

# Trauma severity and outcomes of patients with trauma related to heavy-vehicle traffic accidents



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**Received:** January 19, 2025

**Accepted:** April 13, 2025

**ePublished:** May 11, 2025

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**Citation:** Ghaffarzad A, Seyedi N, Fathollahzadeh A, Sadeghi Bazargani H, Vaezi H, Rahmani F. Trauma severity and outcomes of patients with trauma related to heavy-vehicle traffic accidents. *Journal of Emergency Practice and Trauma* 2024; 10(1): 27-32. doi: 10.34172/jept.2025.06.

## Abstract

**Objective:** The vehicle's heaviness increases the severity of the accident and the probability of death. The study aimed to compare the severity of injuries and the outcome of the injuries caused by accidents between heavy vehicles and light vehicles. The physiological variables of the patients, the variables related to the accident, and the patients' outcomes were evaluated to achieve this goal. The output was based on bivariate analysis.

**Methods:** This cross-sectional descriptive study was conducted in the emergency department of Imam Reza (AS) Hospital of Tabriz between March 2022 and July 2024. Four hundred nine multi-trauma patients related to road traffic accidents (RTAs) were included. The sampling method employed was a full census. Physiologic variables about patients and trauma severity were recorded. All data entered into SPSS 24.0 were compared between two groups using chi-square and independent samples t-tests.

**Results:** This study included 314 (76.8%) patients injured by light-vehicle accidents and 95 (23.2%) patients injured by heavy-vehicle accidents. The mean of trauma severity scores including GAP, RGAP, NTS, RTS, and REMS in heavy-vehicle accidents group were  $17.0 \pm 5.9$ ,  $16.3 \pm 6.5$ ,  $15.6 \pm 6.5$ ,  $6.2 \pm 1.9$ , and  $5.9 \pm 5.6$  respectively, and they were  $22.4 \pm 3.3$ ,  $21.8 \pm 3.7$ ,  $21.8 \pm 3.5$ ,  $7.6 \pm 0.9$ , and  $2.4 \pm 3.1$ , respectively, in light-vehicle accidents. There were significant statistical differences between the two groups concerning the trauma severity scores of patients based on vehicle type ( $P < 0.001$ ).

**Conclusion:** The study results show that the severity of trauma in heavy-vehicle accidents is higher, and the injured are in more critical conditions. Therefore, it is necessary to identify the factors involved in heavy-vehicle accidents and take measures to reduce them.

**Keywords:** Hospital mortality, Blunt trauma, Motor vehicle accidents, Emergency department

## Introduction

Road traffic injuries are a significant public health concern worldwide (1). More than 90% of injury deaths occur in low- and middle-income countries, where preventive measures are either nonexistent or ineffective. In these countries, healthcare systems are also least prepared for the post-crash phase of an accident (2). It is predicted that by 2030, injuries caused by traffic accidents will be the third cause of disease burden in the world (3,4). Due to recent advances in technology and the management of trauma patients, deaths after accidents related to truck accidents have decreased. However, the occurrence of fatal road accidents still affects thousands of people every year. In 2023, 5,375 heavy vehicles were involved in fatal accidents. This rate has decreased from 2022, but

it represents a 43% increase over the past decade(5). The number of fatalities in the United States when a truck crashed in 2015 during inclement weather such as rain, snow, sleet, hail, fog, and strong crosswinds was 458. Compared to light vehicles, trucks are more vulnerable to accidents in inclement weather due to their larger size and higher center of gravity (6). In Iran, according to the statistics provided by the police, the share of heavy vehicles in urban accidents leading to death is 20% (7).

Accidents caused by heavy vehicles have increased severity and a high probability of death, and one of the concerns is the occurrence of severe injuries in accidents with light vehicles (8). Middle-aged truck drivers with average experience and accidents at intersections positively affect accident severity (8). Heavy vehicle driver



fatigue is considered a serious safety hazard and is a major factor in road accidents in the road transport industry (9). The increased fatigue risk in truck drivers is associated with long working hours, poor sleep, and social aspects such as loneliness (10). Most truck drivers must adhere to strict transportation schedules; as a result, driving or speeding violations are aggravated (11).

Careful monitoring is the cornerstone of trauma prevention and the strengthening of trauma systems. Paying attention to the issue of prevention by establishing strict laws, paying attention to the quality of cars and roads, and managing vehicle speed plays a significant role in controlling accidents (12). Decker et al concluded that the safety of truck drivers is ensured by their vehicles, which is why the probability of injury in safe vehicles is low. However, in RTAs involving trucks and conventional passenger vehicles, the latter is at greater risk of injury (13).

According to the available sources, the severity of accidents with heavy vehicles is high, and several factors play a role in the occurrence of accidents and increase the probability of death in accidents with heavy vehicles. Due to the lack of a study at the regional level regarding heavy-vehicle accidents and evaluating the severity and outcome of the injuries caused by those accidents, in this study, we decided to compare the severity of injuries and the outcome of the injuries caused by accidents between heavy and light vehicles.

## Methods

In this cross-sectional descriptive study conducted in the emergency ward of Imam Reza (AS) Hospital affiliated with Tabriz University of Medical Sciences between March 2022 and July 2024, 409 multi-trauma patients related to road traffic accidents (RTAs) were included. Given the lack of a study comparing the severity of trauma between heavy and light vehicles, a pilot study was conducted by collecting 30 samples from each group to calculate the sample size. The severity of trauma was compared between the two groups based on the GAP (Glasgow Coma Scale, Age, Pressure) score. The mean and standard deviation of the GAP score was  $22.46 \pm 2.63$  in the light-vehicle group and  $14.53 \pm 5.56$  in the heavy-vehicle group. Using the sample size formula to compare the mean between the two groups and considering  $\beta = 0.99$  and  $\alpha = 0.01$ , the total sample size was calculated as 34 in each group using G-power software. Finally, 409 patients were included in the study, with 314 patients in the light vehicle group and 95 patients in the heavy vehicle group. The sampling method was a full census.

The inclusion criteria for this study encompassed all injuries resulting from traffic accidents involving heavy or light vehicles. Patients were excluded if they did not consent to participate or if their trauma was due to causes other than traffic accidents. This study has been approved by the Ethics Committee of Tabriz University of Medical

Sciences with the code IR.TBZMED.REC.1401.1091 dated 06.03.2023. Participation in the study was voluntary. The study conditions were explained to the participants before implementation. All methods were carried out according to the Declaration of Helsinki.

At the moment of the patient's arrival to the emergency ward and at the same time as performing the diagnostic and therapeutic procedures, variables including blood pressure, heart rate, respiratory rate, arterial oxygen saturation, and level of consciousness based on GCS (Glasgow Coma Scale) and AVPU (Alert, Verbal response, Pain response, Unresponsive), age, gender, the vehicle involved in the accident (light/heavy vehicle), accident place (inner city/road/highway), time of the accident (day/night), inpatient department (intensive care unit (ICU)/ward), and affected area were recorded. Our checklist was made by the researcher and included all the variables required to conduct the study. All the research team approved the checklist. The measurement methods were the standard methods used for the physical exam of patients.

Light-vehicle accidents included accidents in which all vehicles involved were light vehicles. Heavy-vehicle accidents included accidents in which just one involved vehicle was heavy, and the other party's car was a light or heavy vehicle. The time of the incident from 8 a.m. to 8 p.m. was considered daytime, and other hours were considered nighttime.

Table 1 shows the calculation formulas for GAP, RGAP, New Trauma Score (NTS), Revised Trauma Score (RTS), and Rapid Emergency Medicine Score (REMS) (14-18). The severity classification was based on the available sources for each score, and the death rate in each severity category was compared with the death rate reported in previous studies.

The data were entered into SPSS 22 software. The Kolmogorov-Smirnov test was used to evaluate the normal distribution of quantitative data. The distribution of patients' vital signs and age were non-normal according to the  $P$  value  $< 0.001$  reported by the Kolmogorov-Smirnov test. Frequency (percentage) was used to describe qualitative data, median (first quartile-third quartile) was used for non-normal quantitative data, and mean  $\pm$  standard deviation was used for normal quantitative data distribution. The chi-square test was used to compare qualitative data between the two groups of surviving and deceased patients, the Mann-Whitney U test was used for non-normal-distribution quantitative data, and the independent samples t-test was used for normal-distribution quantitative data. In all cases, a  $P$ -value less than 0.05 was considered significant.

## Results

This study included 409 injured people from RTAs. The

**Table 1.** Calculation of the GAP, R-GAP, NTS, RTS, and REMS based on the parameters in these scoring systems

Scores	Age	SBP	GCS	SpO2	RR	PR	MAP
GAP	<60=3 >60=0	>120=6 60–120=4 <60=0	3–15	–	–	–	
RGAP	<50=3 50–70=0 >70=-3	≥120=6 90–119=4 60–89=2 <60=0	3–15	–	–	–	
NTS	–	110–149=4 ≥150=3 90–109=2 70–89=1 <70=0	3–15	≥94=4 80–93=3 60–79=2 40–59=1 <40=0	–	–	
RTS	–	>89=4 76–89=3 50–75=2 1–49=1 0=0	13–15=4 9–12=3 6–8=2 4–5=1 3=0		10–29=4 >29=3 6–9=2 1–5=1 0=0	–	
REMS	<45=0 45–54=2 55–64=3 65–74=5 >74=6	–	14–15=0 11–13=1 8–10=2 5–7=3 3–4=4	<75=4 75–85=3 86–89=1 >89=0	≤5=4 6–9=2 10–11=1 12–24=0 25–34=1 35–49=3 >49=4	≤39=4 40–54=3 55–69=2 70–109=0 110–139=2 140–179=3 >179=4	≤49=4 50–69=2 70–109=0 110–129=2 130–159=3 >159=4

GAP: GCS, age, pressure; RGAP: revised GAP; NTS: new trauma score; RTS: revised trauma score; REMS: rapid emergency medicine score; SBP: systolic blood pressure; GCS: Glasgow coma scale; SpO2: peripheral oxygen saturation; RR: respiratory rate; PR: pulse rate; MAP: mean arterial pressure.

median age of the patients was 37 (27–53) years. Regarding gender, 301 patients (73.6%) were male, and the rest were female. The time of the accident was daytime for 231 patients (56.5%) and nighttime for the rest. Regarding the type of vehicle involved in the accident, 314 (76.8%) were injured in light-vehicle accidents, and 95 (23.2%) were injured in heavy-vehicle accidents.

The accident occurred in urban areas in 211 (51.6%) cases, on roads in 168 (41.1%) cases, and on highways in 30 (7.3%) cases. Among the studied patients, 220 patients (53.8%) were discharged from the emergency department, 110 patients (26.9%) were hospitalized in normal departments, and 37 patients (9%) were hospitalized in the ICU. Of all patients, 60 patients (14.7%) died (20 in light-vehicle accidents and 40 in heavy-vehicle accidents), and the rest were discharged from the hospital. Of the patients, 42 patients (70%) died in the emergency department, and 18 of them died during hospitalization. The most common anatomical location of injury included the head and face in 77 cases (18.8%), the lower limbs in 34 cases (8.3%), and the upper limbs in 30 cases (7.3%), and the rest were in other areas.

Patients were divided into two groups based on heavy- (95 injured) or light-vehicle (314 injured) accidents. Table 2 compares patients' demographic status and vital signs in the two groups. As can be seen in the table, all the variables related to the patient's vital signs were statistically significantly different between the two groups, and these variables were in more critical conditions in the group injured in heavy-vehicle accidents. Most of the accidents with light vehicles were in the city, while the accidents with heavy vehicles were on the roads. Most of

the victims of light-car accidents were discharged from the emergency department. In contrast, in the heavy-vehicle group, most of the injured were hospitalized or died in the emergency department.

The severity of the patients' injuries was evaluated based on the GAP, RGAP, NTS, RTS, and REMS criteria. Table 3 compares these criteria in two patient groups based on the vehicle type involved in the accident. The table shows that the patients in the heavy-vehicle group had higher severity, and the chance of death was higher in this group of patients.

## Discussion

In this study, the outcome of the injured patients from light- and heavy-vehicle accidents and the role of the variables involved in the outcome of the patients were evaluated. In injuries caused by heavy-vehicle accidents, the vital signs were more critical, and the injuries were more severe. The means of trauma severity scores including GAP, RGAP, NTS, RTS, and REMS were  $17.0 \pm 5.9$ ,  $16.3 \pm 6.5$ ,  $15.6 \pm 6.5$ ,  $6.2 \pm 1.9$ , and  $5.9 \pm 5.6$  in the heavy-vehicle accident group, respectively, and  $22.4 \pm 3.3$ ,  $21.8 \pm 3.7$ ,  $21.8 \pm 3.5$ ,  $7.6 \pm 0.9$ , and  $2.4 \pm 3.1$  in the light-vehicle accident group, respectively. The trauma severity scores significantly differed between the two patient groups based on vehicle type ( $P$  value < 0.001).

Also, the present study's findings showed that most light-vehicle accidents happen inside the city, while heavy-vehicle accidents occur on the roads. Most of the victims of light-vehicle accidents were discharged from the emergency department. In contrast, in the heavy-vehicle group, most of the injured were hospitalized or

**Table 2.** Comparison of demographic status, vital signs, and traffic accident characteristics of patients in two groups

Variable	Outcome		P value
	Car accidents (n=314)	Truck accidents (n=95)	
Age (y)	38 (29–53)	34 (24–56)	0.054 <sup>a</sup>
Gender			0.429 <sup>b</sup>
Male	234 (74.5%)	67 (70.5%)	
Female	80 (25.5%)	28 (29.5%)	
Vital Sign			
Heart rate (/minute)	101 (89–109)	96 (75–110)	0.030 <sup>a</sup>
Respiratory rate (/minute)	15 (15–18)	18 (16–20)	0.017 <sup>a</sup>
Mean arterial pressure (mm Hg)	91.67 (86.7–95)	82.33 (70.3–93.3)	< 0.001 <sup>a</sup>
Arterial oxygen saturation (%)	97 (96–98)	95 (75–97)	< 0.001 <sup>a</sup>
Glasgow coma score	15 (15–15)	11 (5–15)	< 0.001 <sup>a</sup>
AVPU			< 0.001 <sup>b</sup>
Alert	284 (90.4%)	36 (37.9%)	
Verbal response	5 (1.6%)	10 (10.5%)	
Pain response	9 (2.9%)	15 (15.8%)	
Unresponsive	16 (5.1%)	34 (35.8%)	
Time			0.289 <sup>b</sup>
Day	182 (58.0%)	49 (51.6%)	
Night	132 (42.0%)	46 (48.4%)	
Place of accident			< 0.001 <sup>b</sup>
City	210 (66.9%)	1 (1.1%)	
Road	86 (27.4%)	82 (86.3%)	
Highway	18 (5.7%)	12 (12.6%)	
Emergency department report			< 0.001 <sup>b</sup>
Discharge	194 (61.8%)	26 (27.4%)	
Admitted	109 (34.7%)	38 (40.0%)	
Died	11 (3.5%)	31 (32.6%)	

<sup>a</sup> Mann-Whitney U; <sup>b</sup> Chi-square.

died in the emergency department, and this shows that the severity of the accidents was higher in heavy-vehicle accidents. The results of the INRETS institute (Institut National de Recherche sur les Transports et leur Sécurité) study showed that 37% of heavy-vehicle accidents occurred on highways. In comparison, only 15% of light-vehicle accidents occurred on highways (19).

The results of Xu and colleagues' study showed a worrying issue: 97% of vehicle occupants who died in an accident between light and heavy vehicles, such as trucks, were the passengers of the light vehicles (20). In a study conducted by Elshamly et al, the results showed that in accidents involving heavy vehicles, injury and mortality rates were 19% and 13%, respectively; both these rates were 11% in our study (21). Also, similar results were obtained in Bunn and colleagues' study, potentially due to the difference in heavy-truck driving, which usually involves long hours of driving on roads at higher speeds,

**Table 3.** Comparison of trauma severity scores in two groups of patients based on the type of vehicle involved in the accident

Variable	Outcome		P value
	Car accidents (n=314)	Truck accidents (n=95)	
GAP	22.4±3.3	17.0±5.9	< 0.001 <sup>a</sup>
GAP category			< 0.001 <sup>b</sup>
Mild	289 (92.0%)	46 (48.4%)	
Moderate	15 (4.8%)	27 (28.4%)	
Severe	10 (3.2%)	22 (23.2%)	
RGAP	21.8±3.7	16.3±6.5	< 0.001 <sup>a</sup>
RGAP category			< 0.001 <sup>b</sup>
Mild	265 (84.4%)	39 (41.1%)	
Moderate	32 (10.2%)	21 (22.1%)	
Severe	13 (4.1%)	24 (25.3%)	
Very severe	4 (1.3%)	11 (11.6%)	
NTS	21.8±3.5	15.6±6.5	< 0.001 <sup>a</sup>
NTS category			< 0.001 <sup>b</sup>
Mild	288 (91.7%)	45 (47.4%)	
Moderate	11 (3.5%)	19 (20.0%)	
Severe	14 (4.5%)	25 (26.3%)	
Very severe	1 (0.3%)	6 (6.3%)	
RTS	7.6±0.9	6.2±1.9	< 0.001 <sup>a</sup>
REMS	2.4±3.1	5.9±5.6	< 0.001 <sup>a</sup>

<sup>a</sup> Independent samples t-test; <sup>b</sup> Chi-square.

especially highways, which increase the likelihood of higher-severity accidents (22). Based on the results of the present study, the severity of injuries in traffic accidents involving heavy vehicles is high, and those injured in these accidents have more critical vital signs; thus, the hospitalization and death rates are high in this group of injured people.

Studies show that heavy-vehicle accidents may occur more often at certain hours. However, the present study found no significant difference between the rate of night and day accidents. The results of this study showed that accidents that happen at night are more severe. The possibility of death increases many-fold. The results of Xu and colleagues' study showed that heavy-vehicle accidents with light vehicles occur more often late at night and in the early morning, so compared to other hours of the day, the accidents that occur during these hours have a 4.6% higher probability of minor injury and 0.2% increased probability of serious injury (20).

Meanwhile, the results of Charbotel and colleagues' study showed that car accidents are more evenly distributed throughout the entire day, but 87% of truck accidents occurred between 4:00 AM and 6:00 PM (19). Driving a heavy vehicle affects regular sleep and rest patterns; as a result, drivers lack adequate rest (23). Consequently, the probability of severe accidents increases in truck drivers who suffer from fatigue and its complications (10). In

our study, there was no statistically significant difference between the frequency of accidents between the heavy- and light-vehicle accident groups during the day and night. The frequency of accidents during the night and day was almost equal in the heavy-vehicle group, while in the light-vehicle group, the frequency of accidents during the day was higher.

The important findings of our study were that the severity of trauma in accident victims was higher in accidents involving heavy vehicles, such as buses, trucks, or trailers, and the vital signs were worse in this group of victims. The frequency of hospitalization and death was also higher in this group of victims.

One limitation of this study was the lack of differentiation between the types of light and heavy vehicles (such as buses, trucks, trailers, etc) involved in the accident. Another important limitation was our inability to determine whether the injured person was a light or heavy vehicle passenger in the heavy-vehicle accident group. In patients referred to our emergency department with prehospital emergency service, we did not evaluate the timing of prehospital emergency missions and the measures taken before admission.

## Conclusion

According to the findings of the study and similar studies conducted in different countries, in accidents in which heavy vehicles are involved, the intensity of trauma is greater, and the injured are in more critical conditions in terms of vital signs. Most of the injured are light-vehicle passengers. Therefore, it is necessary to identify the factors involved in heavy-vehicle accidents, and necessary measures should be taken to reduce factors such as driver fatigue, long-term driving, use of illegal drugs, etc. We recommend that future studies be conducted using the multicenter method. Also, in heavy-vehicle accidents, the clinical condition of the injured should be assessed based on the type of vehicle.

## Acknowledgments

The authors are grateful to all who participated in the study, including the data collectors, supervisors, and administrative staff of the Emergency Medicine Department of Emam Reza Hospital, Tabriz University of Medical Sciences, Tabriz, Iran. We also thank Dr. Robab Mehdizadeh (PhD in Statistics) for her cooperation in the paper's data analysis. This article was written based on a dataset of Neda Seyedi's thesis entitled "The severity of trauma and its outcome in traffic accidents with heavy vehicles," registered at Tabriz University of Medical Sciences (No. 70389).

## Authors' Contribution

**Conceptualization:** Farzad Rahmani.

**Data curation:** Neda Seyedi.

**Formal analysis:** Abazar Fathollahzadeh.

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**Writing—original draft:** Farzad Rahmani.

## Competing Interests

None.

## Ethical Approval

This study has been approved by the Ethics Committee of Tabriz University of Medical Sciences with the ethics code IR.TBZMED.REC.1401.1091. Participation in the study was voluntary. The study conditions were explained to the participants before implementation. All methods were carried out according to the Declaration of Helsinki.

## Funding

None.

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