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Challenges and Barriers of Reducing Fatalities and Injuries from Road Traffic Accidents: A Systematic Scoping Review of National and International Solutions

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ABSTRACT

Objective: This study aimed to map national and international evidence on the challenges associated with reducing road traffic fatalities and injuries.
Methods: This systematic scoping review was conducted in 2025 following the PRISMA Extension for Scoping Reviews (PRISMA-ScR) guidelines and the Arksey and O'Malley framework. A search of the gray literature and four key databases, including PubMed, Scopus, and Web of Science, was performed from 1956 to September 2025. Of the 9,048 records identified, 36 studies were eligible for inclusion. Data were extracted using a standard format and analyzed through the Haddon Matrix and qualitative content analysis.
Results: Challenges hindering the reduction of road traffic fatalities were identified across several domains: human, vehicle, environmental, sociocultural, administrative-organizational, prehospital, and research. Key problems included dangerous driving behaviors, poor education, low vehicle safety standards, weak law enforcement, lack of institutional coordination, absence of integrated data systems, and minimal prehospital services. The following strategies were identified as planned interventions: strengthening law enforcement, enhancing infrastructure, designing safety-related technologies, fostering education and culture change, and creating an integrated traffic management system.
Conclusion: The findings indicated that reducing traffic fatalities requires a multidimensional and coordinated approach that addresses structural and informational dimensions in addition to human and technical factors. These findings could serve as a foundation for developing evidence-based policies and interventions to improve road safety.

Keywords: Accidents; Traffic; Accident prevention; Challenge; Injuries.

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Introduction

Every year, millions of people die or become disabled as a result of road traffic accidents (RTAs). Largely preventable, RTAs have been identified as one of the major public health problems globally and continue to pose a significant threat to health both in the world and in Iran [1]. According to the World Health Organization (WHO), traffic accidents are the leading cause of death among individuals aged 5-29 years, with approximately 1.19 million people dying each year from road crashes globally [2]. In addition, about two-thirds of road traffic deaths occur among people of working age (18–59 years) [3]. Nine out of ten road deaths occur in low- and middle-income countries, which are home to only 60% of the world's vehicles [2].

In response to this global emergency, the United Nations (UN) and the WHO declared the "Decade of Action for Road Safety" for two consecutive decades. The first decade (2011–2020) emphasized saving millions of lives by enhancing road and vehicle safety, promoting safe road user behavior, strengthening rescue and prehospital emergency services, and controlling the rising trend in road traffic fatalities. The second decade (2021–2030) aimed to reduce road traffic fatalities and related injuries by half and stressed the enforcement of safety laws, such as the use of seat belts and helmets, as well as curbing the use of mobile phones while driving [3, 4]. Despite these efforts, population growth, increasing urbanization, the booming automotive industry, and technological innovations have resulted in greater traffic congestion and a higher frequency and severity of RTAs, particularly in the context of inadequate road networks and facilities [5-8]. Although novel technologies are important for enhancing road safety and reducing crashes, it is necessary to thoroughly evaluate the effect of these technologies on human behavior and their potential to cause new types of accidents [9-11].

In 1973, William Haddon introduced a comprehensive conceptual framework—the "Haddon Matrix"—for understanding the multiple factors involved in crashes. This model examines the three major elements—people, vehicle, and environment (road) —and is used to describe and analyze factors (e.g., human actions, road environment, and vehicle mechanical parameters) that may contribute to the occurrence and seriousness of accidents. This approach allows for the identification of primary sources of human error and system design deficiencies that lead to accidents, fatalities, and serious injuries [12]. The Haddon Matrix is valued for its utility in integrating the epidemiological triangle—host, agent, and environment—with the three levels of prevention (pre-crash, crash, and post-crash). Based on this principle, targeted measures can be planned for the prevention and reduction of RTAs [13]. Beyond their human and social consequences, RTA imposes a substantial financial burden on societies. These costs include medical care, lost work productivity, and broader economic impacts, which in some countries have been estimated to equal around 3% of the gross domestic product [2]. In line with this, the 2030 Agenda for Sustainable Development has set a target of a 50% reduction in road traffic deaths and injuries by 2030 [2]. Despite global actions, evidence indicates that the pattern of road traffic injuries and deaths has been declining over the past two decades. However, this decline has not been as pronounced as anticipated, and road transport remains a significant threat to public health in a large proportion of the world [14]. This is particularly true in low-income (LICs) and lower-middle-income countries (LMICs), where barriers to improving road safety standards, maintaining vehicles, and implementing safe transportation policies remain pervasive [14].

Given the magnitude of the problem, many countries have developed various strategies and policies aimed at reducing the number of deaths and injuries due to road traffic. Evidence suggests that preventive measures implemented prior to accidents—information campaigns, traffic safety education, and surveillance tools such as speed cameras—can reduce the number of road traffic accidents between 9% and 30% [15, 16]. Nevertheless, the complexity of road traffic crashes continues to pose substantial difficulties for policymakers seeking to reduce fatalities [17]. A review of literature revealed that although multiple studies have investigated determinants of road traffic crashes, very few have systematically and comprehensively explored the impediments or barriers to policy implementation using experiences from the national and international settings. Many of the studies concentrated on a single aspect and lacked a holistic or comparative perspective that cuts across borders. Therefore, the work of systematically and comprehensively addressing these challenges and suggesting solutions based on national and international experiences could formulate a holistic and practice-oriented view for planners and policy makers in the arena of traffic safety.

Materials and Methods

The systematic scoping review was conducted in 2025 following the framework by Arksey and O'Malley [18] and adhered to the PRISMA Extension for Scoping Reviews (PRISMA-ScR) checklist [19].

The review was guided by the following research questions:

- Which barriers and challenges prevent the reduction of road traffic deaths and injuries?
- Which interventions have been proposed and/or implemented globally to reduce road traffic deaths and injuries?

Articles published from 1956 up to the end of September 2025 were searched in the Web of

Science, PubMed, and Scopus databases. Required data were collected using Medical Subject Headings (MeSH) and keywords appearing in titles, abstracts, and full texts. Moreover, Google Scholar was utilized to access extensive gray literature, including the full text of conference papers, WHO guidelines, reports from international organizations, and related documents. The following search strategy was applied (example provided for PubMed):

(((((Barriers [Title/Abstract]) OR (challenge[Title/Abstract])) OR (strategy [Title/Abstract])) OR (solutions [Title/Abstract])) OR (obstacles [Title/Abstract])) AND ((((“Accidents, Traffic”[Mesh]) OR (“road traffic accident”[Title/Abstract])) OR (motorcycle accident [Title/Abstract])) OR (Road Traffic Injuries [Title/Abstract]))*

All articles retrieved through the database search strategy were collected by the research team and uploaded to EndNote X20 reference management software. After identifying and removing the duplicates, the screening process was conducted independently by two researchers (N.N. and M.S.). Any disagreements or conflicts during screening were resolved through consultation with a third reviewer (Hr.KH.). The study selection process was as follows: First, titles and abstracts were independently reviewed. Subsequently, the full texts of potentially eligible articles were evaluated and screened based on the predefined inclusion and exclusion criteria (Table 1). The search results and study selection process were reported in the PRISMA flow diagram for systematic reviews and meta-analyses (Figure 1).

Studies addressing the challenges, barriers, and solutions of reducing road traffic deaths and injuries based on national and international experiences were included (Table 1).

Data were extracted using a standard form in Microsoft Excel, which captured the following information: title, first author, year of publication, geographical location of the study, objectives, study design, and key findings. This extraction process was iterative, and the data extraction form was revised as necessary. As this study was a systematic scoping review, no human participants were involved.

For systematic data analysis, the theoretical framework of the Haddon Matrix was used, encompassing its three main components: human factors, vehicle and equipment factors, and environmental factors. Data were initially coded and grouped according to the main categories of the Haddon Matrix. Subsequently, new categories were identified through descriptive and narrative analysis, which are presented in the main table of the findings section as supplementary or emergent categories to maintain the comprehensiveness and flexibility of the analysis.

The extracted data and search results were organized and presented as tables and descriptive statistics. These tables included information such as author names, year of publication, temporal distribution of studies, geographical location, and study design. In addition, the challenges and barriers to reducing road traffic deaths and injuries were analyzed and categorized using a descriptive and narrative approach. To ensure the accuracy and validity of the analysis, the data coding process was performed independently by two researchers (N.N. and M.S.). The extracted categories included the main factors according to the Haddon Matrix framework, as well as new factors identified during the descriptive and narrative analysis, which were presented sequentially in the results section.

Results

The initial search identified 9,048 articles. After removing 3,742 duplicates, the remaining 5,306 articles underwent title screening, which resulted in the exclusion of another 3,760 articles. Abstract screening further narrowed the selection to 1,546 articles. After removing 1,221 irrelevant articles, 325 were selected for full-text review. Ultimately, 36 articles met the inclusion criteria for the final analysis (Figure 1). Through qualitative content analysis, data were extracted and grouped into seven categories: human barriers, vehicles, physical (biological) environment, socio-cultural, administrative-organizational, prehospital care, and research. Effective interventions for reducing road traffic injuries were also described in the reviewed studies.

The 36 studies included were published between 2003 and 2025. In terms of study design, 28 of 36 eligible articles were quantitative studies, six were qualitative, one was a cost-effectiveness analysis, and one was a mixed-methods study (Table 2).

The geographical distribution according to WHO classification [20] was as follows: African Region (4 studies), Region of the Americas (7 studies), South-East Asia Region (4 studies), European Region (3 studies), Eastern Mediterranean Region (8 studies), and Western Pacific Region (9 studies) (Figure 2).

Table 1. Study eligibility criteria.

Inclusion criteria	• Studies that examine challenges and barriers to reducing road traffic deaths and injuries. • Studies that provide solutions to address identified challenges and barriers. • Original research articles resulting from primary studies without geographical and time limitations. • Gray literature including full text of conference articles, WHO guidelines, and reports of international)
Exclusion criteria	• Conference abstracts, the protocols…, systematic review studies, expert opinions, comments, letters, book reviews, blogs and social media. • Papers that are not written in English or Persian.

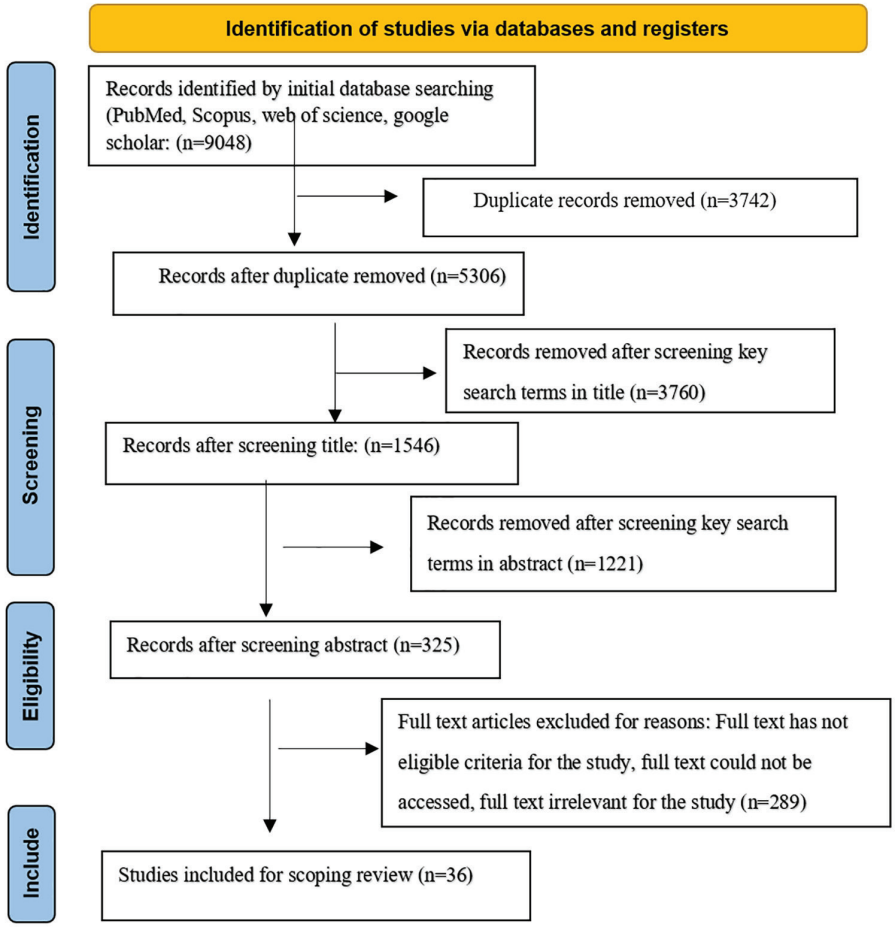

Fig. 1. Flowchart of Article Selection Process.

By country income level, 14 (40.0%) studies were conducted in high-income countries, 20 (57.14%) in middle-income countries, and one study (2.85%) in a low-income country. One study was based on WHO data.

Key Challenges and Corresponding Mitigation Strategies

1. Human Factors

One of the most important obstacles to reducing deaths and injuries caused by traffic accidents is the risky behavior of drivers, including abrupt or aggressive maneuvers [21-26], driving violations (e.g., high speed, driving at night) [1, 21-36], distraction by mobile phones [1, 21, 24, 29, 37, 38], alcohol consumption [22, 24, 25, 28, 29, 35, 38-42], failure to fasten seat belts [23-27, 31, 34, 35, 38, 41]. Certain individual characteristics, such as driving at young and old age (particularly among men), low education level and inexperience [24, 25, 32, 33, 38, 43-45], as well as lack of knowledge and

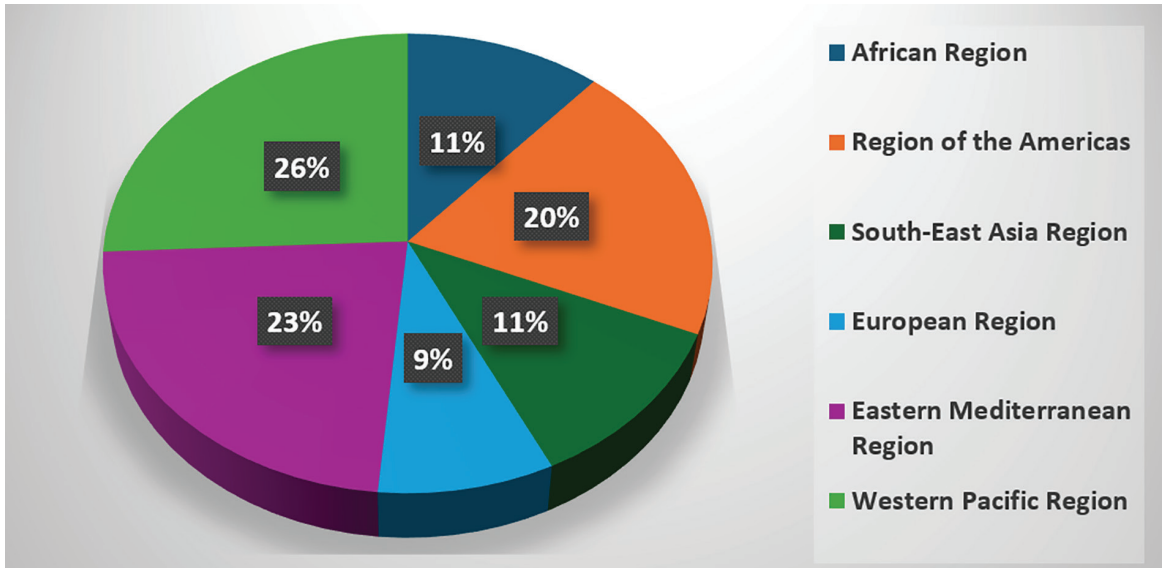

Fig. 2. Studies by geographical context.

Table 2. General characteristics of the included studies.

	1st Author/Pub. Year	Study Design	Location/ Year study
1	Afukaar and et al.-2003 [36]	Observational study(cross-sectional)	Ghana/(1998-2000)
2	Bong-Min Yang-2003 [21]	Observational study(cross-sectional)	Korea/(1970-2000)
3	Thomas S. Dee-2005 [45]	Observational study(cross-sectional)	U.S/(1992-2002)
4	Kwang Sik Kim-2006 [35]	time series analysis	Korea/(1984–2003)
5	Da Khorasani-Zavreh-2009 [22]	Qualitative study	Iran/2007
6	Rajesh Paleti-2010 [23]	Observational study	USA / (2005-2007)
7	Sarah J. Jones-2013 [33]	Observational study	Great Britain/(2000-2009)
8	Vallop Ditsuwan-2013 [42]	Cost-effectivenes analysis	Thailand/2004
9	Connie Hoe-2013 [34]	Observational study	Egypt(2011 -2012)
10	Harold B. Weiss-2014 [37]	Case study	New Zealand/ (2002-2011)
11	Darin J. Erickson-2015 [41]	Survey study	U.S/ (2010-2011)
12	Sam Harper-2015 [44]	Longitudinal observational study	US/ (1995-2010)
13	Fikri M. Abu-Zidan-2015 [32]	(Prospective) observational cross-sectional study	(UAE)/(2006-2007)
14	JinghongGao-2016 [52]	case analysis study	China/(1973-2012)
15	Hedayat SALARI-2017 [46]	Qualitative study	Iran/2016
16	Li-Lu Sun-2019 [50]	Cross-sectional study	China/(2004-2016)
17	Kazimierz Jamroz-2019 [24]	Secondary Analysis	Polish/ (1988-2017)
18	Md. Mazharul Islam -2019 [53]	Cross-sectional study	Saudi Arabia/ (2003- 2013)
19	Fatemeh Shahbazi-2019 [51]	Cross-sectional study	Iran/(2015 -2016)
20	Saber Azami-Aghdash-2019 [47]	Qualitative study	Iran/2016
21	Awtachew Berhe Woldu-2020 [29]	Cross-sectional study	Ethiopia/2015
22	Tefera Bahiru Ambo-2020 [31]	Observational, analytical modeling study	China/ 2016
23	Saber Azami-Aghdash-2020 [49]	Qualitative study	Iran/ 2018
24	Stephen T. Odonkor-2020 [30]	Qualitative study	Ghana/(2018-2019)
25	Xuesong Wang-2020 [38]	Prospective observational study/ Longitudinal cohort study	China/(2012-2015)
26	Shraddha Sagar-2020 [43]	Observational analytic study/ a modelling study	U.S/ (2013-2016)
27	Zhi-Ying Zhan-2020 [54]	Case-crossover study	China/ (2010–2016)
28	Gulnara Yakupova-2020 [28]	Observational analytic study/ a modelling study	Russia/ (2017-2018)
29	Nuntaporn Klinjun-2021[25]	Cross-sectional study	Thailand/(2006-2019)
30	Yajie Zou- 2021 [40]	Observational analytic study/ a modelling study	U.S/ (2001-2016)
31	Saen Fanai-2022 [48]	Qualitative study	Vanuatu/2020
32	Ritika Bhat-2024 [26]	Survey study	Indian/ Not reported
33	Nassim Sohaee-2024 [39]	Observational analytic study/ a modelling study	USA/(1975-2020)
34	Dandabathula Giribabu-2024 [55]	Survey study	Indian/ (2017-2022)
35	Alphonsus A. Adebiyi-2025 [27]	Mixed-methods study	Nigeria(Lagos)/ Not reported
36	Wouter Van den Berghe-2025 [1]	Ecological study	WHO data on road crash fatality rates(2014-2016)

awareness among the general public and even some police officers, were identified as significant obstacles [21, 23, 29, 36, 46-48].

The proposed solutions included strengthening enforcementand imposing fines [22-24, 26, 29-32, 34, 35, 37, 39, 40, 45, 47, 48], creating incentive and financial systems for reporting violations [26, 35], implementing non-monetary penalties (e.g., deprivation of social services) [47], driving restrictions [48, 49], speed reduction measures [26, 35, 36, 48, 50], issuing driving licenses under restrictive policies [33, 43], and public education to improve first-aid skills [23, 24, 26-29, 32, 35, 36, 39, 45-49, 51].

2. Vehicles and Equipment Factors

Major barriers were poor vehicle safety standards [23, 24, 41, 42, 52], manufacturing of vehicles incompatible with road infrastructure [23, 24, 47, 51] and the high cost of motor vehicle modifications [48]. To address these barriers, the literature recommended raising safety standards, tightening inspections [24, 32, 35, 46, 49], halting the production of low-quality vehicles [51], and increasing the use of advanced safety systems [27].

3. Environmental Factors

Critical environmental and road-related barriers contributing to higher death rates included inadequate transport infrastructure standards [22, 23, 27, 28, 30, 49, 51], ineffective traffic signs and poorly identified accident black spots [22-24], insufficient lighting in high-risk road sections [22, 23, 28], suboptimal highway and road construction in terms of time and cost considerations [42, 48, 51], limited pedestrian overpasses alongside a lack of safe walking and cycling facilities [23, 48], as well as seasonal patterns and the weather conditions [42, 53-55]. Proposed actions included improving infrastructure

[22, 23, 35, 46-49], providing traffic safety warning signs [23, 46, 51], ensuring adequate lighting [28], implementing traffic management and new technologies [22, 24, 51] and maintaining emergency service readiness in diverse situations [54, 55].

4. Socio-Cultural Factors

The results indicated that the poor public attitudes towards traffic accident prevention [1, 21, 30, 46, 49], distrust in the police, and limited understanding of traffic safety among senior management [23, 46]. were the main obstacles to reducing traffic-related injuries. In addition, low socio-economic level—including poor economic development and corruption [1, 27, 30, 36, 41, 46, 47, 49, 52], the use of government vehicles [29], cheap cars [52], social acceptance of drug and alcohol use [21, 47] , poverty and unemployment [1, 41, 45], rising gasoline prices [42], declining gross domestic product (GDP) in the transport sector [41, 51], and population growth and urbanization [41, 42, 51]—were reported as important obstacles.

Studies emphasized that improving socio-economic conditions, investing in transportation infrastructure [1, 22, 51], fostering education and culture in the field of safe driving [1, 22, 49, 54], implementing effective social and economic policies for job creation [23, 51], and taking advantage of the capacity of non-governmental organizations (NGOs) and the private sector to enhance social acceptability could help reinforce the safety culture [49] and play an important role in reducing deaths and injuries from traffic accidents.

5. Administrative-Organizational Factors

Various studies showed that inefficient laws and lack of clear regulations—such as the absence of laws on random alcohol and drug testing [22, 23, 46-49], inadequate fines [23, 48], no specific authority to handle traffic violations [21], the absence of a central institution for integrated management of traffic injuries [22, 23, 30, 46, 48, 49, 51], as well as poor political support and the influence of partisan interests on policymaking [36, 41, 46] —were important obstacles to reducing traffic fatalities. Moreover, inefficient road safety management, easy issuance of licenses, poor handling of speeding violations [23, 30, 36, 46, 51], shortage of skilled manpower [30, 46, 47], high workload of transportation workers [47], and lack of an integrated database for accurate accident recording [30, 46, 48]. were identified as serious challenges.

Proposed measures in this domain included increasing the deterrence of fines, reforming road safety laws [34, 41], establishing a joint inspection system between the police and related agencies [26], and improving coordination between organizations and the private sector to clarify responsibilities [23, 48, 49, 51]. Additionally, recommendations included employing trained manpower, strengthening police capacity, conducting regular inspections on high-risk roads [39, 46, 47], improving the licensing process [51], establishing a national database to standardize traffic accident information [34, 48], and raising awareness among the public and officials about the consequences of traffic accidents [46].

6. Prehospital Care System

The findings indicated that long emergency response times [24, 48, 56], a weak emergency medical communication system [47], lack of a single call number [48], and inefficient roadside assistance systems[22, 47]. were major barriers to prehospital services. Suggested solutions include establishing an integrated communication system [48, 49], forming multidisciplinary teams [48], reinforcing emergency infrastructure [22], and securing government support to improve the coordination and efficiency of emergency services [24], These measures could positively impact response times and increase service quality.

7. Research and Development

The results indicated that the absence of applied research on traffic accidents and their economic aspects, the lack of innovation in the transportation system [23, 51]v, the absence of academic training in traffic safety, and incorrect allocation of research priorities [46]. To overcome these challenges, the following measures have been proposed: conducting targeted research on traffic injuries [48, 49], developing long-term road safety plans [32], increasing the number of research centers and training researchers, and utilizing conferences and media to promote awareness and knowledge exchange [46].

Discussion

This systematic scoping review aimed to identify the challenges and barriers to reducing road traffic deaths and injuries. The classic framework of the 1973 Haddon Matrix remains a valuable tool for analyzing human, vehicle, equipment, and environmental factors. However, the findings of this study indicated that the challenges extend beyond these three dimensions, including sociocultural, administrative, prehospital care, and research barriers, all of which contribute significantly to the persistence of traffic-related injuries.

Studies have revealed that human barriers continue to play a major role in the incidence and severity of accidents. High-risk driver behaviors—such as speeding, failing to comply with traffic laws, mobile phone use, and alcohol consumption—reduce driver concentration and increase the likelihood of irreparable errors, thereby significantly raising the probability of fatal accidents [56-58]. Demographic factors also influence vulnerability; young people (aged 15-24 years) and older adults (particularly men) account for the highest proportion of fatal accidents [59-62]. This might be attributed to insufficient

driving experience and reduced attentional capacity in these groups. Additionally, low educational level attainment and marital status were associated with decreased safe behaviors, increased alcohol consumption, and low rates of seat belt use [63-65]. These barriers might also reflect inadequate formal and public education, normalization of high-risk behaviors, weak law enforcement and monitoring, lack of adequate social support, and a poor driving culture. Addressing these challenges requires multifaceted interventions that target behavioral, educational, and enforcement domains.

Beyond human challenges, vehicle insecurity contributes substantially to the severity of injuries. Studies have shown that the absence of safety equipment (e.g., airbags, anti-lock braking systems [ABS]) and the use of substandard parts and components are directly linked to increased deaths and serious injuries [66-68]. This obstacle stems primarily from weak monitoring of production standards, a lack of a regular inspection system, and manufacturers' focus on production rather than vehicle safety quality. Improving vehicle safety regulations, designing vehicles to be more compatible with vulnerable road users, and implementing strict quality control for domestic vehicles are measures that have proven effective in successful countries [69, 70]. Although these solutions require strong political will and strengthened regulatory institutions, they are technically achievable, and the experience of successful countries confirms their effectiveness. The physical environment and road infrastructure also affect the persistence of this crisis. Substandard road design, accident hotspots, poor street lighting, and inadequate signage are directly linked to the occurrence of fatal accidents [57, 68, 71]. These shortcomings, which result from insufficient investment and a lack of safety prioritization in construction projects, demonstrate that an unsafe environment prevents injury reduction even when safe vehicles and drivers are present.

Furthermore, adverse weather conditions, such as heavy rain, which reduces road surface friction and visibility, or extremely hot weather, substantially increase the probability of traffic crashes and related casualties by affecting road traction and driver performance at a micro-level [72-74]. These phenomena contribute to fatalities and injuries by causing loss of vehicle control and increasing stopping distances. Research indicated that enhanced management of meteorological conditions (e.g., through driver warning systems and modifications to road infrastructure to better withstand adverse weather) could help reduce the number of accidents and, ultimately, the number of fatalities [73, 75, 76].

Social and economic dimensions are closely linked to other barriers and challenges. Poor attitudes towards accident prevention, corruption, misallocation of resources, and public distrust of the police often lead to flawed decision-making and ineffective transport policies, which in turn contribute to the spread of risky behaviors [30, 77-79]. In addition, problems such as unemployment, low income, and social inequalities place low-income groups at higher risk, as they are less able to maintain vehicles, purchase high-quality cars, or adopt safe behaviors [43, 80, 81]. In such circumstances, the lack of social and economic justice not only renders safety policies ineffective but also prevents the reduction of deaths at the community level. These challenges typically arise from inequalities and a lack of public awareness. The lack of attention to safety culture and ignoring public opinions exacerbate these problems. To improve the situation, education, supportive policies, and information programs are required. Public participation in these processes can help reinforce the culture of traffic safety.

Administrative-organizational challenges play an important role in this cycle. The absence of a central authority to coordinate actions, the dispersion of tasks among institutions, ineffective laws, and the lack of long-term planning all reduce the effectiveness of policies and executive actions [23, 48]. Furthermore, poor data collection quality and the absence of a unified database constrain the potential for evidence-informed decision-making. As a result, policy remains fragmented and short-term, and a sustainable reduction in casualty numbers cannot be achieved [48, 50]. These barriers arise from inadequate institutional capacity and poor coordination among the responsible agencies. The efficiency of the system could be enhanced by forming a central agency for traffic accident management, unifying laws and regulations, strengthening human resources, and developing an integrated database. Clearly, the implementation of these measures will necessitate political will and the commitment of adequate resources [71].

Prehospital care deficiencies, such as delays in emergency services, poor staff skills, and intervention by non-specialists, deprive victims of vital services during the "golden hour" [83-85]. These deficiencies not only increase the likelihood of death but also cause secondary complications and substantial economic and social costs [86]. Consequently, weaknesses in the prehospital care system break the chain of rescue and prevent a real reduction in injuries.

Finally, the lack of applied research and the absence of specialized training in the field of traffic safety represent important gaps that affect other challenges [87, 88]. The scarcity of research prevents policies from being formulated based on scientific evidence, and weaknesses in academic and public education hinder awareness-raising and behavioral change among drivers. Therefore, the lack of knowledge and innovation indirectly weakens every other link in the chain and delays the sustainable reduction of casualties.

Although this systematic review provided valuable insights, several limitations should be acknowledged. The review was restricted to studies published in

English, as articles in other languages could not be assessed. In addition, some potentially eligible studies were excluded because full texts were not available.

The findings of this review demonstrated that while the Haddon Matrix—focusing on human factors, vehicles, and the physical environment—provides a valuable framework, the challenges in road traffic safety have become more complex than these three categories alone. New challenges, such as socio-cultural, administrative-organizational, inefficient pre-hospital systems, and lack of applied research, must be integrated into the framework. To make solutions practical, the Haddon Matrix should be revised to incorporate these emerging barriers. In addition, integrated actions—including strengthening regulations, enhancing vehicle and road quality, promoting public education, and reinforcing inter-agency coordination—are necessary measures. To advance understanding and better inform interventions, it is recommended that more qualitative research be conducted to examine the experiences and perceptions of key stakeholders, based on the findings of the present study.

Declaration

Ethics approval and consent to participate: This study is part of a PhD thesis in the field of Health in Emergency and Disaster with an ethics code number IR.USWR.REC.1403.050. As this study was a Systematic Scoping Review, no participants were involved.

Consent for publication: Hereby the authors declared that informed consent was obtained from all participants, and the participants were aware of the study's purpose, potential risks, and benefits.

Conflict of Interests: The authors declared no competing interests, financial or otherwise, relevant to the content of this article.

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Declaration of generative AI in scientific writing: We used ChatGPT (OpenAI; GPT-4-based) artificial intelligence capabilities to improve language clarity and manuscript structure.

Authors' Contribution: NNH: Drafted the manuscript, developed search strategy and conducted the initial search; HRK: Conceptualization, study design, provided supervisory and feedback on the methodology final revision of the manuscript and supervision; MF: Provided supervisory and feedback on the methodology. MEM: Provided supervisory and feedback on the methodology; STH: manuscript revision; MS: Developed search strategy, conducted the initial search. All authors read and approve the publishing of this Systematic Scoping Review manuscript.

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