



In-hospital costs of patients following road traffic accidents in Tehran: results from a single trauma registry center

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Abstract

Background: Road traffic accidents (RTAs) are the leading cause of death for children and young adults aged 5 to 39 and the third-leading cause of death in Iran.

Objectives: The aim of this study was to assess in-hospital costs of patients following RTAs and identify associated factors among the patients admitted to Sina Hospital, a collaborating hospital with the National Trauma Registry of Iran (NTRI).

Methods: A hospital-based registry study was conducted between September 17, 2016, and April 30, 2022, involving 3245 patients affected by RTAs. Data collection utilized the NTRI minimum dataset. To assess the factors influencing in-hospital costs of RTAs, various statistical analyses were performed, including independent sample t-tests, one-way ANOVA, and multiple linear regression analysis.

Results: The distribution of studied subjects based on sex, age, and road user group revealed that the majority were male (91%), within the working age range of 21-60 years (78.2%), and motorcyclists (55.2%). The mean in-hospital cost per patient following RTAs was 152.3 million Iranian Rial (IRR) (\$609.35). In the multiple linear regression analysis, several factors were significantly associated with higher in-hospital costs ($p < 0.05$). These factors included undergoing surgery, admission to the intensive care unit (ICU), the year of admission, having a moderate injury severity, being a car occupant, being female, and having a longer length of stay (LOS) at the hospital. Patients who required surgery had an additional cost of 102 million IRR, while those admitted to the ICU had an additional charge of 43.4 million IRR ($p < 0.001$).

Conclusions: The study findings revealed that in-hospital costs resulting from RTAs were influenced by factors such as gender, injury severity, road user group, ICU admission, surgery operation, and LOS at the hospital. The mean in-hospital costs per patient were relatively high, amounting to 152.3 million IRR (\$609.35). These findings highlight the need for increased efforts to mitigate the burden of RTAs in the country and implement measures to reduce their occurrence.

Keywords: Hospital Costs, Traffic Accident, Trauma Registry.

Introduction

Road traffic accidents (RTAs) are a significant global public health issue.^[1] RTAs are collisions involving at least one moving vehicle on a public or private road, resulting in injury or death to at least one person.^[2,3] The number of deaths caused by RTAs has been steadily increasing, with over 1.35 million fatalities reported each year.^[4] In 2019, RTAs ranked as the seventh-leading cause of death, predominantly affecting individuals aged 10 to 49 years.^[5]

RTAs are a prevalent issue, particularly in low- and

middle-income countries (LMICs), where over 90% of RTA-related deaths occur. In LMICs, the mortality rates due to RTAs are three times higher compared to high-income countries (HICs).^[6] In Iran, RTAs rank as the third-leading cause of mortality and are the primary cause of death among children and young adults aged 5 to 39.^[7,8] The mortality rate for RTAs in Iran was 21.66 per 100,000 in 2019.^[8]

RTAs impose significant economic burdens on individuals, families, and countries worldwide.^[9] RTAs

have been estimated to cause a loss of approximately 3% of a country's gross domestic product (GDP).^[10-12] Recent reviews have revealed that RTA costs in European countries range from 0.4% to 4.1% of the GDP.^[13] In HICs, the expenses associated with RTAs range from 0.5% to 6.0% of the GDP, while in LMICs, the range is from 1.1% to 2.9%.^[14] Notably, in Iran, the impact of RTAs on the country's GDP was 2.19% in 2009, 2.18% in 2011, and 6.0% in 2013.^[15-17] These figures underscore the substantial economic consequences of RTAs and the urgent need for effective measures and policies to address this issue.

Objectives

The costs associated with RTAs are staggering and difficult to comprehend.^[18] Understanding the financial implications of RTAs can offer valuable insights for evidence-based policy-making. Therefore, the primary objective of this study was to evaluate the in-hospital costs of RTAs and identify the factors contributing to these costs at Sina Hospital. By examining these costs, we aim to provide critical information that can inform effective decision-making and policy development about RTAs.

Methods

Study Design and Setting

This hospital-based registry study was conducted at Sina Hospital, affiliated with the Tehran University of Medical Sciences. The study utilized data collected from the National Trauma Registry of Iran (NTRI) between September 17, 2016, and April 30, 2022. Sina Hospital is renowned as a prominent referral center for trauma patients nationwide.

National Trauma Registry of Iran

The NTRI is a comprehensive hospital-based registry program initiated in 2016 at the Sina Trauma and Surgery Research Center. The NTRI collects data on various aspects of trauma patients, including demographic information, injury details, pre-hospital care, emergency department admissions, procedures, diagnoses, severity, and outcomes. This study focused on patients admitted to Sina Hospital following RTAs. At the same time, the NTRI encompasses a broader range of trauma cases, such as falls, drowning, burns, poisoning, suffocation, electrocution, animal attacks, and animal bites/stings.

Since its establishment, the NTRI has connected 25 trauma centers in different provinces. The registry includes data from patients who meet specific criteria, such as those who stayed in the hospital for more than 24

hours, those who died at the hospital, or those who were transferred from the intensive care units of other hospitals.

To identify trauma patients, a daily list of admissions to the hospital's emergency department was generated and then filtered based on the trauma registration criteria. NTRI registrars then interviewed the patients or their representative decision-makers to collect the required information using a form based on the NTRI minimum dataset. The completed forms, along with relevant medical records, were uploaded to the NTRI web-based portal. Trained nurses were responsible for data collection and upload, with a subsequent review conducted by an observer to ensure data quality.^[19-23]

The NTRI's minimum dataset consists of 109 variables recorded for all patients. For this study, specific data related to patient characteristics and hospital costs were extracted. Patient characteristics included age group (categorized as ≤ 20 , 21-40, 41-60, and ≥ 61), gender, admission year, whether the patient underwent surgery, length of hospital stay, admission to the intensive care unit (ICU), and mortality. The road user group variable was classified into four categories: pedestrians, cyclists, motorcyclists, and car occupants. Injury severity was assessed using the injury severity score (ISS), categorized as mild (≤ 8), moderate (9-15), or severe (≥ 16). Hospital costs encompassed various services such as surgery, anesthesia, hospital stay, operating room, laboratory tests, imaging services, nursing care, electrocardiogram, and other related services. Pharmaceutical and medical equipment costs were excluded due to hospital pharmacy outsourcing and lack of accessibility. To ensure accuracy, 10% of the data were randomly checked by reviewing the NTRI portal and corresponding medical records.

Ethical consideration

The study was conducted in accordance with the Declaration of Helsinki. This research project was approved by the Research Ethics Committee of Tehran University of Medical Sciences, with the approval ID: IR.TUMS.SINAHOSPITAL.REC.1399.090. Verbal informed consent was obtained from all participants involved in the study or their substitute decision-makers, ensuring their understanding and agreement to participate.

Statistical Analysis

Descriptive statistics, including numbers and percentages, were used to summarize nominal and categorical variables. In-hospital costs were calculated as mean \pm standard deviation. To compare the mean costs

among different groups, student's t-tests and analysis of variance (ANOVA) were employed. Post hoc analysis (Bonferroni's test) was conducted for pairwise comparisons. Additionally, a multiple linear regression model was utilized to identify factors associated with in-hospital costs. A significance level of $p < 0.05$ was considered statistically significant. All statistical analyses were performed using STATA 14.0 software (Stata Corp LLC, College Station, Texas, USA).

Results

The study included a total of 3245 patients who experienced RTAs. Table 1 presents the baseline characteristics of the RTA patients, along with their corresponding in-hospital costs and the results of the comparison. The in-hospital costs are reported in millions of Iranian Rials (IRR). The mean in-hospital cost per patient for RTAs was 152.3 million IRR [As of the data extraction date (April 30, 2022), the exchange rate was set

at 1 million IRR equal to \$4.00, according to the "National Exchange of Iran."] (\$609.35).

The male-to-female ratio among the RTA patients was 9:1. Although the mean in-hospital costs were 1.15 times higher for females compared to males, this difference was not statistically significant (172.2 million IRR vs. 150.4 million IRR, $p = 0.12$). The average age of the patients was 37.7 years, with the highest proportion (48.2%) falling within the 21-40 age group. While there was a slight increase in mean in-hospital costs with advancing age, no significant differences were observed between the age groups ($p = 0.13$). Motorcyclists accounted for most RTA patients, with 1,360 cases (55.2%), followed by pedestrians with 959 cases (39.0%). The mean in-hospital costs varied significantly across road user groups, ranging from 121.0 million IRR for bicyclists to 246.7 million IRR for car occupants ($p < 0.001$). In 2016, the mean cost was 95.7 million IRR, which increased to 247.6 million IRR in 2021 [Table 1].

Table 1. Baseline characteristics of RTA patients, in-hospital costs, and the comparison results (n=3245)

Variables	Number (%)	Mean cost (\pm SD) [in millions IRR]	P value	Pairwise Comparison ^f
Gender (n=3245; 100%) ^a				
Male	2952 (91.0%)	150.4 (172.2)	0.12 ^d	-
Female	293 (9.0%)	172.2 (235.8)		
Age group (n=3245; 100%) ^a				
≤20	371 (11.4%)	133.2 (144.4)	0.13 ^e	-
21-40	1564 (48.2%)	152.0 (181.0)		
41-60	973 (30.0%)	158.0 (182.0)		
≥61	337 (10.4%)	159.0 (193.5)		
Road user group ^b (n=2462; 75.9%) ^a				P<M
Pedestrian	959 (39.0%)	142.9 (166.1)	<0.001 ^e	P<C
Bicyclist	14 (0.6%)	121.0 (175.6)		M<C
Motorcyclist	1360 (55.2%)	180.1 (189.0)		
Car occupant	129 (5.2%)	246.7 (274.8)		
Admission year ^c (n=3245; 100%) ^a				
2016	452 (13.9%)	95.7 (108.0)	<0.001 ^e	A<E
2017	587 (18.1%)	102.0 (137.5)		A<F
2018	641 (19.8%)	94.9 (188.2)		B<D
2019	520 (16.0%)	204.8 (208.4)		B<E
2020	616 (19.0%)	191.0 (166.9)		B<F
				C<D
				C<E
2021	429 (13.2%)	247.6 (180.2)	C<F	
			D<F	
			E<F	

Data expressed as numbers and valid percentages are in parentheses.

^a available data, ^b pedestrian=P, bicyclist=B, motorcyclist=M, car occupant =C, ^c 2016=A, 2017=B, 2018=C, 2019=D, 2020=E, 2021=F

^d Independent Samples T-Test, ^e One-way ANOVA, ^f Bonferroni test - only the significant comparison results were presented

Table 2 presents the clinical characteristics of the RTA patients, along with their in-hospital costs and the comparison results. Among the patients, 81.2% had a mild ISS, 17.0% had a moderate ISS, and 1.8% had a severe ISS. The mean in-hospital cost was highest for patients with a moderate ISS, and there were statistically significant differences in mean costs across the ISS categories ($p < 0.001$). Out of the total cases, 84.9% of injuries were managed surgically. Patients who underwent surgery had a significantly higher mean in-hospital cost than others

(169.8 million IRR vs. 66.7 million IRR, $p < 0.001$). A total of 506 patients (15.6%) were admitted to the ICU. The ICU-admitted patients had a significantly higher mean in-hospital cost than others (259.2 million IRR vs. 132.6 million IRR, $p < 0.001$). Among the included patients, there were 70 deaths (2.2%). There was no significant difference in mean in-hospital costs between deceased patients and others (187.1 million IRR vs. 151.4 million IRR, $p = 0.15$) [Table 2].

Table 2. Clinical characteristics of RTA patients and in-hospital costs (n=3245)

Variables	Number (%)	Mean cost (\pm SD) [in millions IRR]	P Value	Pairwise Comparison ^e
ICU Admission (n=3245; 100%) ^a				-
No	2739 (84.4%)	132.6 (150.1)	<0.001 ^c	
Yes	506 (15.6%)	259.2 (264.6)		
ISS ^b (n=2787; 85.9%) ^a				
Mild (≤ 8)	2262 (81.2%)	148.9 (160.5)	<0.001 ^d	Mi<Mo
Moderate (9-15)	475 (17.0%)	218.4 (263.1)		
Severe (≥ 16)	50 (1.8%)	198.1 (212.8)		
Surgery (n=3068; 94.5%) ^a				-
No	464 (15.1%)	66.7 (107.7)	<0.001 ^c	
Yes	2604 (84.9%)	169.8 (185.1)		
Death (n=3229; 99.5%) ^a				-
Yes	70 (2.2%)	187.1 (201.8)	0.15 ^c	
No	3159 (97.8%)	151.4 (178.2)		

Data expressed as numbers and valid percentages are in parentheses

^a available data; ^b mild ISS =Mi, moderate ISS=Mo, severe ISS =Se; ^c Independent Samples T-Test; ^d One-way ANOVA; ^e Bonferroni test - Only the significant comparison results were presented

A multiple linear regression model was used to analyze the impact of gender, ISS, road user group, ICU admission, surgery, LOS, and admission year on in-hospital costs. After adjusting for these variables, the results showed that female patients, on average, had 22.7 million IRR higher expenses than male patients ($p < 0.05$). Regarding the ISS variable, patients in the moderate group had in-hospital costs of 37.3 million IRR higher than those in the mild group ($p < 0.001$). However, the mean costs for patients in the severe group were 50.6 million IRR lower than those in the mild group, but this difference was not statistically significant ($p = 0.054$).

After adjusting for other variables, the analysis based on the road user group variable revealed that, compared to pedestrians, car occupants had mean in-hospital costs that

were 36.2 million IRR higher ($p < 0.05$), while motorcyclists had costs that were 12.9 million IRR higher ($p = 0.79$). On the other hand, bicyclists had mean in-hospital costs that were 45.0 million IRR lower than pedestrians ($p = 0.32$). ICU admission and surgically managed patients were associated with significant increases in mean in-hospital costs. Specifically, ICU admission contributed an additional 43.4 million IRR ($p < 0.001$), while surgically managed added 102.0 million IRR ($p < 0.001$) to the costs. For each additional day of hospital LOS, the mean in-hospital costs for RTA patients increased by 9.2 million IRR ($p < 0.001$). Furthermore, compared to the year 2016, there was a significant increase in the mean in-hospital costs per patient from 2019 to 2021 ($p < 0.05$) [Table 3].

Table 3. Factors associated with the mean in-hospital costs of RTAs at Sina hospital (n=3245)

Variables	Beta [in a million IRR]	P value	95% conf. interval
Gender			
Male	Ref		
Female	22.7	<0.05	0.2 to 45.3
Injury Severity Score			
Mild (≤ 8)	Ref		
Moderate (9-15)	37.3	<0.001	19.0 to 55.6
Severe (≥ 16)	-50.6	0.054	-102.0 to 0.9
Road user group			
Pedestrian	Ref		
Bicyclist	-45.0	0.32	-133.0 to 42.6
Motorcyclist	12.9	0.79	-1.5 to 27.2
Car Occupant	36.2	<0.05	6.2 to 66.3
ICU Admission			
Underwent Surgery	43.4	<0.001	22.8 to 64.1
LOS (day)	102.0	<0.001	84.2 to 119.0
Admission Year			
2016	9.2	<0.001	8.3 to 10.0
2017	Ref		
2018	-59.3	<0.05	-115.0 to -3.4
2019	-44.4	0.109	-98.7 to 10.0
2020	61.9	<0.05	7.3 to 117.0
2021	65.0	<0.05	10.9 to 119.0
2022	125.0	<0.001	70.6 to 180.0

Discussion

The objective of this study was to examine in-hospital costs of RTAs and identify associated factors among the patients admitted to Sina Hospital between September 2016 and April 2022. The findings revealed that RTA patients who were surgically managed, those who were admitted to the ICU, patients who had a moderate ISS instead of a mild ISS, those who were car occupants, female patients with RTAs, and those who had longer hospital stays had higher in-hospital costs. The mean in-hospital cost per patient for RTAs in this study was 152.3 million IRR (\$609.35). Based on the exchange rate provided by the "National Exchange of Iran," 1 US dollar was equivalent to 249,940 IRR at the time of the study. It is worth noting that the in-hospital costs were at least 1.3 times higher than the total health expenditure per capita in Iran, which is approximately \$470. A separate study conducted in Mozambique reported that the in-hospital costs for RTAs were 7.6 times higher than the total health expenditure per capita in that country.^[24]

Compared to a survey conducted on 1024 non-fatal patients in the Netherlands,^[25] the mean in-hospital costs due to RTAs in this study were lower. This discrepancy can be attributed to factors such as the availability of subsidies

for medical services and the relatively lower cost of healthcare in Iran, as well as potential differences in the quality of medical care between Iran and the Netherlands. However, the mean in-hospital costs in this study were higher than those reported in other studies conducted in Iran. For instance, a survey conducted in Yazd reported that the price for RTA patients in 2021 was 20.02 million IRR.^[26] This difference can be explained by the fact that the current study only included patients with a LOS of more than one day, while in the Yazd study, over 55% of the sample had an LOS of less than one day.

Furthermore, another study conducted in 2013 reported a mean in-hospital cost of 1.1 million IRR for RTA patients.^[27] The disparity between that study and the current findings may be attributed to variations in the severity of injuries and the overall increase in healthcare costs in recent years. Our study findings indicate that the female gender is associated with higher in-hospital costs for RTAs, which is consistent with a previous study conducted in three European countries^[28] and a study from the Netherlands.^[25] Another study revealed that although females have a lower risk of RTA, they are more likely to sustain RTA-related injuries that require extensive healthcare.^[29] In contrast, a study conducted in the Yazd province of Iran reported that females had lower hospital

costs than males.^[26] However, it is essential to note that the proportion of motorcyclists in the Yazd study was 1.6 times higher than in our study, suggesting that the variations in the distribution of road user groups may contribute to these differences.

The study findings revealed that most RTA patients fell within the age range of 21-40 years. This observation aligns with previous literature indicating that young and productive populations are more susceptible to RTAs.^[30,31] The impact of RTAs extends beyond individual consequences, as they impose economic burdens on families and the nation when affecting the most economically active population. Interestingly, patients aged 41-60 years and those aged 61 years and above had the highest mean in-hospital costs, amounting to 158.0 million IRR and 159.0 million IRR, respectively. This can be attributed to age-related issues, such as the presence of chronic diseases, which can lead to longer hospital stays and subsequently increase healthcare costs. These factors contribute to delays in hospital discharge and require additional healthcare services, resulting in higher financial burdens.

The study findings highlighted the significant impact of RTAs on vulnerable road users, including pedestrians, bicyclists, and motorcyclists, who are particularly susceptible to injuries or fatalities in such incidents.^[32] Motorcyclists were the most affected road user group in this study, accounting for 55.2% of the cases. These findings are consistent with similar previous studies.^[30,31,33-35] Interestingly, the mean in-hospital costs were higher for car occupants compared to vulnerable road users. This can be attributed to various factors, including the use of unsafe or low-quality vehicles in Iran,^[36] as well as the non-compliance of car occupants with traffic regulations, such as driving at high speeds. These factors increase injury severity among car occupants, leading to higher in-hospital costs. It is important to note that this issue poses a significant threat to life in Iran.^[37]

Based on the ISS assessment, 81.2% of the patients had a mild ISS (≤ 8). This proportion is higher than reported in previous studies, where mild ISS accounted for 52% to 56% of all RTA patients.^[27,34] The disparity in these findings may be attributed to differences in the causes of RTAs. Furthermore, patients with higher ISS scores had the highest mean in-hospital costs, consistent with results from other studies.^[27,28] This can be explained by the more significant medical intervention and increased need for healthcare services among individuals with higher ISS scores, resulting in higher hospital costs. Interestingly, our study revealed that patients with severe ISS had lower in-

hospital expenses than those with moderate ISS, although this difference was not statistically significant. A potential explanation for this finding is that a majority of patients with severe ISS may, unfortunately, experience fatal outcomes within a few hours of being admitted to the hospital due to the severity of their injuries. As a result, they have shorter hospital stays and do not receive expensive medical services, leading to lower in-hospital costs.

Conclusions

The study findings revealed that mean in-hospital costs per patient for RTAs between 2016 and 2022 amounted to 152.3 million IRR, a substantial amount. Several factors were identified as significant predictors of these costs, including being female, having a moderate ISS, longer hospital stays, being a car occupant, and admission to the ICU. These findings emphasize the importance of comprehending the in-hospital costs and associated factors related to RTAs. They also provide valuable insights for policymakers to develop strategies that effectively mitigate the consequences of RTAs in the country.

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Competing interests

The authors declare that they have no competing interests.

Abbreviations

Road traffic accidents: RTAs;
National Trauma Registry of Iran: NTRI;
Intensive care unit: ICU;
Length of stay: LOS;
Iranian Rial: IRR;
Low- and middle-income countries: LMICs;
High-income countries: HICs;
Gross domestic product: GDP;
Injury severity score: ISS.

Authors' contributions

All authors read and approved the final manuscript. All authors take responsibility for the integrity of the data and the accuracy of the data analysis.

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Availability of data and materials

The data used in this study are available from the corresponding author on request.

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki. This research project was approved by the Research Ethics Committee of Tehran University of Medical Sciences, with the approval ID: IR.TUMS.SINAHOSPITAL.REC.1399.090. Verbal informed consent was obtained from all participants involved in the study or their substitute decision-makers, ensuring their understanding and agreement to participate.

Consent for publication

By submitting this document, the authors declare their consent for the final accepted version of the manuscript to be considered for publication.

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