Archives of Academic Emergency Medicine. 2026; 14(1): e67

ORIGINAL ARTICLE

Vehicle Characteristics as Risk Factors for the Severity of Road Traffic Crash Outcomes: A Systematic Review of Global and National Evidence

Sahar Sotoodeh Ghorbani[1], Alireza Jamshidi[2], Shadi Azimzadeh[3], Maryam Jamshidi[1], Mehran Rostami Varnousfaderani[4,5], Niloufar Taherpour[6], Fatemeh Hatami[4], Azadeh Nouhi Siahroudi[4], Elahe Zare[7], Gol Jamal Jorjani[4], Hanieh Yeganeh[4,5], Seyed Saeed Hashemi Nazari[8]*

1. Department of Legal Criminal Science, Research Institute for Legal Innovation, Tehran, Iran.
2.Department of Criminal Law and Criminology, Faculty of Law, Central Tehran Branch, Islamic Azad University, Tehran, Iran.
3.Department of Criminal Law and Criminology, Faculty of Law, South Tehran Branch, Islamic Azad University, Tehran, Iran.
4.Department of Epidemiology, School of Public Health and Safety, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
5.Student Research Committee, School of Public Health and Safety, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
6.Prevention of Cardiovascular Disease Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
7.Julius Center for Health Sciences and Primary Care, University Medical Center Utrecht, Utrecht University, Utrecht, The Netherlands.
8.Safety Promotion and Injury Prevention Research Center, Research Institute for Health Sciences and Environment, Shahid Beheshti University of Medical Sciences, Tehran, Iran.

Received: September 2026; Accepted: October 2026; Published online: November 2026

Abstract: **Introduction:** Road traffic injuries (RTIs) are a leading cause of death and disability worldwide, especially in low- and middle-income countries. Among contributing factors, vehicle-related characteristics may influence crash severity. This systematic review synthesizes global and national evidence on vehicle-related risk factors. **Methods:** This systematic review was conducted in accordance with preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines. A systematic search was conducted in international databases (ProQuest, Web of Science, PubMed, Scopus, Embase) and national databases (SID, Magiran) up to May 2025. Eligible studies examined the relationship between vehicle characteristics and crash outcomes. Exclusion criteria included case reports, preprints, narrative reviews, and non-English/Persian publications. Screening and selection were performed independently by four reviewers (2 assesed Persian articles and 2 English), and study quality was assessed using the Newcastle–Ottawa Scale (NOS). Because of heterogeneity among the included studies, a narrative synthesis was performed without meta-analysis. **Results:** Screening of 102 full-text articles yielded 34 studies that met the inclusion criteria, all rated as high quality (NOS ≥7). Of these, 10 studies scored 10, 12 scored 9, 10 scored 8, and two scored 7. Vehicle type (heavy vs. light; motorized vs. non-motorized), ownership, and vehicle age emerged as frequently reported factors associated with injury severity and fatality. Poor maintenance, overloading, and other vehicle-related safety conditions were also associated with adverse outcomes. Conversely, seatbelt use and child restraint systems generally showed protective associations, whereas findings regarding airbags varied across studies. **Conclusion:** Vehicle-related factors, particularly vehicle type, vehicle age, and safety equipment use, are associated with road traffic crash severity and fatality. Fleet renewal, proper use of seatbelts and child restraints, and regular technical inspections may help reduce injuries and deaths. In Iran, enforcing safety regulations and modernizing older vehicles may be particularly important. However, heterogeneity among studies limits the strength of these conclusions.

Keywords: Accidents; Traffic; Accidental Injuries; Motor Vehicles; Systematic Review

Cite this article as: Ghorbani SS, Jamshidi A, Azimzadeh S, Jamshidi M, Varnousfaderani MR, Taherpour N, et al. Vehicle Characteristics as Risk Factors for the Severity of Road Traffic Crash Outcomes: A Systematic Review of Global and National Evidence. Arch Acad Emerg Med. 2026;14(1):e67. https://doi.org/10.22037/aaem.v14i1.3086.

1. Introduction

Road traffic crashes (RTCs) remain a major global public health problem, causing substantial mortality and disability worldwide. The World Health Organization (WHO) estimated approximately 1.19 million road traffic deaths annually and identified road traffic injury as a leading cause of death among people aged 5–29 years. The burden is also unevenly distributed across road-user groups, with vulnerable road users accounting for more than half of global road traffic fatalities (1). These figures underscore the importance of identifying modifiable factors that influence not only crash occurrence but also injury and fatality severity once a crash occurs.

Crash severity depends on the interaction of human, environmental, roadway, and vehicle-related factors. Among these, vehicle characteristics are of particular interest because the physical properties and safety provisions of a vehicle can affect the forces transmitted during a collision and the protection available to occupants or other road users. Previous observational research has examined vehicle-related characteristics in relation to injury severity, but the variables investigated and the outcomes reported have varied considerably across studies (2). Although previous systematic reviews have examined road traffic injury risk factors more broadly, the extent to which vehicle-specific characteristics have been comprehensively synthesized remains an important question.

Vehicle type and size are among the most frequently investigated characteristics. Evidence from pedestrian and pedal cyclist crashes indicates that collisions involving larger vehicles can be associated with greater injury severity, while differences have also been reported across vehicle categories (3).

***Corresponding Author:** Seyed Saeed Hashemi Nazari; Safety Promotion and Injury Prevention Research Center, Research Institute for Health Sciences and Environment, Shahid Beheshti University of Medical Sciences, Tehran, Iran. Postal Code: 198353-5511.
Email: Saeedh_1999@yahoo.com; ORCID: 0000-0002-0883-3408;
Telephone: +98 (21) 22431993.

This open-access article distributed under the terms of the Creative Commons Attribution NonCommercial 3.0 License (CC BY-NC 3.0).
Downloaded from: https://journals.sbmu.ac.ir/aaem/index.php/AAEM/index

Epidemiological evidence further demonstrates the substantial contribution of motor-vehicle crashes to pedestrian injury and mortality (4). Among two-wheeled vehicles, differences between vehicle types have also been examined in relation to traumatic brain injury (5). These findings suggest that vehicle configuration may influence the consequences of a crash, although the magnitude and direction of associations can depend on the road-user group and crash context.

Vehicle dimensions and design may also influence outcomes among vehicle occupants. A recent retrospective cohort study from Japan comparing occupants of standard and K-car vehicles reported differences in survival and severe traumatic injury after traffic crashes, providing contemporary evidence that vehicle category may be relevant to clinical outcomes (6). Vehicle age or model year is another potentially important characteristic because changes in vehicle design and safety technology over time may alter occupant protection. Recent observational evidence has examined vehicle model year together with restraint use and other factors in relation to injury among motor-vehicle occupants (7). Safety equipment constitutes another important vehicle-related domain. Restraint systems and child-protection devices are intended to reduce injury during a crash, and observational evidence has reported associations between appropriate child safety-seat use and clinical outcomes among young road-traffic-injury patients (8). Contemporary analyses of motor-vehicle occupants have likewise considered restraint use among factors associated with injury risk (7). Accordingly, the presence or absence of relevant safety features represents an important component of the vehicle-related factors examined in this review.

Vehicle speed requires particular consideration because it lies at the intersection of vehicle characteristics, driver behaviour, and crash circumstances. Studies of speeding-related crashes have identified associations between speed-related factors and driver injury severity, while also demonstrating that these relationships vary across driver and crash characteristics (9). For the present review, speed was therefore retained within the predefined vehicle-related exposure framework, while recognizing that it is not an exclusively intrinsic vehicle characteristic.

Despite this growing body of evidence, the literature remains fragmented across vehicle types, populations, exposure definitions, outcome measures, and study settings. Some studies focus on occupants, whereas others examine pedestrians, cyclists, or motorcycle riders; similarly, studies differ in whether severity is represented by severe injury, traumatic injury, hospitalization, or mortality (3, 9). This heterogeneity limits direct comparison of findings and makes it difficult to determine how the different vehicle-related characteristics have collectively been investigated. A systematic synthesis is therefore needed to identify the characteristics that have been studied, summarize the direction of reported associations, and clarify important differences in the available evidence.

A systematic review and meta-analysis published in 2021 examined road traffic injury risk factors and reported limitations in the available evidence for some vehicle-related exposures (10). Other research has modeled road traffic fatalities at the provincial level, further demonstrating the importance of examining crash-related determinants in the national context (11). However, the extent to which existing reviews have comprehensively synthesized vehicle-related characteristics across different vehicle types, road-user groups, and crash-severity outcomes remains unclear. The present review addresses this gap by systematically synthesizing the available evidence across diverse study settings.

This question has practical relevance to emergency medicine. Information about the vehicle involved, the use or availability of protective equipment, and the likely collision mechanism may help prehospital teams anticipate injury patterns and communicate risk during triage and clinical handover. Such information should complement—not replace—physiological assessment and established trauma-triage protocols. A clearer synthesis of vehicle-related evidence may also help emergency departments and trauma systems anticipate patterns of injury and plan resource allocation and patient assessment (12).

This systematic review aims to synthesize global evidence on the associations between vehicle-related characteristics and the severity of road traffic crash outcomes, including severe injury and mortality.

2. Methods

2.1. *Study design and setting*

A systematic search was conducted in international databases ProQuest, Web of Science, MEDLINE (PubMed), Scopus, and Embase, as well as in national databases SID and Magiran, up to May 2025. The search was performed using relevant keywords including accident, traffic accidents (road), mortality, injuries, damages, vehicles, and their combinations, along with their equivalents, utilizing logical operators (AND, OR). A manual search in Google Scholar (in Persian and English) was conducted to identify potentially missed studies. Study authors were not contacted to identify additional studies, as a formal meta-analysis was not performed.

This systematic review was designed using an explicit PICOS framework. The objective was to synthesize the available global and national evidence on the association between vehicle characteristics and the severity of road traffic crash outcomes, while identifying areas of consistency, heterogeneity, and evidence gaps. This explicit statement of rationale and objectives is consistent with preferred reporting items for systematic reviews and meta-analyses (PRISMA) 2020 recommendations for systematic reviews (13). This review was conducted in accordance with meta-analysis of observational studies in epidemiology (MOOSE) guidelines for systematic reviews of observational studies.

2.2. *Eligibility Criteria*

The elements used to define the research question according to the PICOS system were as follows: Population: Vehicles involved in road traffic crashes; Intervention / Exposure: Vehicle characteristics; Comparator: Different vehicle types or the presence versus absence of the vehicle characteristics under study; Outcomes: Severity of crash outcomes; and Study design: Observational studies (cross-sectional, case-control and cohort studies). No restriction was placed on the follow-up period for cohort studies.

Studies that examined the relationship between vehicle characteristics (type, safety features, speed, and vehicle age) and the severity or occurrence of accidents or injuries were included. Articles published in reputable and peer-reviewed scientific journals were considered.

Studies unrelated to the topic and research objectives (those solely focusing on environmental or human factors); articles in a language other than Persian and English; and letters to the

This open-access article distributed under the terms of the Creative Commons Attribution NonCommercial 3.0 License (CC BY-NC 3.0).
Downloaded from: https://journals.sbmu.ac.ir/aaem/index.php/AAEM/index

editor, brief reports, preprint articles, case reports, narrative reviews or case series, and reports or local and regional news under the title of grey literature were excluded.

2.3. *Search Syntax*

The search strategy combined relevant keywords using Boolean operators. Medical subject headings (MeSH) terms were used where applicable, and the search syntax was adapted for each database using appropriate field codes and syntax. The core search syntax applied in the mentioned databases was as follows:

("road traffic accidents" OR "RTAs" OR "road traffic crash" OR "traffic accident" OR "road accident" OR "road traffic injury" OR "road fatality") AND ("Fatal Outcome" OR fatal OR death OR dead OR mortality) AND ("Wounds and Injuries" OR injure OR trauma OR wound) AND (frequency OR prevalence OR "risk factor" OR "related factor" OR cause)

2.4. *Screening and Selection Process*

The search and article screening process was performed independently by four researchers; two researchers were responsible for searching international databases and two other researchers were responsible for searching national databases. To identify potentially unretrieved studies, a manual search in Google Scholar in Persian and English was conducted. After aggregating international and national articles, duplicates were removed using the reference management software EndNote. The remaining records were screened based on title and abstract relevance to the predefined inclusion and exclusion criteria. Studies considered potentially eligible after the initial screening were assessed for eligibility, and full-text articles were reviewed against the predefined criteria. Studies that met all eligibility criteria were included in the systematic review and proceeded to data extraction. Data were extracted by nine researchers using a structured data extraction form designed based on the information required for the review. The extracted information included country, year of publication, study design, sample size, vehicle type, number and type of outcomes, risk factor, and effect size. No study investigators were contacted to obtain or confirm additional data. The selection and screening process is presented in the PRISMA flow diagram (Figure 1).

2.5. *Summary measures*

The extracted effect sizes from the included studies mainly included odds ratios (OR), risk ratios (RR), hazard ratios (HR), and regression coefficients (B), together with their 95% confidence intervals when these were reported. When no numerical effect size was given, the findings were summarized in narrative form.

2.6. *Data synthesis*

Due to substantial heterogeneity in study designs, vehicle classifications, and reported outcomes, a formal meta-analysis was not performed. The findings were therefore synthesized narratively and presented in structured tables according to the main categories of vehicle-related factors. As no quantitative pooling was undertaken, measures of consistency (such as I^2), formal assessment of publication bias or selective reporting, and additional analyses (sensitivity analyses, subgroup analyses, or meta-regression) were not applicable.

2.7. *Quality Assessment*

The quality assessment of the included studies was performed independently by two investigators at the study level using the Newcastle-Ottawa Scale (NOS) checklist for observational studies (cross-sectional, case-control, and cohort). This tool includes three domains: Selection, Comparability, and Exposure/Outcome, where each question is assigned a score of zero or one based on standard guidelines. The total scores ranged from zero to 10, and according to the scoring protocol, scores of 0 to 4 were considered poor quality, 5 to 6 moderate quality, 7 to 8 good quality, and 9 to 10 excellent quality. In cases of disagreement between the two evaluators, the issue was resolved through discussion with a third researcher (14). Quality scores were reported descriptively and were not used for weighting or subgroup analysis in the synthesis.

3. Results

A total of 12,250 records were identified through the database searches. After removing duplicates, 3,062 unique records remained and were screened based on title and abstract. Of these, 2,960 records were excluded because they did not meet the inclusion criteria (not related to vehicle characteristics, focused solely on human/environmental factors, or were published in languages other than English or Persian). Subsequently, 102 full-text articles were assessed for eligibility. Of these, 68 articles were excluded for lack of adequate data on vehicle-related factors, or not reporting crash severity or fatality outcomes. Finally, 34 studies met the inclusion criteria and were included in the present qualitative synthesis (Figure 1).

For quality assessment, the Newcastle–Ottawa Scale (NOS) was used for cohort, case-control, cross-sectional, and registry-based studies. Among the 34 included studies, 10 (29.41%) received a score of 10, 12 (35.29%) scored 9, 10 (29.41%) scored 8, and 2 (5.88%) scored 7. The mean NOS score was 8.88, indicating high methodological quality across all included studies, with all studies scoring above 5 (Table 1).

3.1. *General Characteristics of the Vehicle (Vehicle type, Vehicle owner, Vehicle life, Vehicle number)*

A synthesis of 22 international studies published between 2009 and 2024 reveals that vehicle-related characteristics, including vehicle type, ownership, age, and operational context, play a pivotal role in determining the severity and outcome of road traffic crashes. Among these, most articles highlighted vehicle type as an influential factor in both injury severity and fatality risk (Table 2).

3.1.1. Vehicle Type as a Determinant of Injury Severity and Mortality

Across the included studies, odds ratios for fatal outcomes associated with vehicle type ranged from 0.42 (95% confidence interval (CI): 0.35–0.50; tricycle/bicycle vs. light vehicle) (11) to 5.82 (95% CI: 3.67–9.21); bus vs. passenger car (4), with a median OR of 1.24. For injury outcomes, odds ratios ranged from 0.14 (95% CI: 0.03–0.70; motorcycle vs. bus) (15) to 7.53 (95% CI: 1.20–47.40; fold-up bike vs. city bike) (16), with a median OR of 1.63.

Heavy and large vehicles (e.g., trucks, buses, commercial and heavy-duty vehicles) were repeatedly associated with higher mortality risk for both vehicle occupants and vulnerable road users such as pedestrians and cyclists. Studies conducted in Taiwan, Iran, the U.S., Brazil, and Spain consistently found that

This open-access article distributed under the terms of the Creative Commons Attribution NonCommercial 3.0 License (CC BY-NC 3.0).
Downloaded from: https://journals.sbmu.ac.ir/aaem/index.php/AAEM/index

these vehicle types significantly increased the odds of fatal outcomes when compared to passenger cars (4, 7, 11, 17-19). For example, Chong et al. (4) reported that buses (OR = 5.82, 95% CI: 3.67–9.21) and heavy trucks (OR = 2.15, 95% CI: 1.16–3.97) were associated with substantially higher pedestrian mortality than passenger cars, while Lin et al. (19) found that heavy-duty vehicles carried an OR of 2.83 (95% CI: 2.26–3.55) for fatal outcomes compared with special cars.

These associations are likely due to the greater kinetic energy transferred during collisions involving high-mass vehicles, longer braking distances, and higher points of impact, particularly for pedestrians. In Brazil, for example, buses and trucks were linked to severe injuries in crashes involving cyclists and other non-motorized users (17), while in Taiwan and Iran, heavy-duty vehicles showed a disproportionately high contribution to crash-related deaths (11, 19). In Spain, bus involvement showed a higher likelihood of very serious injuries, especially in multi-party collisions (18).

Motorcycles and mopeds, though smaller in size, were disproportionately represented in fatal and serious injury crashes across multiple settings. Overall, motorcycles were associated with a median OR of 3.15 for injury outcomes (range: 1.06–3.78), indicating a consistently elevated risk relative to passenger cars or trucks (15, 20, 21).

Their lack of protective structure, high maneuverability in traffic, and exposure to external hazards increase the risk of severe trauma, including traumatic brain injury (TBI) and death. This pattern was evident in the UK (22), Cameroon (23), Ethiopia (21, 24), Japan (5), and Iran (11, 20, 25), where motorcycles were consistently linked to high rates of mortality and morbidity. In Japan, TBI was more frequent among moped riders than motorcyclists (5), while in the UK, motorcyclists had the highest adjusted odds of being killed or seriously injured (20). In Cameroon, motorcycle crashes accounted for a significant proportion of hospital deaths (23).

Conversely, passenger cars were associated with lower injury severity across several studies (7, 15, 16, 18, 25, 26). This trend is likely due to the widespread implementation of crash-mitigating features such as airbags, electronic stability control, and seatbelt restraint systems in modern passenger vehicles, which absorb collision energy and enhance occupant protection. Newer cars, in particular, performed better: a study in the U.S. found that vehicles manufactured after 2015 were significantly associated with lower risks of TBI and death (7).

Among non-motorized vehicles, bicycle type was also found to influence crash risk. In Poland, the use of mountain bikes and fold-up bikes significantly increased the odds of injury compared to city bikes (16), likely due to differences in their structural design, such as smaller wheels or less stable frames, and the typical environments in which they are used. These results emphasize the need for bicycle-specific infrastructure and better integration of various bike types into urban traffic systems.

3.1.2. Vehicle Ownership and Driver–Vehicle Relationship

Across the included studies, odds ratios for fatal or injury outcomes associated with vehicle ownership ranged from 0.39 (95% CI: 0.19–0.80; owner vs. employed driver) (21) to 0.96 (95% CI: 0.68–1.35; other vs. private) (27), with a median OR of 0.84, indicating a generally protective effect of owner-operated vehicles.

Studies from Ethiopia (21, 24, 27) and Australia (28) indicated that vehicles operated by non-owner (hired) drivers were more frequently involved in severe and fatal crashes than those driven by their owners. Hired drivers may face pressures related to performance-based pay, long hours, or limited familiarity with the vehicle. Owner-drivers, by contrast, may exercise greater care due to personal investment in vehicle condition and higher accountability. This pattern was particularly evident in the Ethiopian context, where minibuses operated by hired drivers were more likely to be involved in high-injury crashes (21, 24, 27). Similarly, in Australia, taxi drivers and truck operators who often operate employer-owned vehicles had higher risks of severe injury or death, particularly during commuting hours (28).

3.1.3. Vehicle Age (Vehicle Life) and Injury Outcomes

Across the included studies, odds ratios for fatal or injury outcomes associated with vehicle age ranged from 0.51 (95% CI: 0.45–0.58; 2015–2018 vs. pre-1999) (7) to 1.46 (95% CI: 1.27–1.67; ≥15 years vs. 10–14 years) (11), with a median OR of 0.76, indicating that newer vehicles are generally associated with lower risk.

Another key factor affecting injury outcomes was vehicle age and the presence or absence of safety technologies. Studies from Iran (11, 29), Taiwan (19), and the U.S. (7) demonstrated that older vehicles, especially those lacking modern safety features such as advanced braking systems, side-impact protection, airbags, and crash-absorbent frames, were significantly more likely to be involved in fatal or severe crashes. For example, in Iran, older vehicles had a higher association with crash fatality (11, 29), while in New York State, vehicles produced after 2015 showed substantially lower TBI and death rates (7). Specifically, in Iran, Jahanjoo et al. (11) reported that vehicles aged ≥15 years had an OR of 1.46 (95% CI: 1.27–1.67) for fatal outcomes compared with vehicles aged 10–14 years, while vehicles aged 5–9 years showed the lowest risk (OR = 0.72, 95% CI: 0.66–0.79).

In addition to lacking safety systems, older vehicles may also suffer from mechanical wear and insufficient maintenance, further compounding risk.

Lastly, some studies highlighted the elevated risk associated with specific vehicle types such as minibuses in low- and middle-income countries (LMICs) and off-road vehicles (ORVs) in high-income settings. For example, in Ethiopia, minibuses were among the vehicles most commonly involved in serious and fatal crashes (21, 24). These vehicles often carry many passengers under poorly regulated conditions, with limited safety oversight or vehicle inspection. In Canada, off-road vehicles such as all-terrain vehicles (ATVs) and dirt bikes were linked to rising rates of severe injury and death, particularly during recreational use (30).

These findings highlight how crash risk is not only influenced by the type of vehicle but also by how and where the vehicle is used.

3.2. *Vehicle Maintenance and Safety Status (Servicing, Overloading, Accident History, and Insurance)*

Several studies conducted in different countries have examined the role of vehicle-related factors in the severity and likelihood of road traffic crashes. One study conducted in Ethiopia (21) found that vehicles with a longer history of regular servicing were less likely to be involved in fatal crashes. Specifically, regular vehicle servicing was associated with lower odds of fatal crash involvement (OR = 0.90, 95% CI: 0.83–0.98),

This open-access article distributed under the terms of the Creative Commons Attribution NonCommercial 3.0 License (CC BY-NC 3.0).
Downloaded from: https://journals.sbmu.ac.ir/aaem/index.php/AAEM/index

indicating approximately 10% lower odds of fatal crash involvement. This finding suggests that consistent vehicle maintenance may reduce the likelihood of fatal crash involvement (Table 3).

In Iran, Bakhtiyari et al. (29) identified technical failures such as brake defects, tire wear, and faulty lighting systems as significant predictors of higher injury severity, especially in nighttime crashes.

In China, Zhang et al. (26) reported that overloaded vehicles and those with poor safety status were more likely to be involved in both traffic violations and severe crashes. For example, unfit safety status was associated with an OR of 1.77 (95% CI: 1.60–1.95), and overloading with an OR of 1.28 (95% CI: 1.16–1.42) for fatal or injury outcomes. Lack of third-party insurance coverage, while not associated with increased violations, was linked to more serious crash outcomes. Having compulsory third-party insurance was protective (OR = 0.77, 95% CI: 0.71–0.83).

Moreover, a study in Iran by Moradi et al. (31) indicated that drivers with a history of previous crashes had significantly higher odds of being involved in future accidents (OR: 2.63, 95% CI: 1.29–5.26), highlighting the importance of both behavioral and mechanical history in crash recurrence.

Overall, the evidence emphasizes that vehicle maintenance status, safety deficiencies, overloading, insurance coverage, and prior crash involvement are critical factors that influence both the risk and severity of road traffic crashes.

3.3. *Vehicle Safety Equipment (Seatbelt, Airbag, Child Restraint, Safety device use)*

Numerous studies have consistently highlighted the critical role of safety equipment such as seatbelts, airbags, child restraint systems, and protective gear in reducing the severity of road traffic injuries and fatalities (Table 4).

Seatbelt use emerged as one of the most consistently reported protective factors. Studies from Iran, Croatia, Malawi, and South Korea demonstrated that not wearing a seatbelt significantly increased the risk of both injury and death in road traffic crashes (31-40). For instance, in Croatia, seatbelt non-use was associated with higher odds of fatal and severe injuries (OR: 2.33, 95% CI: 1.22–4.45) (8). In Iran, several national and regional studies confirmed this pattern. One nationwide study found that individuals not wearing seatbelts had 23.1 times higher odds of sustaining injuries (95% CI: 16.90–32.90) and 1.43 times higher odds of death (95% CI: 1.18–1.73) (34). Additional studies identified non-use of seatbelts as a key risk factor for crash involvement among truck drivers (41), and increased injury severity among front- and rear-seat passengers (36, 37). For example, Habybabady et al. (32) reported an OR of 1.81 (95% CI: 1.10–2.99) for crash/injury among non-users, while Rostom et al. (36) found ORs of 1.88 (95% CI: 1.34–2.63) for abdominal injury and 1.49 (95% CI: 1.06–2.10) for head injury.

In low-income contexts, like Malawi, seatbelt use was also shown to reduce the odds of serious injuries among vehicle occupants (38). Similarly, studies in South Korea revealed that rear-seat passengers without seatbelts were at significantly higher risk of severe injury or ejection from the vehicle during a crash. Zhang et al. (26) reported that restrained occupants had an OR of 0.19 (95% CI: 0.17–0.21) for fatal or injury outcomes compared with unrestrained occupants, representing an 81% reduction in risk.

Child restraint systems, especially child safety seats, were also found to provide superior protection compared to seatbelts alone. In South Korea, Park et al. (8) reported that the use of child safety seats reduced the odds of intracranial injury by 69% and intensive care unit (ICU) admission by 53%. In contrast, standard seatbelts alone did not significantly reduce serious injury risk for children, underscoring the need for age-specific safety measures.

Airbag deployment has been examined primarily as a complementary protective measure to seatbelts, although findings are complex and affected by selection bias. In Palestine, Rostom et al. (36) found that the absence of airbags was associated with an OR of 1.85 (95% CI: 1.31–2.63) for neck injury, suggesting a protective role. In South Korea, Kim et al. (33) reported that, compared with seatbelt use alone, the combination of seatbelt and airbags was associated with an OR of 1.70 (95% CI: 1.31–2.19) for in-hospital mortality, while airbag-only use was associated with an OR of 10.24 (95% CI: 7.49–13.99) and no protection was associated with an OR of 5.94 (95% CI: 4.76–7.42). These elevated estimates should be interpreted with caution: the reference category was seatbelt-only use, and the study population comprised hospitalized patients, a group likely enriched for severe crashes in which airbags deployed. This selection bias, rather than a harmful effect of airbags, most plausibly explains the higher odds. The consistent finding across studies is that airbags alone, without seatbelt use, provide insufficient protection and are associated with the highest risk of severe injury or death (33, 36). A U.S.-based study similarly showed that rear-seat occupants without airbags and restraints were especially vulnerable to ejection and severe trauma (7). In-vehicle protective equipment played a significant role in injury prevention. In studies from Belgium and South Korea, the absence of safety measures, particularly seatbelt use, was associated with significantly higher odds of mortality following a crash (42, 43). For instance, Hounkpe Dos Santos et al. (42) reported an unadjusted OR of 3.10 (95% CI: 1.20–8.50) for mortality associated with the absence of protective equipment, while Lee et al. (43) found that safety device use was protective (OR = 0.76, 95% CI: 0.64–0.89) for injury outcomes.

In summary, the evidence across 13 studies strongly supports the effectiveness of occupant safety systems, especially seatbelts, child car seats, and airbags in reducing crash severity and fatality risk. The findings emphasize the importance of not only mandating safety equipment but also ensuring proper use and enforcement across vehicle types and user populations.

3.4. *Vehicle-Related Determinants of Severity Supported by Global Recommendations*

Several global organizations have formally recognized the role of vehicle-related factors in reducing the burden of road traffic injuries and fatalities. According to the World Health Organization's Global Status Report on Road Safety (2018) (44), key recommendations include the implementation of mandatory periodic technical inspections for vehicles, the removal of unsafe vehicles that lack essential safety features such as seatbelts, anti-lock braking systems (ABS), and airbags, and the enforcement of compulsory third-party insurance. Furthermore, the United Nations Global Plan for the Decade of Action for Road Safety 2021–2030 (41) calls for stronger regulations to ensure that both new and existing vehicles meet high safety standards, while also promoting insurance schemes that facilitate fair compensation after crashes.

This open-access article distributed under the terms of the Creative Commons Attribution NonCommercial 3.0 License (CC BY-NC 3.0).
Downloaded from: https://journals.sbmu.ac.ir/aaem/index.php/AAEM/index

In addition to vehicle-related maintenance and regulatory aspects, these global frameworks also emphasize the critical role of in-vehicle safety systems and consistent safety practices. The use of seatbelts and airbags in passenger vehicles is identified as a highly effective intervention in reducing the severity of injuries and preventing fatalities. The importance of consistent and proper use of these safety devices is well documented in international guidelines, reinforcing their inclusion in legislative enforcement and public awareness campaigns (41, 44).

These global priorities align closely with the findings of the present review, reinforcing the importance of vehicle-related factors including regular maintenance, overloading control, crash history, insurance coverage, and in-vehicle safety systems as essential determinants of both crash severity and risk. This convergence of evidence and policy highlights the relevance of implementing internationally endorsed safety standards at the national level.

4. Discussion

This study aimed to systematically review the available evidence regarding the role of vehicle characteristics in determining the severity of traffic crash outcomes. To do so, we conducted a comprehensive systematic search in major international databases, including ProQuest, Web of Science, PubMed, Scopus, and Embase, as well as national databases (SID and Magiran), up to May 2025. We identified 12,250 records, of which 102 full-text articles were assessed after removing duplicates and applying eligibility criteria. Ultimately, 34 studies met the inclusion criteria and were included in the qualitative synthesis. All included studies demonstrated high methodological quality, as assessed by the Newcastle-Ottawa Scale (NOS), with scores ranging from 7 to 10. Their findings were categorized into three main domains: general vehicle characteristics (type, ownership, and age), vehicle maintenance and service status, and vehicle safety equipment.

Our findings are broadly consistent with previous systematic reviews and meta-analyses reporting associations between vehicle characteristics, safety equipment use, and crash-related injury outcomes (41, 44). For instance, the WHO Global Status Report on Road Safety (2018) and the Global Plan for the Decade of Action for Road Safety 2021–2030 emphasize the importance of vehicle safety and restraint systems in reducing road traffic injuries and fatalities (41, 44). Similarly, a systematic review and meta-analysis of cohort studies found that seatbelt use was associated with a lower risk of major injuries among vehicle occupants (RR = 0.47, 95% CI: 0.29–0.80), although substantial heterogeneity was observed across studies (45). Another systematic review and meta-analysis reported that pedestrians and cyclists struck by SUVs or light truck vehicles had higher odds of severe injury or death than those struck by passenger cars (45, 46). Our review extends this evidence base by providing a focused synthesis of studies from low- and middle-income countries (LMICs), where vehicle safety standards and fleet composition may differ substantially from those in high-income countries. In addition to vehicle type, vehicle age, and safety equipment, our review highlights vehicle ownership status and the driver–vehicle relationship (e.g., hired versus owner-operated vehicles) as factors associated with crash outcomes. These findings broaden the discussion of vehicle-related risk factors, although the strength and generalizability of the reported associations depend on the evidence available for each factor.

4.1. *General Vehicle Characteristics*

One of the key findings of this review was the significant role of vehicle type in determining crash severity and outcomes. Multiple studies have reported that heavy vehicles, such as trucks and buses, are associated with higher mortality risks (11, 19). This can be attributed to their larger size and mass, which make them more difficult to control, as well as their higher kinetic energy and elevated structure, both of which increase the vulnerability of pedestrians and cyclists (18, 25). Moreover, from a biomechanical perspective, collisions involving heavy vehicles transfer considerably greater kinetic energy to vulnerable road users and occupants of smaller vehicles, leading to higher fatality risks. The longer braking distance and higher bumper height of such vehicles further increase the severity of pedestrian and cyclist injuries (27).

In contrast, newer passenger cars, equipped with advanced safety technologies such as airbags, anti-lock braking systems, and electronic stability control, have demonstrated a greater protective effect (7).

On the other hand, motorcycles and bicycles account for a substantial proportion of fatalities and severe injuries in most countries, particularly in low- and middle-income settings (22, 23). The absence of physical protection, direct exposure to the environment, and the high likelihood of traumatic brain injury are the main reasons for the elevated severity of crashes in this group. Moreover, in some countries, such as Japan, a significant difference has been observed between motorcycles and lighter motorized two-wheelers (e.g., mopeds) in terms of the incidence of brain injuries (5).

Vehicle ownership was another factor influencing crash outcomes. Studies conducted in Ethiopia and Australia reported that drivers who did not own the vehicles they operated, particularly hired or employed drivers, were more frequently involved in severe crashes (21, 28). Previous occupational safety research suggests that factors such as long working hours, economic pressures, and vehicle maintenance practices may contribute to the observed associations among hired and commercial drivers (47, 48). However, these factors should be interpreted as potential explanations rather than established causal mechanisms.

The age of the vehicle, or its degree of wear and obsolescence, was also strongly associated with injury severity. Older vehicles, due to mechanical deterioration and the lack of modern safety technologies, were linked with higher mortality risks. In contrast, passenger cars manufactured after 2015 in the United States were significantly associated with reductions in both traumatic brain injuries and fatalities (22). The protective effect of newer vehicles may partly reflect cumulative improvements in crashworthiness and the availability of safety technologies, including side-impact protection, crumple zones, advanced airbag systems, and electronic stability control (7).

4.2. *Vehicle Maintenance and Service Status*

Several studies highlighted that mechanical defects, such as brake failure, tire wear, and lighting system malfunction, were among the most critical contributors to increased injury severity, particularly in nighttime crashes (29). In addition, vehicle overloading in China and several other developing countries was directly associated with a higher likelihood of severe crashes (49). Insurance status was also identified as an indirect indicator; although lack of insurance coverage was not linked to the occurrence of crashes, it was significantly

This open-access article distributed under the terms of the Creative Commons Attribution NonCommercial 3.0 License (CC BY-NC 3.0).
Downloaded from: https://journals.sbmu.ac.ir/aaem/index.php/AAEM/index

associated with greater injury severity (26). Furthermore, a history of previous crashes among drivers was recognized as a predictive factor for subsequent high-risk collisions (50). In the Iranian context, the high proportion of old vehicles combined with irregular technical inspections magnifies the role of poor maintenance in increasing crash severity. This gap in regulatory enforcement should be explicitly targeted by policymakers (29).

4.3. *Vehicle Safety Equipment*

Most reviewed studies reported protective associations between the use of safety equipment, including seat belts and child restraint systems, and crash outcomes. However, findings varied across studies and occupant subgroups, particularly regarding airbags and the effect of seatbelt use by seating position (35, 40). A study conducted in Iran demonstrated that individuals not wearing seat belts had a 23-fold higher risk of injury and a 1.43-fold higher risk of death compared to those using seat belts (35). These results are consistent with international crash test data (e.g., NHTSA, IIHS), which show that seat belts reduce fatal injury risk for front-seat occupants by nearly 45% (35). Although most studies found a protective effect of seatbelt use, two studies (7, 8) reported no significant association in specific subgroups (e.g., rear-seat passengers), suggesting that the protective effect may vary by occupant position.

Among children, the use of child safety seats markedly reduced the likelihood of traumatic brain injuries and ICU admissions. In South Korea, Kim et al. (33) reported that, compared with seatbelt use alone, the combination of seatbelt and airbags was associated with an OR of 1.70 (95% CI: 1.31–2.19) for in-hospital mortality, while airbag-only use was associated with an OR of 10.24 (95% CI: 7.49–13.99) and no protection was associated with an OR of 5.94 (95% CI: 4.76–7.42). These findings should be interpreted cautiously because the reference category was seatbelt-only use and the study population consisted of hospitalized patients, which may have introduced selection bias. Therefore, the higher odds observed in this study should not be interpreted as evidence that airbags increase mortality. Airbags are designed to supplement seatbelts rather than replace them; therefore, their protective role should be interpreted in the context of seatbelt use and other vehicle safety features (1, 41). A U.S.-based study similarly showed that rear-seat occupants without airbags and restraints were especially vulnerable to ejection and severe trauma (39).

4.4. *Practical Implications*

Our systematic findings should be interpreted within the broader context of global road safety inequities. Recent meta-analyses from Ethiopia illustrate how rapid urbanization and motorization in low- and middle-income countries continue to exacerbate road traffic crash rates despite multiple intervention efforts (51). Vehicle-related risk factors identified in our review, including aging vehicle fleets, limited adoption of safety technologies, and insufficient maintenance programs, are particularly pronounced in resource-limited settings.

The disproportionate burden of vehicle-related fatalities in LMICs underscores the need for technology transfer and financial mechanisms to support fleet renewal and the adoption of safety equipment in resource-limited settings.

Implementing vehicle safety standards requires coordinated approaches that account for both manufacturing requirements and post-market compliance. Our systematic evidence supports WHO recommendations for mandatory periodic technical inspections, safety feature requirements, and strict enforcement of protective equipment use. However, the effectiveness of these interventions is highly dependent on adequate regulatory infrastructure and enforcement capacity.

4.5. *Limitations and Recommendations*

Substantial heterogeneity was observed across studies, primarily attributable to differences in vehicle classification schemes, outcome definitions, and confounder adjustment. This heterogeneity limited the comparability of findings and effect estimates and precluded meta-analysis for most vehicle-related factors. Therefore, findings for these factors were synthesized narratively and should be interpreted cautiously.

Publication bias cannot be ruled out, as studies with null or negative findings may be less likely to be published. However, the comprehensive search strategy and inclusion of both international and national databases may have mitigated this risk.

The restriction to English and Persian language publications may have introduced language bias, potentially excluding relevant studies published in other languages.

The majority of included studies were conducted in low- and middle-income countries, while data from highly populated developed countries were less accessible. The predominance of studies from LMIC settings may limit the generalizability of the findings to high-income countries, where differences in vehicle fleet composition, access to safety technologies, and regulatory enforcement may affect the applicability of the results. Moreover, many of the studies were observational in nature, which limits causal inference regarding the relationship between vehicle-related factors and crash outcomes. Residual confounding is a concern in observational studies, as unmeasured factors (e.g., driver behavior, road conditions, socioeconomic status) may have influenced both vehicle characteristics and crash outcomes. The quality of reporting also varied across studies, particularly with respect to detailed vehicle specifications and documentation of safety features.

For future research, we recommend conducting multinational studies with harmonized designs and the use of national registry data. Priority should be given to standardized vehicle classification systems, which would facilitate international comparisons and allow robust meta-analytic approaches. Longitudinal studies tracking vehicle fleets over time could provide stronger evidence regarding the relationship between vehicle aging and safety performance. In addition, future investigations should assess the impact of emerging interventions, such as electric vehicles and advanced driver-assistance systems, on crash severity and outcomes.

5. Conclusions

This systematic review synthesizes evidence indicating that vehicle characteristics are associated with road traffic crash severity, although the consistency and strength of the reported associations vary across factors. Seatbelt use was generally associated with reduced injury severity, whereas heavy vehicle involvement and older vehicle age were frequently associated with more severe crash outcomes. However, differences in study designs, outcome definitions, vehicle classifications, and adjustment for confounding limit the comparability of findings across studies. Although the methodological quality of the included studies was assessed using the Newcastle–Ottawa Scale, the overall certainty of the evidence for each vehicle-

This open-access article distributed under the terms of the Creative Commons Attribution NonCommercial 3.0 License (CC BY-NC 3.0).
Downloaded from: https://journals.sbmu.ac.ir/aaem/index.php/AAEM/index

related factor was not formally graded. Policies promoting fleet renewal, improving access to safety equipment and its proper use, and enforcing regular technical inspections could contribute to reducing road traffic-related deaths and injuries. Future research should prioritize standardized vehicle classification systems, longitudinal studies tracking vehicle fleets over time, and evaluations of emerging technologies such as advanced driver-assistance systems.

6. Declarations

6.1. *Acknowledgments*

The authors would like to thank the Research Affairs of the School of Public Health and Safety at Shahid Beheshti University of Medical Sciences for their technical support of this study. This project was approved by the Safety and Injury Prevention Center of Shahid Beheshti University of Medical Sciences, Tehran, Iran, and ethical approval was granted by the Ethics Committee of the School of Public Health and Safety (IR.SBMU.PHNS.REC.1403.076).

6.2. *Conflict of interests*

The authors declare that they have no competing interests.

6.3. *Funding and supports*

No external funding was received for this study.

6.4. *Authors' contributions*

Seyed Saeed Hashemi Nazari: Conceptualization, Study design, Supervision, Data interpretation, Manuscript writing, and Final approval of the manuscript. Niloufar Taherpour & Sahar Sotoodeh Ghorbani: Statistical analysis, Manuscript drafting, Literature review, and Final approval of the manuscript; critically revised the manuscript for important intellectual content. Alireza Jamshidi, Shadi Azimzadeh, Maryam Jamshidi, Mehran Rostami Varnousfaderani, Fatemeh Hatami, Azadeh Nouhi Siahroudi, Elahe Zare, Gol Jamal Jorjani, Hanieh Yeganeh: Articles were screened based on inclusion and exclusion criteria, Data extraction, and the quality of extracted data was assessed using a quality assessment tool. All authors read and approved the final version of the manuscript and agree to be accountable for all aspects of the work, ensuring the accuracy and integrity of any part of the work.

6.5. *Ethical statement*

Not applicable.

6.6. *Informed consent*

Not applicable.

6.7. *Availability of supporting data*

Not applicable.

6.8. *Using artificial intelligence chatbots statement*

During the preparation of this work, the authors used Claude 4.5 in order to paraphrase the sentences and check the grammar of the text. After using the tool/service, the authors reviewed and edited the content as needed and took full responsibility for the publication's content.

7. References

1. World Health Organization. Global status report on road safety 2023: country and territory profiles. Geneva: World Health Organization;2024. Available from: https://www. who. int/publications/i/item/9789240087712.

2. Abu-Zidan FM, Eid HO. Factors affecting injury severity of vehicle occupants following road traffic collisions. Injury. 2015;46(1):136–41.

3. Edwards M, Leonard D. Effects of large vehicles on pedestrian and pedalcyclist injury severity. J Safety Res. 2022;82:275–82.

4. Chong SL, Chiang LW, Allen JC, Jr., Fleegler EW, Lee LK. Epidemiology of Pedestrian-Motor Vehicle Fatalities and Injuries, 2006-2015. Am J Prev Med. 2018;55(1):98–105.

5. Inamasu J, Nakatsukasa M. Traumatic brain injury among two-wheeled motor vehicle riders in Utsunomiya, Japan: a comparison between mopeds and motorcycles. Eur J Trauma Emerg Surg. 2021;47(5):1477–82.

6. Ono Y, Uzawa T, Sugiyama J, Tomita N, Kakamu T, Ishida T, et al. Comparison of survival outcomes and anatomically specific severe injuries following traffic accidents among occupants of standard and K-car vehicles: A retrospective cohort study at a teaching hospital in Japan. PLoS One. 2025;20(2):e0318748.

7. Zhang L, Pawlowski E, Hines LM, Bauer MJ, Pressley JC. Risk and protective factors for injury in adult front- and rear-seated motor vehicle occupants in New York State. Int J Environ Res Public Health. 2024;21(6):663.

8. Park GJ, Ro YS, Shin SD, Song KJ, Hong KJ, Jeong J. Preventive effects of car safety seat use on clinical outcomes in infants and young children with road traffic injuries: A 7-year observational study. Injury. 2018;49(6):1097–103.

9. Se C, Champahom T, Jomnonkwao S, Ratanavaraha V. Examining factors affecting driver injury severity in speeding-related crashes: a comparative study across driver age groups. Int J Inj Contr Saf Promot. 2024;31(2):234–55.

10. Yousefifard M, Toloui A, Ahmadzadeh K, Gubari MIM, Madani Neishaboori A, Amraei F, et al. Risk Factors for Road Traffic Injury-Related Mortality in Iran; a Systematic Review and Meta-Analysis. Arch Acad Emerg Med. 2021;9(1):e61.

11. Jahanjoo F, Sadeghi-Bazargani H, Asghari-Jafarabadi M. Modeling road traffic fatalities in Iran's six most populous provinces, 2015–2016. BMC Public Health. 2022;22(1):2234.

12. Beck EM, Wolthers SA, Blomberg SN, Breindahl N, Eskesen V, Lippert F, et al. Head injuries related to bicycle collisions and helmet use–an observational study. Traffic Inj Prev. 2024;25(8):1081–8.

13. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372: n71.

14. Wells GA, Shea B, O'Connell D, Peterson J, Welch V, Losos M, et al. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses. Ottawa Hosp Res Inst; 2011;2(1):1-2

15. Damsere-Derry J, Ebel BE, Mock CN, Afukaar F, Donkor P. Pedestrians' injury patterns in Ghana. Accid Anal Prev. 2010;42(4):1080–8.

16. Bogusiak K, Pyfel M, Puch A, Kopertowska M, Werfel D, Neskoromna-Jędrzejczak A. Characteristics and risk factors of bike-related accidents: Preliminary analysis. Adv Clin Exp Med. 2018;27(10):1403-1409.

17. de Oliveira RP, Achcar JA. Victims of road accidents with serious injuries and dependence on some individual, climatic and infrastructure factors on federal highways in Brazil. Int J Inj Contr Saf Promot. 2020;27(3):355–61.

This open-access article distributed under the terms of the Creative Commons Attribution NonCommercial 3.0 License (CC BY-NC 3.0).
Downloaded from: https://journals.sbmu.ac.ir/aaem/index.php/AAEM/index

18. Delgado-Fernández VJ, Rey-Merchán MDC, López-Arquillos A, Choi SD. Occupational traffic accidents among teachers in Spain. Int J Environ Res Public Health. 2022;19(9):5175.

19. Lin H-A, Chan C-W, Wiratama BS, Chen P-L, Wang M-H, Chao C-J, et al. Evaluating the effect of drunk driving on fatal injuries among vulnerable road users in Taiwan: a population-based study. BMC Public Health. 2022;22(1):2059.

20. Rahmanian V, Rahmanian N, Zahedi R, Mansoorian E, Khoubfekr H. Risk factors of mortality following road accident in southern Iran. Trauma Mon. 2021;26(4):199–205.

21. Tadege M. Determinants of fatal car accident risk in Finote Selam town, Northwest Ethiopia. BMC Public Health. 2020;20(1):624.

22. Wiratama BS, Chen P-L, Chen L-H, Saleh W, Chen S-K, Chen H-T, et al. Evaluating the effects of holidays on road crash injuries in the United Kingdom. Int J Environ Res Public Health. 2021;18(1):280.

23. Ngekeng S, Kibu O, Oke R, Bassah N, Touko DA, Yost MT, et al. Prehospital factors associated with mortality among road traffic injury patients: analysis of Cameroon trauma registry data. BMC Emerg Med. 2024;24(1):194.

24. Derese BM, Trueha DK. Modeling frequency of injuries per vehicle crash in Gurage Zone, Southern Ethiopia. Ethiop J Health Sci. 2021;31(1):101-110.

25. Jafari H, Amini-Rarani M, Ranjbar M, Shafiee M, Haj-Hashemi A. Investigating the effects of social determinants of traffic crash mortality in Isfahan City. J Community Health Res. 2022;11(2):91-98.

26. Zhang G, Yau KK, Chen G. Risk factors associated with traffic violations and accident severity in China. Accid Anal Prev. 2013;59:18–25.

27. Alemayehu M, Woldemeskel A, Olani AB, Bekelcho T. Epidemiological characteristics of deaths from road traffic accidents in Addis Ababa, Ethiopia: a study based on traffic police records (2018–2020). BMC Emerg Med. 2023;23(1):19.

28. Boufous S, Williamson A. Factors affecting the severity of work related traffic crashes in drivers receiving a worker's compensation claim. Accid Anal Prev. 2009;41(3):467–73.

29. Bakhtiyari M, Delpisheh A, Monfared AB, Kazemi-Galougahi MH, Mehmandar MR, Riahi M, et al. The road traffic crashes as a neglected public health concern; an observational study from Iranian population. Traffic Inj Prev. 2015;16(1):36–41.

30. Vanlaar W, McAteer H, Brown S, Crain J, McFaull S, Hing MM. Injuries related to off-road vehicles in Canada. Accid Anal Prev. 2015;75:264–71.

31. Moradi A, Rahmani K, Hasani J, Gilasi H, Darabi F. Assessment of risk factors related to traffic crashes among drivers in Kashan. Saf Promot Inj Prev. 2018;6(2):55-64.

32. Habybabady RH, Okati-Aliabad H, Sabouri M, Mohammadi M, Ansari-Moghaddam A. Prevalence and factors associated with road traffic crashes among truck drivers in Southeast Iran. PLoS One. 2025;20(4):e0320974.

33. Kim JH, Park GJ, Kim YM, Chai HS, Kim SC, Kim H, et al. Effect of seat belt use and airbags deployment on mortality in patients with road traffic injury. Signa Vitae. 2024;20(6):58-66.

34. Mansouri Jalilian M, Safarpour H, Bazyar J, Safi-Keykaleh M, Farahi-Ashtiani I, Khorshidi A. Epidemiology of road traffic crashes in Ilam Province, Iran, 2009-2013. BMC Res Notes. 2020;13(1):517.

35. Mehmandar M, Soori H, Amiri M, Norouzirad R, Khabzkhoob M. Risk factors for fatal and nonfatal road crashes in Iran. Iran Red Crescent Med J. 2014;16(8):e10016.

36. Rostom AH, Suboh D, Dweikat T, Hindi I, Farounyeh Z, Shawahna R. Epidemiological pattern of injuries among road traffic crash victims: the first experience of a large tertiary care hospital in the West Bank of Palestine. BMC Emerg Med. 2024;24(1):229.

37. Soroosh D, Nematshahi M, Javadinia SA, Hesamifard M. Study of the pattern and frequency of road traffic injuries in car occupants in the eastern part of Iran. Int J Med Toxicol Forensic Med. 2020;10(2):28112.

38. Sundet M, Mulima G, Kajombo C, Gjerde H, Christophersen AS, Madsen JE, et al. Geographical mapping of road traffic injuries in Lilongwe, Malawi. Injury. 2021;52(4):806–13.

39. Vafaee-Najar A, Khabbazkhoob M, Alidadi-Soltangholi H, Asgari S, Ibrahimipour H. Investigating the relative risk factors of injuries caused by accidents on roads in the Mashhad area in 2007. Iran Red Crescent Med J. 2011;13(8):530-536.

40. Vorko-Jović A, Kern J, Biloglav Z. Risk factors in urban road traffic accidents. J Safety Res. 2006;37(1):93–8.

41. World Health Organization, United Nations Regional Commissions. Global Plan for the Decade of Action for Road Safety 2021–2030. 2021. Available from: https://www. who. int/publications/m/item/global-plan-for-the-decade-of-action-for-road-safety-2021-2030.

42. Dos Santos BH, Ahanhanzo YG, Kpozehouen A, Daddah D, Ouendo E-M, Coppieters Y, et al. Referral conditions for severe road traffic injuries and their influence on the occurrence of hospital deaths in Benin. J Public Health Afr. 2022;13(2):2138.

43. Lee JJ, Kim BW, Kong SY, Park GJ, Chai HS, Kim YM, et al. Age-specific characteristics of road traffic injuries among children and adolescents in South Korea. Traffic Inj Prev. 2023;24(6):482-487.

44. World Health Organization. Global status report on road safety 2018. Geneva: World Health Organization;2018. Available from: https://www. who. int/publications/i/item/9789241565684.

45. Fouda Mbarga N, Abubakari AR, Aminde LN, Morgan AR. Seatbelt use and risk of major injuries sustained by vehicle occupants during motor-vehicle crashes: a systematic review and meta-analysis of cohort studies. BMC Public Health. 2018;18(1):1413.

46. Robinson E, Edwards P, Laverty A, Goodman A. Do sports utility vehicles (SUVs) and light truck vehicles (LTVs) cause more severe injuries to pedestrians and cyclists than passenger cars in the case of a crash? A systematic review and meta-analysis. Inj Prev. 2026;32(1):16–24.

47. Ju S, Belzer MH. Follow the money: Trucker pay incentives, working time, and safety. Econ Labour Relat Rev. 2024;35(1):7-26.

48. Hege A, Perko M, Johnson A, Yu CH, Sönmez S, Apostolopoulos Y. Surveying the impact of work hours and schedules on commercial motor vehicle driver sleep. Saf Health Work. 2015;6(2):104–13.

49. Zhang G, Li Y, King MJ, Zhong Q. Overloading among crash-involved vehicles in China: identification of factors associated with overloading and crash severity. In: Zhang G, Zhong Q, editors. Road Safety in China: Key Facts, Risk Analysis, Policy Impacts in Guangdong, Hong Kong and Macau. Singapore: Springer;2021. p. 95-120.

50. Daigneault G, Joly P, Frigon J-Y. Previous convictions or accidents and the risk of subsequent accidents of older drivers. Accid Anal Prev. 2002;34(2):257–61.

51. Getachew E, Lakew G, Yirsaw AN, Mekonnen GB, Shibabaw AA, Chereka AA, et al. Socioeconomic and behavioral factors of

This open-access article distributed under the terms of the Creative Commons Attribution NonCommercial 3.0 License (CC BY-NC 3.0).
Downloaded from: https://journals.sbmu.ac.ir/aaem/index.php/AAEM/index

road traffic accidents among drivers in Ethiopia: systematic review and meta analysis. BMC Public Health. 2024;24(1):2857.

52. Mandacarú PMP, Rabelo IVM, Silva MAAd, Tobias GC, Morais Neto OLd. Deaths and serious injuries due to traffic accidents in Goiânia, Brazil - 2013: the magnitude and associated factors. Epidemiol Serv Saude. 2018;27:e2017295.

This open-access article distributed under the terms of the Creative Commons Attribution NonCommercial 3.0 License (CC BY-NC 3.0).
Downloaded from: https://journals.sbmu.ac.ir/aaem/index.php/AAEM/index

Table 1: Methodological quality of included studies using the Newcastle–Ottawa Scale (NOS)

First Author	Selection	Comparability	Exposure/outcome	Total
Soufiane Boufous (28)	4	2	3	9
James Damsere-Derry (15)	4	2	3	9
Guangnan Zhang (26)	4	2	2	8
Mahmood Bakhtiyari (29)	3	2	3	8
Ward Vanlaar (30)	4	2	3	9
Shu-Ling Chong (4)	4	2	3	9
Katarzyna Bogusiak (16)	4	2	2	8
Polyana Maria Pimenta Mandacarú (52)	4	2	3	9
Joji Inamasu (5)	4	2	3	9
Melaku Tadege (21)	5	2	3	10
Ricardo Puziol de Oliveira (17)	5	2	3	10
Vahid Rahmanian (20)	4	2	2	8
Bayu Satria Wiratama (22)	4	2	3	9
Biru Mohammed Derese (24)	4	2	2	8
Hui-An Lin (19)	5	2	3	10
Fatemeh Jahanjoo (11)	5	2	3	10
Vicente Joaquín Delgado-Fernández (18)	5	2	3	10
Hasan Jafari (25)	4	2	3	9
Michael Alemayehu (27)	5	2	3	10
Serge Ngekeng (23)	5	2	3	10
Laura Zhang (7)	5	2	3	10
Ali Moradi (31)	4	0	3	7
Ariana Vorko-Jović(40)	4	2	2	8
Ali Vafaee-Najar(39)	3	2	3	8
Mohammadreza Mehmandar (35)	4	2	2	8
Gwan Jin Park (8)	5	2	3	10
Davood Soroosh (37)	4	2	1	7
Marzieh Mansouri Jalilian (34)	4	2	3	9
Mads Sundet (38)	4	2	2	8
Bella Hounkpe Dos Santos (42)	4	2	3	9
Jung Ju Lee (43)	4	2	3	9
Alaa H. Rostom (36)	4	2	2	8
Jong Hee Kim (33)	5	2	3	10
Raheleh Hashemi Habybabady (32)	4	2	3	9

Study quality was assessed using a modified 10-point version of the Newcastle–Ottawa Scale (NOS) and categorized as follows: very good (9–10 points), good (7–8 points), satisfactory (5–6 points), and unsatisfactory (0–4 points)

This open-access article distributed under the terms of the Creative Commons Attribution NonCommercial 3.0 License (CC BY-NC 3.0).
Downloaded from: https://journals.sbmu.ac.ir/aaem/index.php/AAEM/index

Table 2. General Characteristics of the Vehicle (Vehicle type, Vehicle owner, Vehicle life)

First Author	Study type	Publication Year	Country	Sample size	Outcome(s) Assessed	Vehicle Type(s)	Vehicle related factors	Significant Predictors
Soufiane Boufous (28)	Registry-based	2009	Australia (New South Wales)	13,124	Permanent disability or death resulting from work-related traffic crashes (including both on-duty and commuting incidents)	Cars, Light trucks, Heavy trucks, Motorcycles, Buses, Taxis, Emergency vehicles	Vehicle type	Taxi drivers had more than twice the risk of severe injury or death compared to car drivers. Heavy and light truck drivers were also at increased risk, especially during on-duty crashes. Commuting drivers had a significantly higher risk of severe injury than those driving during work duties.
James Damsere-Derry (15)	Cross-sectional	2010	Ghana – Accra-Kumasi Highway	812	Pedestrian injury severity (fatal, hospitalized, minor injury)	Private cars, Buses, Pickup trucks, Motorcycles, Heavy goods vehicles (HGVs), Unknown vehicles (often hit-and-run)	Vehicle type	Vehicles classified as "unknown" (mostly hit-and-run) had the highest odds of causing pedestrian fatalities. Compared with buses, the likelihood of pedestrian fatality was significantly lower when struck by: • Private cars (52% reduction) • Pickup trucks (57% reduction) • Motorcycles (86% reduction)
Guangnan Zhang (26)	Retrospective study	2013	China	37,340	fatal or serious injury	Passenger vehicles, Goods vehicles, Motorcycles	Vehicle type	Passenger and goods vehicles had higher odds of traffic violations compared to motorcycles.
Mahmood Bakhtiyari (29)	Registry-based	2015	Iran	592,168	Injury severity in road crashes	All vehicle types	vehicle life	Older vehicles were significantly associated with more severe injuries in crashes, likely due to a lack of modern safety features and greater mechanical wear.
Ward Vanlaar (30)	Descriptive	2015	Canada	2,000,000	Fatal and serious injuries	Off-Road Vehicles (ORVs): Snowmobiles, All-Terrain Vehicles (ATVs), Dirt Bikes	Vehicle type	Fatality rates increased for ATV and dirt bike users, while snowmobile fatality rates declined. Serious injuries rose for ATV/dirt bikes but declined for snowmobiles. ORV type was a significant factor in injury trends and severity
Shu-Ling Chong (4)	Cross-sectional	2018	United States	47,789	Pedestrian death after collision with motor vehicles	Passenger cars, Light trucks (SUVs, vans, pickups), Heavy trucks, Buses	Vehicle type	Heavier vehicles increased pedestrian fatality risk. Buses, heavy trucks, and light trucks (SUVs, vans, pickups) were all associated with higher odds of death compared to passenger cars.
Katarzyna Bogusiak (16)	Cohort	2018	Poland	729	Bike-related injuries	Bicycles (City bike, Mountain bike, Touring bike, Road bike, Fold-up bike, Electric bike)	Vehicle type	Use of mountain bikes and fold-up bikes significantly increased the risk of accidents compared to city bikes.
Polyana Maria Pimenta Mandacarú (52)	Cross-sectional	2018	Brazil / Goiânia	9,795	Death; Serious Injury	Car, Motorcycle, Bicycle	Vehicle type	Pedestrians and cyclists had a higher risk of both death and serious injury compared to car occupants. Motorcyclists were at a significantly increased risk of sustaining serious injuries, though their risk of death was not notably higher than that of car occupants.
Joji Inamasu (5)	Cohort	2019	Japan	255	Injury, Mortality	Mopeds and Motorcycles	Vehicle type	Traumatic brain injury (TBI) was more frequent among moped riders than motorcycle riders

This open-access article distributed under the terms of the Creative Commons Attribution NonCommercial 3.0 License (CC BY-NC 3.0).
Downloaded from: https://journals.sbmu.ac.ir/aaem/index.php/AAEM/index

First Author	Study type	Publication Year	Country	Sample size	Outcome(s) Assessed	Vehicle Type(s)	Vehicle related factors	Significant Predictors
Melaku Tadege (21)	Cohort	2020	Finote Selam, Northwest Ethiopia	255	Fatal, serious, and slight road traffic accidents (RTAs)	Minibus, Bajaj, Cargo, Pickup	vehicle type, vehicle owner, vehicle-to-driver relation	Minibus vehicles were involved in the most serious and fatal accidents, although the association wasn't statistically significant. The relationship between vehicle and driver (whether the driver owned the vehicle or was employed) had a significant impact on the accident outcome. Drivers who owned their vehicles were less likely to be involved in fatal accidents than those employed.
Ricardo Puziol de Oliveira (17)	Cross-sectional	2020	Brazil	11,809	Serious injuries and deaths in road traffic accidents	Automobile, Truck, Motorcycle, Bus, Others (e.g., bicycles, carts)	Vehicle type	Motorcycles were strongly associated with a higher risk of both serious injuries and fatalities compared to passenger cars. Other vehicle types (e.g., bicycles, carts) also had very high odds of serious injury and death. Trucks were linked to a lower probability of causing serious injuries in crashes relative to passenger cars. Buses presented a moderate risk for injury but were less likely to be involved in fatal outcomes compared to passenger vehicles.
Vahid Rahmanian (20)	Cross-sectional	2021	Iran (Southern Region)	1,792	Hospital mortality following road accidents	Motorcycles, others (general reference; not all vehicle types categorized)	Vehicle type (notably motorcycle crashes)	Motorcycle accidents were significantly associated with higher mortality rates. No specific analysis comparing all vehicle types; however, motorcycle involvement was highlighted as a dominant factor in fatal cases.
Bayu Satria Wiratama (22)	Cross-sectional	2021	United Kingdom	3,751,998	KSI (Killed or Seriously Injured) vs. Slight Injury	Automobiles, Motorcycles, Bicycles, Large Vehicles	Vehicle type	Motorcyclists had the highest odds of KSI compared to automobile drivers. Cyclists also showed elevated odds of KSI. Crashes with large vehicles as the partner vehicle increased the likelihood of KSI Automobiles had the lowest injury severity baseline among vehicle types.
Biru Mohammed Derese (24)	Cohort	2021	Ethiopia	334	Injury	Minibus, Isuzu (load), motorcycle, autobus, bajaj, Toyota pickup, long-vehicle, Sino-truck	Vehicle type (commercial vs. private), driver-vehicle ownership (hired vs. owner)	Minibus-type vehicles ,which are commonly used for public transportation and carry multiple passengers were associated with a substantially higher number of injuries per crash compared to smaller vehicles such as motorcycles, private cars, or cargo trucks. Vehicle operated by hired drivers, that is, drivers who were not the owners of the vehicles, were more likely to be involved in crashes that resulted in a higher number of injuries per accident, compared to vehicles driven by their private owners

This open-access article distributed under the terms of the Creative Commons Attribution NonCommercial 3.0 License (CC BY-NC 3.0).
Downloaded from: https://journals.sbmu.ac.ir/aaem/index.php/AAEM/index

First Author	Study type	Publication Year	Country	Sample size	Outcome(s) Assessed	Vehicle Type(s)	Vehicle related factors	Significant Predictors
Hui-An Lin (19)	Registry-based	2022	Taiwan	1,416,168	Fatal injury (Death within 24 hours after crash)	Passenger car, Heavy-duty vehicle (Truck, Bus, Trailer, Tractor)	Automobile type	Heavy-duty vehicles (trucks, buses) are significantly associated with higher fatality rates. Vehicle type (passenger car vs. heavy-duty vehicle) plays a critical role in fatal injury risk, with heavy-duty vehicles showing a higher mortality rate
Fatemeh Jahanjoo (11)	Cross-sectional	2022	Iran	384,614	Road traffic fatalities	heavy vehicles	Vehicle type, Vehicle life	Heavy vehicles increased the odds of fatal crashes. Old vehicles were more likely to be involved in fatal crashes.
Vicente Joaquín Delgado-Fernández (18)	Registry-based	2022	Spain	102,778	Injury severity (Light, Serious, Very Serious, Fatal)	Car, Motorbike, Bus	Vehicle type	Car use was associated with a higher likelihood of light injuries and a lower likelihood of serious injuries. Motorbike use was significantly associated with increased odds of serious and very serious injuries. Bus involvement showed a potential increase in very serious injuries, but results were not statistically conclusive for fatal injuries.
Hasan Jafari (25)	Cross-sectional	2022	Iran – Isfahan City	29,909	In-hospital mortality due to road traffic crashes	Bicycle/tricycle, Motorcycle, Car, Van/small truck, Heavy vehicles, Bus, Other	Vehicle type	Passengers of vans and small trucks had significantly higher odds of mortality compared to pedestrians. Motorcyclists and car occupants had lower odds of mortality compared to pedestrians.
Michael Alemayehu (27)	Cross-sectional	2023	Ethiopia (Addis Ababa)	8,458	fatality and injury	Two/Three-wheeler, Public Transport, Commercial Truck, Automobile	Vehicle type, Vehicle ownership (Private, Governmental, Others)	Heavy vehicles like trucks showed a higher mortality risk compared to other vehicles. Public transport vehicles were also associated with increased death risk. Vehicle type and ownership significantly influenced mortality outcomes, with lighter or private vehicles having a lower risk than heavy vehicles, such as commercial trucks and public transport vehicles.
Serge Ngekeng (23)	Registry-based	2024	Cameroon	3,203	Mortality	Motorcycles, private 4+ wheel vehicles, commercial 4+ wheel vehicles, pedestrians, trucks	Vehicle type	Crashes involving motorcycles had significantly higher odds of in-hospital death compared to commercial 4+ wheel vehicles
Laura Zhang (7)	Registry-based	2024	United States (New York State)	958,704	Injury severity, Traumatic brain injury (TBI), Mortality rate per 100,000 occupants	Passenger vehicles (front- and rear-seated occupants)	Vehicle model year	Newer vehicles (especially model years 2015–2018) were significantly associated with a lower risk of severe injury or death in crashes.
Marzieh Mansouri Jalilian (34)	Cross-sectional	2020	Iran / Ilam Province	2,314	Road traffic crash leading to death/injury	Heavy, light, Motorcycle	Vehicle type	Injuries were reported among 78.3% of drivers involved in crashes involving small vehicles, whereas 69 (0.3%) of those involved in motorcycle crashes died.

This open-access article distributed under the terms of the Creative Commons Attribution NonCommercial 3.0 License (CC BY-NC 3.0).
Downloaded from: https://journals.sbmu.ac.ir/aaem/index.php/AAEM/index

Table 3: Vehicle Maintenance and Usage Status (Servicing, Overloading, Accident History, and Insurance)

First Author	Study type	Publication Year	Country	Sample size	Outcome(s) Assessed	Vehicle Type(s)	Vehicle-related factors	Significant Predictors
Guangnan Zhang (26)	Retrospective study	2013	China	37,340	fatal or serious injury	Passenger vehicles, Goods vehicles, Motorcycles	Vehicle safety status, Overload condition, Insurance coverage	Unfit safety status increased the odds of both traffic violations and accident severity. Overloaded vehicles showed increased risk for both violations and severity. Lack of compulsory third-party insurance was not associated with violations, but increased severity.
Mahmood Bakhtiyari (29)	Registry-based	2015	Iran	592,168	Injury severity in road crashes	All vehicle types	lighting system, faulty vehicle	Presence of mechanical problems such as brake failure or tire issues was significantly associated with greater injury severity. Vehicles with broken, dim, or malfunctioning lights were more likely to be involved in crashes resulting in severe injuries, especially at night.
Ali Moradi (31)	Case-control	2018	Iran (Kashan)	310	Traffic crash involvement (injury and death)	Private passenger cars	Number of previous crashes	Drivers with a history of previous crashes had a higher likelihood of involvement in future traffic accidents.
Melaku Tadege (21)	Cohort	2020	Finote Selam, Northwest Ethiopia	255	Fatal, serious, and slight road traffic accidents (RTAs)	Minibus, Bajaj, Cargo, Pickup	Vehicle service year	The longer the vehicle was in service, the lower the likelihood of fatal accidents (0.91 times decrease for each year).

This open-access article distributed under the terms of the Creative Commons Attribution NonCommercial 3.0 License (CC BY-NC 3.0).
Downloaded from: https://journals.sbmu.ac.ir/aaem/index.php/AAEM/index

Table 4: Vehicle safety equipment (Airbag, Seatbelt, Safety device use)

First Author	Study type	Publication Year	Country	Sample Size	Outcome(s) assessed	Vehicle type(s)	Vehicle related factors	Significant Predictors
Ariana Vorko-Jović (40)	Cross-sectional	2006	Croatia / Zagreb	528	Fatal injury (died at scene or during transport); Severe injury; Mild injury	Cars, motorcycles, bicycles	Seatbelt use	Lack of seatbelt use was associated with a higher likelihood of fatal and severe injuries.
Ali Vafaee-Najar (39)	Case-control	2008	Iran/ Mashhad	312	Physical injury (wounding) in road traffic crashes	Passenger cars	Seatbelt use	Not using a seatbelt was significantly associated with higher risk of injury.
Mahmood Bakhtiyari (29)	Registry-based	2015	Iran	592,168	Injury severity in road crashes	All vehicle types	Seatbelt use	Not wearing a seatbelt was linked to a higher risk of severe injuries among occupants.
Mohammadreza Mehmandar (35)	Cross-sectional	2014	Iran (27 provinces)	2,585	Injury, Death	Not specified	Seatbelt use	According to the study findings, not using a seatbelt was significantly associated with an increased risk of both injury and fatality in road traffic crashes. Specifically: Individuals who were not wearing seat belts had 23.1-fold higher odds of sustaining an injury than those who used seat belts. Failure to use a seat belt was significantly associated with higher odds of death, with a 1.43-fold increase in the risk of fatality compared with seat belt users.
Gwan Jin Park (8)	Cross-sectional	2018	South Korea	5,545	Intracranial injury, ICU admission, Mortality	Passenger vehicles	Use of car safety seat, seatbelt use,	Use of a child car safety seat was associated with a 69% reduction in the odds of intracranial injury and a 53% reduction in ICU admission compared to children not using a car seat. In contrast, using a seatbelt alone did not significantly lower the risk of severe outcomes, indicating that seatbelts may not offer sufficient protection for young children in RTIs.
Ali Moradi (31)	Case-control	2018	Iran (Kashan)	310	Traffic crash involvement (injury and death)	Private passenger cars	seat belt	Not wearing a seat belt was significantly associated with higher crash risk.
Davood Soroosh (37)	Cross-sectional	2020	Iran (Eastern provinces)	300	Road traffic injuries in car occupants	Passenger cars	Seatbelt use	Not wearing a seatbelt significantly increased injury severity; most injuries occurred in sedans; head and neck were most affected.
Marzieh Mansouri Jalilian (34)	Cross-sectional	2020	Iran / Ilam Province	2,314	Road traffic crash leading to death/injury	Heavy, light, Motorcycle	Seatbelt use	Among drivers who were wearing seat belts, 3,819 (65.7%) sustained injuries, whereas 122 (1.2%) drivers who were not wearing seat belts died. Similarly, 123 (11%) passengers who had not fastened their seat belts died.

This open-access article distributed under the terms of the Creative Commons Attribution NonCommercial 3.0 License (CC BY-NC 3.0).
Downloaded from: https://journals.sbmu.ac.ir/aaem/index.php/AAEM/index

First Author	Study type	Publication Year	Country	Sample Size	Outcome(s) assessed	Vehicle type(s)	Vehicle related factors	Significant Predictors
Mads Sundet (38)	Cross-sectional	2021	Malawi, specifically Lilongwe	1,259	Road traffic injuries, injury severity, and geographical hotspots for injuries	Car passenger or driver, Bicyclist/passenger, Cab of lorry, Bed of lorry, Minibus, Pedestrian	Seatbelt use	Seatbelt use is linked to a lower risk of serious injuries among car passengers and drivers.
Bella Hounkpe Dos Santos (42)	Prospective-Cohort	2022	Benin / Ouidah	336	Referral conditions for severe road traffic injuries and their influence on hospital deaths	Cars, Two-wheelers, Pedestrians	Protective equipment use	In the study, not using protective equipment (such as helmets for motorcyclists and seatbelts for car occupants) was found to significantly increase the risk of mortality following a road traffic injury. Specifically, individuals who did not wear protective equipment were 4.5 times more likely to die from their injuries compared to those who wore protective equipment.
Jung Ju Lee (43)	Cross-sectional	2023	South Korea	66,632	Age-specific characteristics and severity of road traffic injuries among children and adolescents	Cars, Bicycles, Pedestrians	Protective equipment use	Across all age groups, the use of protective equipment, such as helmets for cyclists or seat belts for car passengers, was significantly associated with lower mortality rates. Non-use of protective equipment, particularly in vulnerable road users (cyclists, pedestrians), increased the risk of severe injury and death in road traffic accidents.
Alaa H. Rostom (36)	Retrospective cohort	2024	Palestine / Nablus, West Bank	1,544	Pattern and severity of road traffic injuries	Car, Truck, Motorcycle, Bicycle, Scooter	Seatbelt use, airbag deployment	Not using a seatbelt increased the risk of abdominal and head injuries; no airbag deployment increased risk of neck injuries.
Laura Zhang (7)	Registry-based	2024	United States (New York State)	958,704	Injury severity, Traumatic brain injury (TBI), Mortality rate per 100,000 occupants	Passenger vehicles (front- and rear-seated occupants)	Restraint use (seatbelt) Airbag deployment	Rear-seat occupants had a higher risk of severe injury or death when not controlling for restraint use, but after adjusting for seatbelt use, the rear seat was more protective than the front seat. Airbags were more likely to deploy for front-seated occupants. Rear-seated occupants had limited airbag protection. Full or partial ejection from the vehicle was one of the strongest predictors of severe injury or death, particularly among unrestrained occupants and in vehicles with less advanced safety features.

This open-access article distributed under the terms of the Creative Commons Attribution NonCommercial 3.0 License (CC BY-NC 3.0).
Downloaded from: https://journals.sbmu.ac.ir/aaem/index.php/AAEM/index

First Author	Study type	Publication Year	Country	Sample Size	Outcome(s) assessed	Vehicle type(s)	Vehicle related factors	Significant Predictors
Jong Hee Kim (33)	Retrospective-Cohort	2024	South Korea	82,262	In-hospital mortality, intracranial injury	Vehicles with <10 seats	Seatbelt use, airbag deployment	Seatbelt use was found to have a strong protective effect against both in-hospital mortality and intracranial injuries among patients involved in road traffic crashes. Individuals who wore seatbelts regardless of whether the airbag deployed had significantly lower odds of dying or sustaining serious brain injuries. In contrast, airbag deployment alone, without seatbelt use, was not sufficient to offer meaningful protection. In fact, those in the airbag-only group had substantially higher risks of both death and brain injury compared to those who used seatbelts.
Raheleh Hashemi Habybabady (32)	Cross-sectional	2025	Iran (Southeast – Zahedan)	592	Road traffic crash involvement (3 years)	Truck drivers	Seatbelt use	Neglecting seatbelt use was significantly associated with a higher likelihood of crash involvement among truck drivers, indicating its critical role in road safety.

ICU: intensive care unit; RTI: road traffic injury.

This open-access article distributed under the terms of the Creative Commons Attribution NonCommercial 3.0 License (CC BY-NC 3.0).
Downloaded from: https://journals.sbmu.ac.ir/aaem/index.php/AAEM/index

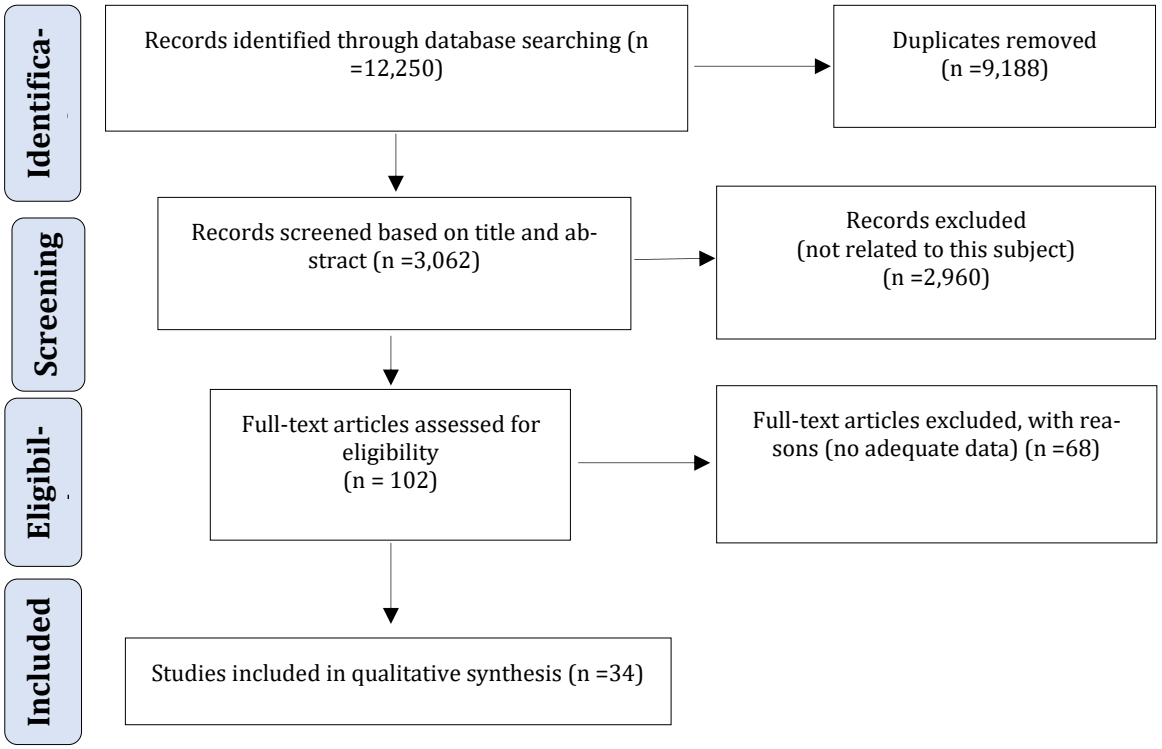


Figure 1: Flow diagram of the studies' selection.

This open-access article distributed under the terms of the Creative Commons Attribution NonCommercial 3.0 License (CC BY-NC 3.0).
Downloaded from: https://journals.sbmu.ac.ir/aaem/index.php/AAEM/index