on a newly developed algorithm. This was the first study in Shiraz and in Iran to employ such a method of calculating and reporting injury severity. This study may also provide a primitive framework to construct annual reports of trauma patients to inform the medical community, the public, and decision makers based on a large trauma database in Fars. We propose that trauma centers should actively provide reports, with special focus on pre-hospital determinants, injury characteristics, and outcomes/costs of care. Developing a national trauma surveillance system is also a primary step towards more comprehensive trauma surveillance, since it allows for benchmarking actions undertaken at the national level.

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Footnotes

Authors' Contribution: Mahnaz Yadollahi, Haleh Ghaem, Mehrdad Anvar contributed to the design of the study and carried out data analysis and interpretation, and preparation of the initial manuscript. Fateme Izianloo contributed to the acquisition of data. All the authors carried out critical revisions of the manuscript.

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