Systematic Review/Meta-analysis

ANNALS OF MEDICINE & SURGERY

OPEN

Effective factors of severity of traffic accident traumas based on the Haddon matrix: a systematic review and meta-analysis

Saeed Golfiroozi, MD[a], Hossein-Ali Nikbakht, PhD[e], Seyede Almas Fahim Yegane, MD[b], Saeed Gholami Gharab, MD[f], Layla Shojaie, MD[g], Seyed Ahmad Hosseini, MD[c], Abdolhalim Rajabi, PhD[d,*], Mousa Ghelichi-Ghojogh, PhD[c,*]

Objective: This study aims to investigate the factors affecting the severity of trauma caused by traffic accidents based on martrix Haddon; a systematic review and meta-analysis.

Methods: In this study searched five international databases in this study, including Medline/PubMed, ProQuest, Scopus, Web of Knowledge, and Google Scholar, for published articles by the end of 2022. Data were entered into the statistical program and analyses were performed using STATA 17.0 software. Odds ratio (OR) values were computed for severity accidents.

Results: Results of study showed that among the risk factors related to the host, not using helmet increased the risk of injury severity by 3.44 times compared to people who have used helmets ($OR_{\text{Not using helmet/Using helmet}} = 3.44$, 95% CI: 2.27–5.00, $P = 0.001$, $I^2 = 0.00\%$). Also, crossing over a centre divider has a protective role for the risk of injury severity compared to undertaking ($OR_{\text{crossing over a centre divider/undertaking}} = 0.39$, 95% CI: 0.20–0.75, $P = 0.01$, $I^2 = 25.79\%$). in terms of the type of accident, accident of car-car reduces the risk of injury severity by 23% compared to accident of car-pedestrian ($OR_{\text{accident of car-car/accident of car-pedestrian}} = 0.77$, 95% CI: 0.61–0.96, $P = 0.02$, $I^2 = 0.00\%$).

Conclusions: It is necessary to pay attention to the intersection of human, vehicle and environmental risks and their contribution and how they interact. Based on the Haddon matrix approach, special strategies can be designed to prevent road damage. Safety standards for vehicles should also be addressed through stricter legal requirements and inspections.

Keywords: haddon matrix, Meta-analysis, prevention, severity of trauma, traffic accident

Introduction

Traffic accidents are a major global health and development problem and are one of the most common causes of death and disability and have significant human, economic and social costs[1,2]. Every year, due to road traffic accidents, more than five million people are injured in the world[3]. Damages caused by road accidents take the lives of more than one million two hundred and fifty thousand people all over the world every year[4]. Also, in 2000, road accidents were the tenth cause of death in the world, in 2016, they were the eighth cause of death, and according to the WHO, they could be the fifth cause of death in the world by 2030[3,5].

HIGHLIGHTS

- It is necessary to pay attention to the intersection of human, vehicle and environmental risks and their contribution and how they interact. Based on the Haddon matrix approach, special strategies can be designed to prevent road damage.
- There are some simple recommendations applicable to all countries that should be implemented in policies designed to improve traffic safety decision-making. Recommendations include improving high-risk human behaviours including; giving the necessary training to the relevant audience, handling and dealing with drunk driving, observing the speed limit, using a helmet and seat belt, and not driving while tired.
- Also, the physical infrastructure of the roads should be improved. Safety standards for vehicles should also be addressed through stricter legal requirements and inspections.
- Finally, post-accident measures can also be improved through government support for increased first aid training among the general population and better coordination of emergency services.

[a]Department of Emergency Medicine, School of Medicine, [b]Department of Surgery, [c]Neonatal and Children's Research Center, Department of Biostatistics and Epidemiology, School of Health, Faculty of Health, Golestan University of Medical Sciences, Gorgan, Iran, [d]Environmental Health Research Center, Faculty of Health, Golestan University of Medical Sciences, Gorgan, [e]Social Determinants of Health Research Center, Health Research Institute, Babol University of Medical Sciences, Babol, [f]Emergency Medicine, Management Research Center, Health Management Reaearch Institute, Iran University of Medical Sciences, Tehran, Iran and [g]Department of Medicine, Keck School of Medicine, University of Southern California, Los Angeles, CA

Sponsorships or competing interests that may be relevant to content are disclosed at the end of this article.

*Corresponding author. Address: Golestan University of Medical Sciences, Gorgan, Iran, Tel.: +98 1732160330. fax: +98 1732160330. E-mail m.ghelichi97@gmail.com (M. Ghelichi-Ghojogh), and E-mail: rajabiepid@gmail.com (A. Rajabi).

Annals of Medicine & Surgery (2024) 86:1622–1630

Received 5 September 2023; Accepted 19 January 2024

Published online 8 February 2024

http://dx.doi.org/10.1097/MS9.0000000000001792

However, in many developing countries, this issue is not given much attention and the health sector is not quickly acknowledging RTIs as a priority in public health[6]. Many studies show that respiratory infections can be stopped easily, and many wealthy countries have stopped them by using methods that have been proven to work and are not too expensive[7,8]. The number of people who own vehicles is going up, so there is an increase in a thing called RTI in developing countries. Almost 90% of all deaths on roads happen in countries that have lower income levels, and these countries only have about 48% of the world's registered vehicles. In countries with low- and middle-income, road traffic accidents cost around $100 billion every year, which is 1–3% of the country's total income. This cost is due to disabilities, premature deaths, decrease in productivity, medical expenses, and damage to property[9]. New technologies increase road safety every day, and their impact on human behaviour and how much they reduce the risk of accidents should be investigated[10–12]. Understanding the causes and human factors and their impact in reducing accidents is a very important topic, according to the studies conducted, three factors of the driver (human factors), vehicle and environmental factors play a role in the occurrence of accidents[13,14,15]. Haddon's matrix was first proposed by William Haddon (1973) in America, which shows the interaction of three components: human, vehicle and environment (road). According to Martis Haddon, it is possible to examine behavioural factors, road factors, and vehicle factors that affect the number and severity of accidents and identify the most important sources of errors or design weaknesses that lead to accidents, deaths and death and serious injuries[16,17].

Based on the results of various studies of human factors such as drowsiness while driving, gender, age, smoking and factors related to the vehicle including not using seat belts, speed while driving, the nature of the vehicle and environmental factors of the day, week, travel time, driving and road design, traffic rules are the main factors of reported accidents[18,19]. Considering the importance of traffic accidents and its significant consequences, including death and disability, this study aims to investigate the factors affecting the severity of trauma caused by traffic accidents based on martrix Haddon; a systematic review and meta-analysis.

Methods

Study design

This systematic review and meta-analysis was reported in according to referred reporting items for systematic reviews and meta-analyses (PRISMA) guideline[20]. The work has been reported in line with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) Guidelines. Also, the work has been reported in line with AMSTAR (Assessing the methodological quality of systematic reviews) Guidelines.

Search strategy and data sources

Literature search were conducted for evidences in PubMed/Medline, Scopus, ProQuest, Cochrane and Web of Sciences to end of 2022. The following keywords were used: "Road Traffic Injury" OR "Road Traffic accident" OR "Traffic accident" OR "Road Traffic Trauma" AND "Haddon Matrix". No restriction for publication date was applied. We also performed a manual search of related articles' references to avoid missing any relevant published papers. Two reviewers independently screened the output of the search to identify potentially eligible studies (M.G.H. and A.R.). Any disagreements between the two reviewers were resolved by the consultation with the principal investigator (S.G.).

Selection criteria

In the present study, cross-sectional, cohort, and case-control studies investigating risk factors for road accident severity were included. Exclusion criteria were the lack of result odds ratio (OR) or relative risk (RR), insufficient data (three groups of risk factor based on the Haddon matrix, including: agent (car by pedestrian, car by car, car by motorcycle, motorcycle by motorcycle, motorcycle by pedestrian, and rollover), environment (inside road, outside road, safety, and time of accident) and host (age, helmet, seat belt, crossing over, undertaking, speed limit violation, and violation of right way). for calculation of measure of effects, case-report studies, letter to the editor studies, failure to investigate risk factors for accident severity, case-series studies, and review studies.

Data extraction

The outcome of road accident was defined as severity. The severity of injury was calculated using injury severity score (ISS). Traumas with a score of 1–9 were categorized as mild, 10–15 as moderate, 16–25 as severe, and over 25 as critical[21]. The risk factors of accident severity were divided into three groups based on the Haddon matrix, including: agent (car by pedestrian, car by car, car by motorcycle, motorcycle by motorcycle, motorcycle by pedestrian, and rollover), environment (inside road (inside the city accidents), outside road (outside the city accidents), safety, and time of accident) and host (age, helmet, seat belt, crossing over, undertaking, speed limit violation, and violation of right way). The following data were extracted from each study: first author's name, date of publication, country, study design, sex, age, sample size, severity accidents, host factors, environment factor, and agent factors.

Risk of bias assessment

Two investigators (M.G.H. and A.R.) critically appraised and rated the quality of all eligible studies. Discrepancies in quality assessment were resolved via consensus.

Statistical analyses

Data were entered into the statistical program and analyses were performed using STATA 17.0 software (Stata Corporation, College Station). OR values were computed for severity accidents using available data based on the recommendations of Borenstein, Hedges, and Higgins[22] and Peterson and Brown[23]. The random effects model was used to account for heterogeneity among studies. Heterogeneity was assessed with the Higgins I^2 test. Forest plots were used to display the effect size of each study and the pooled estimates. A p value of less than 0.05 was statistically significant.

Results

Search results

As the initial phase of this study, 45 articles were selected from the international databases. Subsequently, duplicate studies were excluded and 34 studies were moved into the review phase in terms of title and abstract. Following the review of the titles and abstracts, 14 articles selected for the next phase, at which the full text was examined and 3 articles were finally selected for analysis. The references of the articles were also reviewed to add relevant studies (Fig. 1).

Characteristics of eligible study

The included studies were published from 1999 to 2022 (45 were selected). Based on their geographical locations, two studies were conducted in Iran and one study in Ethiopia.

Quality appraisal

All three articles were of good quality.

Effective factors of severity of traumas based on the Haddon matrix

Host

Among the risk factors related to the host, using safety tools and moving violation are associated with the risk of injury severity. Not using helmet increased the risk of injury severity by 3.44 times compared to people who have used helmets ($OR_{\text{Not using helmet/Using helmet}} = 3.44$, 95% CI: 2.27–5.00, $P = 0.001$, $I^2 = 0.00\%$) (Fig. 2A). Also, according to Fig. 3, among the variables related to moving violation, crossing over a centre divider has a protective role for the risk of injury severity compared to undertaking ($OR_{\text{crossing over a centre divider/undertaking}} = 0.39$, 95% CI: 0.20–0.75, $P = 0.01$, $I^2 = 25.79\%$) (Fig. 3A). Violation of right-of-way reduces the risk of injury severity by 54% compared to undertaking ($OR_{\text{violation of right-of-way/undertaking}} = 0.46$, 95% CI: 0.27–0.77, $P = 0.01$, $I^2 = 0.00\%$) (Fig. 3C).

According to Fig. 4, risk of injury severity was higher in all ages groups compared to the age group less than 16 years.

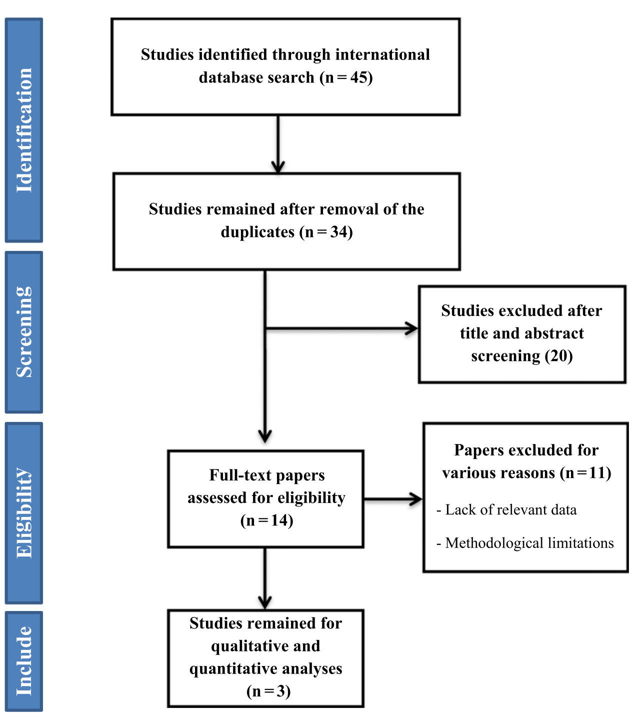

Figure 1. Flowchart of the included eligible studies in systematic review.

Agent

According to Fig. 5, in terms of the type of accident, accident of car-car reduces the risk of injury severity by 23% compared to accident of car-pedestrian ($OR_{\text{accident of car-car/accident of car-pedestrian}} = 0.77$, 95% CI: 0.61–0.96, $P = 0.02$, $I^2 = 0.00\%$) (Fig. 5A). Accident of car-motorcycle increased the risk of injury severity by 1.57 times compared to accident of car-pedestrian ($OR_{\text{accident of car-motorcycle/ accident of car-pedestrian}} = 1.57$, 95% CI: 1.11–2.22, $P = 0.01$, $I^2 = 50.94\%$) (Fig. 5B). Also, Accident of motorcycle-motorcycle increased the risk of injury severity by 2.51 times compared to accident of car-pedestrian ($OR_{\text{accident of motorcycle-motorcycle/ accident of car-pedestrian}} = 2.51$, 95% CI: 1.24–5.09, $P = 0.01$, $I^2 = 60.25\%$) (Fig. 5C).

Environment

Among the risk factors related to the environment, in term of place of accident, despite the lack of statistical significance, accident of outside the city increased the risk of injury severity 7% compared to accident of inside the city ($OR_{\text{accident of outside the city/accident of inside the city}} = 1.07$, 95% CI: 0.51–2.23, $P = 0.086$, $I^2 = 92.37\%$) (Fig. 6A). Also, Safety of the accident location was associated with the risk of injury severity, so that Not-safety of the accident location increased the risk of injury severity by 2.34 times compared to Safety of the accident location ($OR_{\text{Not-safety of the accident location/ Safety of the accident location}} = 2.34$, 95% CI: 1.88–2.92, $P = 0.001$, $I^2 = 0.00\%$) (Fig. 6B).

Discussion

Traffic accidents are a major health and development problem in all countries and the most common causes of death and disability. Among the approaches studied in traffic accidents, the Haddon matrix is a useful tool for examining multiple factors related to damage and its severity. According to this approach, three factors of the driver (human factors), vehicle and environmental factors play a role in the occurrence of accidents. In this review study, the results showed that among the factors related to the host, the most important causes of injury severity are: not using a helmet and undertaking; From the point of view of the agent (vehicle): motorcycle-motorcycle, car-motorcycle and car-pedestrian accidents were the most causes of severity of injuries in accidents. Also, among the risk factors related to the environment, safety of the accident location was related to the risk of injury severity. A study in Iran shows that the cause of most accidents leading to death in driving accidents is related to human risk factors[24].

In this study, not using a helmet increased the risk of injury by more than three times compared to people who used a helmet. In a study of all fatal injuries, 60.2% occurred while the victim was walking or riding a bicycle along the road. Also, 22.3% happened when the victim was trying to cross the road. There were no

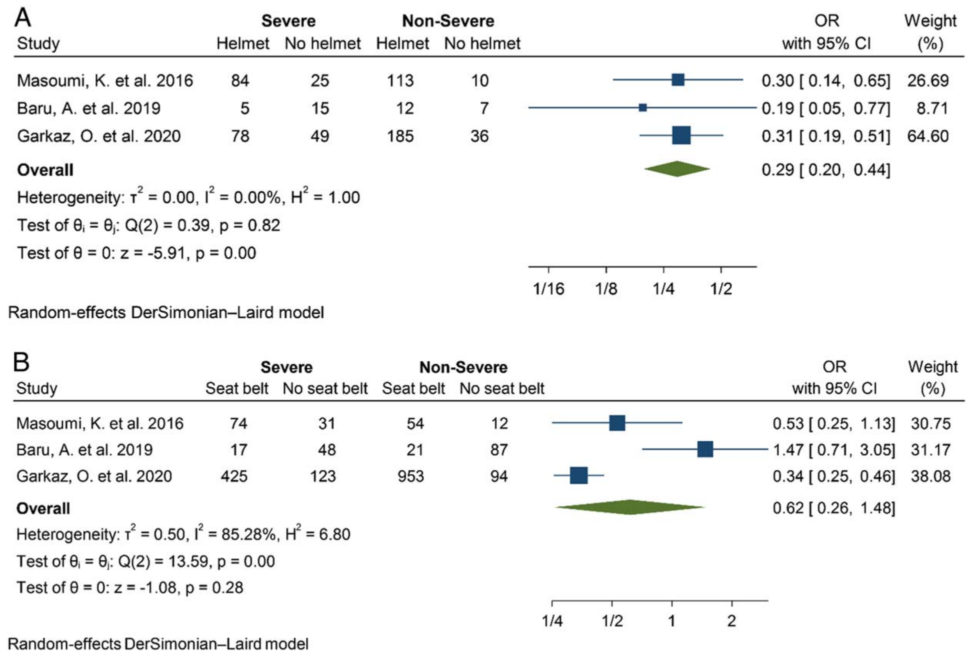

Figure 2. Risk of injury severity in term of factors related to the host (using safety tools), (A) risk. of injury severity not using helmet compared to using the helmet, (B) risk of injury severity not using seat belt compared to using the seat belt. OR, odds ratio.

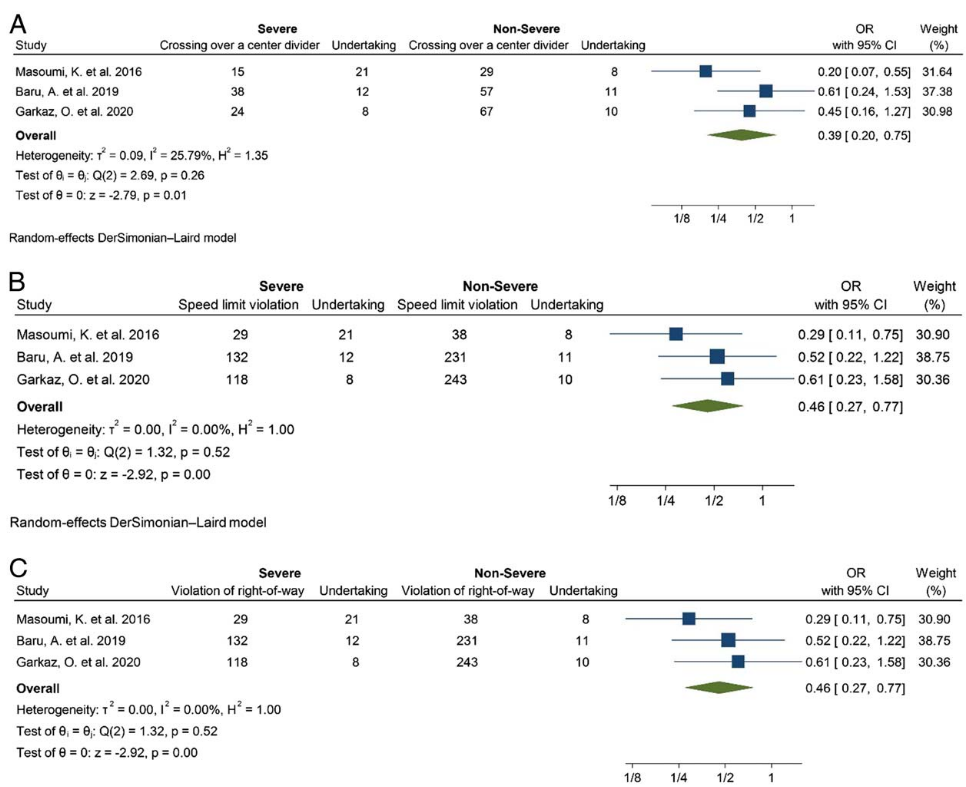

Figure 3. Risk of injury severity in term of factors related to the host (moving violation), (A) risk. of injury severity crossing over a centre divider compared to undertaking, (B) risk of injury severity speed limit violation compared to undertaking, (C) risk of injury severity violation of right-of-way compared to undertaking. OR, odds ratio.

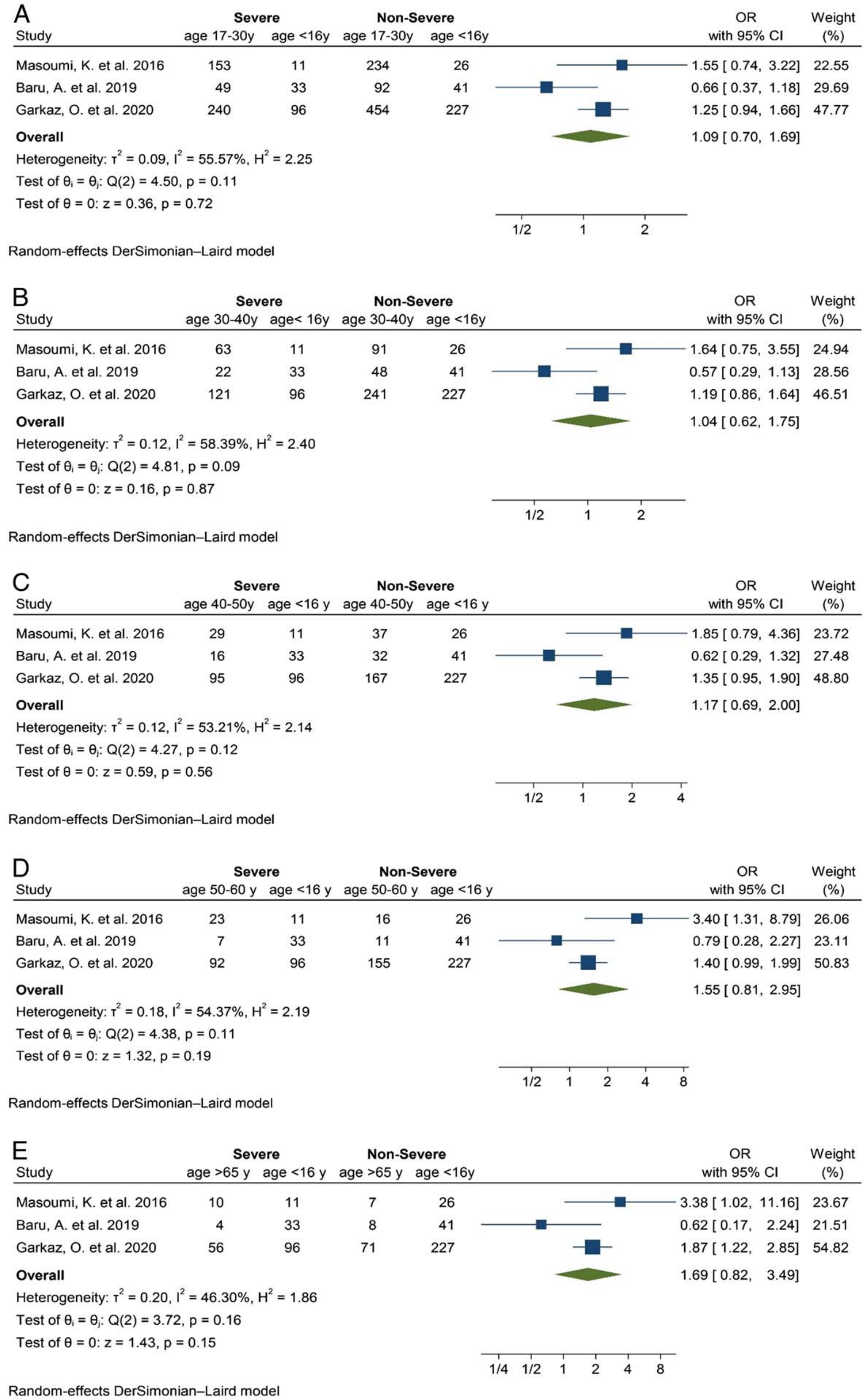

Figure 4. Risk of injury severity in term of factors related to the host (age), (A) risk of injury. severity age group of 17–30 years compared to age group <16 years, (B) risk of injury severity age group of 30–40 years compared to age group <16 years, (C) risk of injury severity age group of 40–50 years compared to age group <16 years, (D) risk of injury severity age group of 50–60 years. compared to age group <16 years, € risk of injury severity age group of > 60 years compared to age group <16 years. OR, odds ratio.

helmets for any of the cyclists[25]. In Baru *et al.*[26]'s study, accident involving a motorcyclist or motorcycle passenger without a helmet increased the risk of injury more than four times. The protective effect of helmet use on injury outcomes has been confirmed in other studies[24,27]. Various studies have shown that the main causes of road accidents are related to human errors such as violation of speed limit, distraction, alcohol-related errors, traffic law violations, and fatigue and sleepiness[28,29]. In a

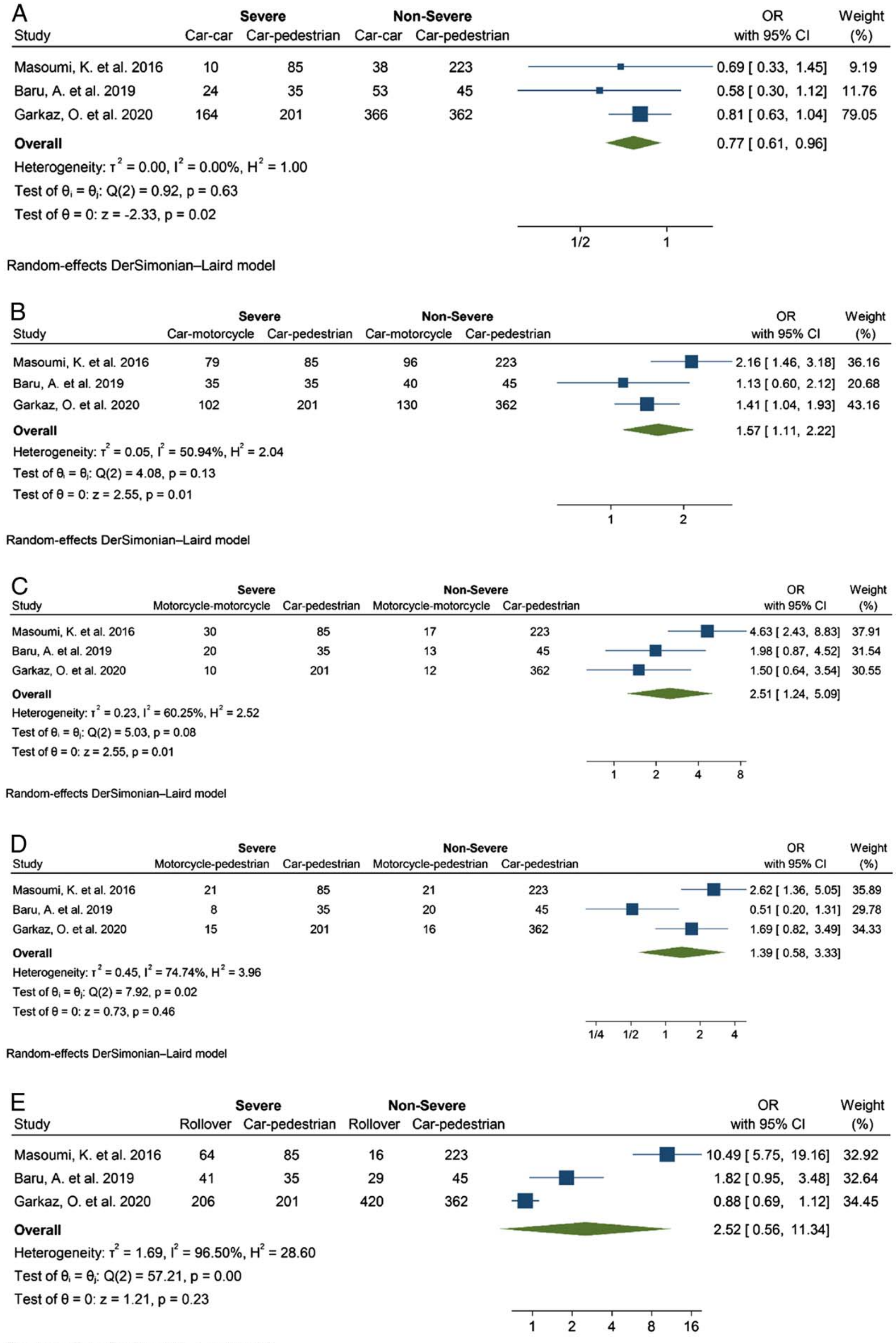

Figure 5. Risk of injury severity in term of factors related to the agent (type of accident). (A) Risk. of injury severity in accident of car-car compared to accident of car-pedestrian, (B) risk of injury severity in accident of car-motorcycle compared to accident of car-pedestrian, (C) risk of injury severity in accident of motorcycle-motorcycle compared to accident of car-pedestrian, (D) risk of injury severity in accident of motorcycle-pedestrian compared to accident of car-pedestrian, € risk of injury severity in accident of rollover compared to accident of car-pedestrian. OR, odds ratio.

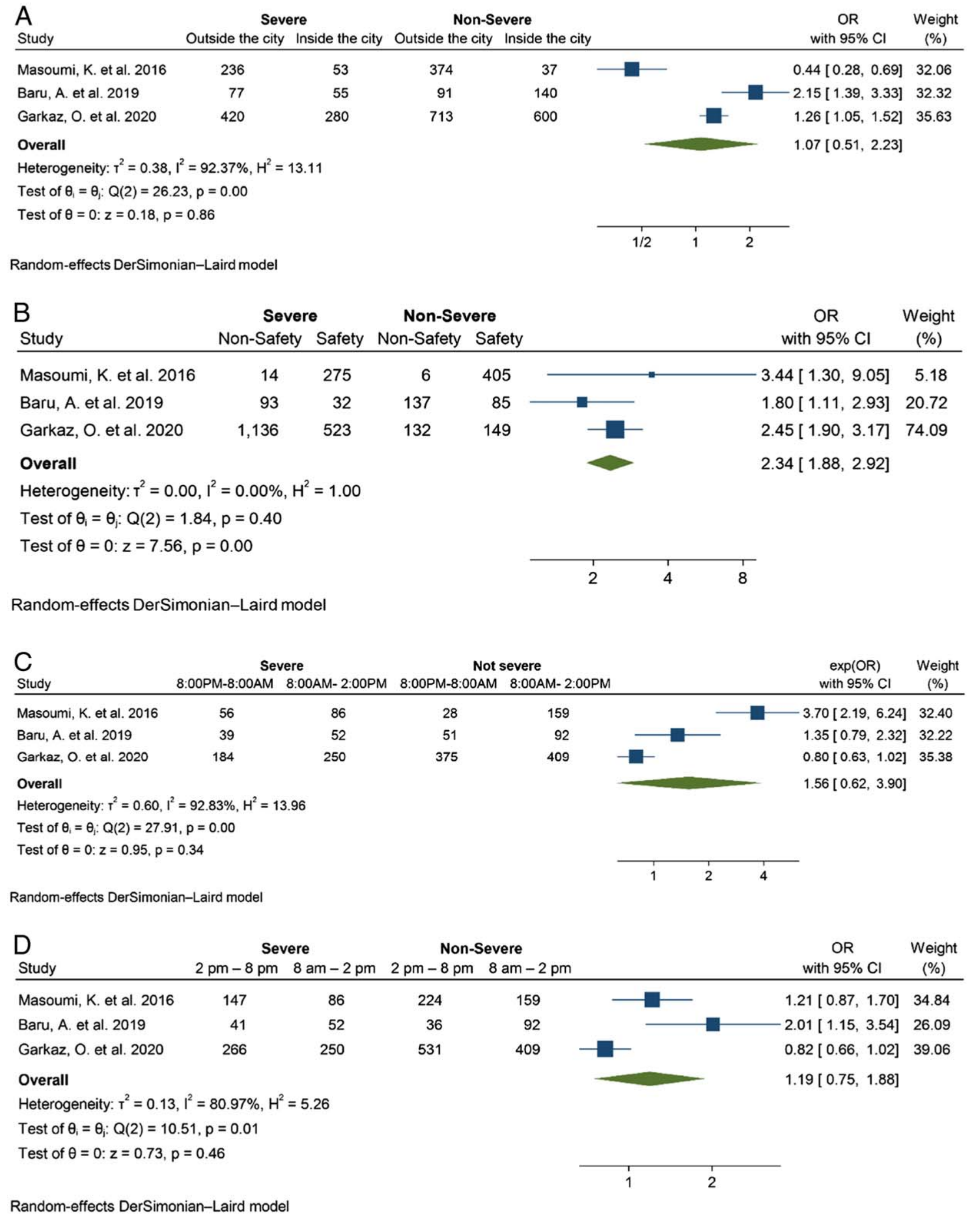

Figure 6. Risk of injury severity in term of factors related to the environmental. (A) Risk of injury. Severity in accident of outside the city compared to accident of inside the city, (B) risk of injury severity not-safety of the accident location compared to safety of the accident location, (C) risk of injury severity accident in 8:00 PM–8:00 AM compared to accident in 8:00 AM–8:00 PM, (D): risk of injury severity accident in 2:00 PM–8:00 PM compared to accident in 8:00 AM–8:00 PM. OR, odds ratio.

study, the factors related to the risks related to passengers included not using seat belts, sitting in the cargo area and the van cabin[28].

In this study, the risk of injury severity was higher in all age groups compared to the age group of less than 16 years. Therefore, young age groups are more at risk of injury due to not having a driver's license and being at a young age and having risky driving behaviours. The cultural and social conditions of the society are also effective on these factors. The results of a study conducted in the United States on young people aged 16–19 while driving confirm this and the reason for that was using high speed, passing through unauthorized areas, driving dangerously for fun and entertainment, and passing between several cars[30]. In other studies, injuries and deaths caused by road accidents often occurred among people under 30 years of age[28,31]. These risk factors can be prevented by stricter law enforcement, along with considering the use of advanced technologies to help monitor risky behaviour in real time[28].

In this study, in terms of the agent (vehicle); Motorcycle-motorcycle, car-motorcycle and car-pedestrian accidents were the most serious causes of injuries in accidents, respectively. Other studies also reported the existence of a relationship between the type of accident and the severity of the injury[21,32]. Speed of vehicle reduce is very important for both primary and secondary prevention of road traffic injuries. An Australian study found that if drivers obeyed speed limits, there would be a 13% reduction in pedestrian fatalities. Also, if all drivers drove 10 km/h slower, a 48% reduction in pedestrian deaths could be expected[33]. In addition, the use of two-wheelers as family vehicles is a common and unsafe method of transportation[34]. This is important to understand from a public health point of view, as more people in the population will likely buy and use two-wheelers and small passenger cars due to lower prices and lower fuel consumption[35].

In this study, from the point of view of the environmental factor, safety of the accident location was related to the risk of injury severity, so that the unsafeness of the accident location increased the risk of injury severity by more than two times compared to the safe accident location. In other studies, environmental risks were included fixed objects on the side of the road, lack of traffic lights, lack of protective rails, lack of traffic signs[28,29]. In various studies in developing and developed countries, it was shown that accidents that occur in dark conditions are almost twice as severe as accidents that occur in daylight[25,36–38]. There is also good evidence from other low-income countries that building speed bumps and speed tables at relevant sites reduces injuries and deaths[39–41]. A study also showed that people who suffered traffic injuries in environments that were equipped with safety tools such as traffic lights, protective fences, speed breakers, and safety signs such as traffic symbols, pictures, and pedestrian lines had less severe injuries[42].

One of the limitations of this study is the number and quality of studies. Only two study countries were eligible for this review and systematic study. Therefore, in order to make a more accurate estimate, more studies are needed, especially in countries without reports. On the other hand, there may be differences in the registration and reporting of countries. Future studies should not focus only on the immediate injury because it is only the tip of the iceberg. Therefore, it is important to seek in-depth information and conduct detailed studies on all elements of road damage to find the root cause of the problem for future basic measures.

Conclusions

The results show that many factors affect the occurrence and severity of accidents based on the Haddon matrix. On the other hand, a large number of risk factors of traffic injuries can be prevented. It is necessary to pay attention to the intersection of human, vehicle and environmental risks and their contribution and how they interact. Based on the Haddon matrix approach, special strategies can be designed to prevent road damage. There are some simple recommendations applicable to all countries that should be implemented in policies designed to improve traffic safety decision-making. Recommendations include improving high-risk human behaviours including; giving the necessary training to the relevant audience, handling and dealing with drunk driving, observing the speed limit, using a helmet and seat belt, and not driving while tired. Also, the physical infrastructure of the roads should be improved. Safety standards for vehicles should also be addressed through stricter legal requirements and inspections. Finally, post-accident measures can also be improved through government support for increased first aid training among the general population and better coordination of emergency services.

Ethics approval

This study was approved by the research ethics committee of Golestan University of Medical Sciences (IR. GOUMS. REC.1401.437). All methods were performed in accordance with the relevant guidelines and regulations of the Declaration of Helsinki.

Consent

Consent for review article does not necessarily.

Source of funding

No financial support, funding, and sponsorship in this review study.

Author contributions

All authors of this paper have directly participated in the planning, execution, or analysis of this study. S.G., M.G.G., and A.R.: concepting the work and study design; H.A.N., S.A.F.Y. and S.G. G.: data acquisition and literature searching; L.S., S.G.G.: drafting the manuscript; S.G. and M.G.G: reviewing and editing for intellectual content; All authors read and approved the final manuscript.

Conflicts of interest disclosure

The authors declare that they have no conflicts of interests.

Research registration unique identifying number (UIN)

This paper is registered through PROSPERO (register number: CRD42023454583).

Guarantor

Mousa Ghelichi-Ghojogh.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Provenance and peer review

Not commissioned, externally peer-reviewed.

References

[1] Pogorzelski GF, Silva TA, Piazza T, *et al*. Epidemiology, prognostic factors, and outcome of trauma patients admitted in a Brazilian intensive care unit. Open Access Emergency Medicine: OAEM 2018;10:81.
[2] Alberdi F, García I, Atutxa L, *et al*. Epidemiología del trauma grave. Medicina Intensiva 2014;38:580–8.
[3] Benhamed A, Ndiaye A, Emond M, *et al*. Road traffic accident-related thoracic trauma: Epidemiology, injury pattern, outcome, and impact on mortality—a multicenter observational study. PLoS one 2022;17: e0268202.

[4] Omdls Global status report on road safety 2015. World Health Organization; 2015.
[5] WHO. Global action plan on physical activity 2018–2030: more active people for a healthier world. World Health Organization; 2019.
[6] Watkins K. “Safe and sustainable roads: An agenda for Rio + 20,” 2012. [Online]. Available: http://www.youthforroadsafety.org/uploads/nieuws_bijlagen/rio_20_report_lr.pdf
[7] Alemayehu M, Woldemeskel A, Olani AB, *et al*. Epidemiological characteristics of deaths from road traffic accidents in Addis Ababa, Ethiopia: a study based on traffic police records (2018–2020). BMC Emergency Medicine 2023;23:1–6.
[8] Mohan D. Road safety in less-motorized environments: future concerns. International Journal Of Epidemiology 2002;31:527–32.
[9] Organization WH. Global status report on road safety 2015: Summary. World Health Organization; 2015.
[10] Safaee M, Samani RE, Abdolazimi R. Road traffic accident fatality predictors: a case–control study in Isfahan. Archives of Trauma Research 2021;10:227–31.
[11] Mohtasham-Amiri Z, Dastgiri S, Davoudi-Kiakalyeh A, *et al*. An epidemiological study of road traffic accidents in Guilan Province, Northern Iran in 2012. . Bulletin of Emergency & Trauma 2016;4:230.
[12] Shafabakhsh GA, Famili A, Bahadori MS. GIS-based spatial analysis of urban traffic accidents: case study in Mashhad. Iran Journal of Traffic And Transportation Engineering (English edition) 2017;4:290–9.
[13] Taravatmanesh L, Mortazavi SM, Baneshi MR, *et al*. Epidemiology of road traffic accidents in Rafsanjan city, Iran. Electronic Physician 2018;10:6859.
[14] Peden M, Scurfield R, Sleet D, *et al*. World report on road traffic injury prevention. World Health Organization; 2004.
[15] Cummings P, McKnight B, Greenland S. Matched cohort methods for injury research. Epidemiologic Reviews 2003;25:43–50.
[16] Haddon W Jr. Advances in the epidemiology of injuries as a basis for public policy. Public Health Reports 1980;95:411.
[17] Christoffel T, Gallagher SS. Injury prevention and public health: practical knowledge, skills, and strategies: Jones & Bartlett Learning; 2006.
[18] Bendak S. Seat belt utilization in Saudi Arabia and its impact on road accident injuries. Accident Analysis & Prevention 2005;37:367–71.
[19] Vorko-Jović A, Kern J, Biloglav Z. Risk factors in urban road traffic accidents. Journal of Safety Research 2006;37:93–8.
[20] Page MJ, McKenzie JE, Bossuyt PM, *et al*. Updating guidance for reporting systematic reviews: development of the PRISMA 2020 statement. Journal of Clinical Epidemiology 2021;134:103–12.
[21] Masoumi K, Forouzan A, Barzegari H, *et al*. Effective factors in severity of traffic accident-related traumas; an epidemiologic study based on the Haddon matrix. Emergency 2016;4:78.
[22] Borenstein M, Hedges LV, Higgins JP, *et al*. Introduction to meta-analysis. John Wiley & Sons; 2021.
[23] Peterson RA, Brown SP. On the use of beta coefficients in meta-analysis. Journal of Applied Psychology 2005;90:175.
[24] Chang F, Li M, Xu P, *et al*. Injury severity of motorcycle riders involved in traffic crashes in Hunan, China: a mixed ordered logit approach. International Journal Of Environmental Research And Public Health 2016;13:714.
[25] Sundet M, Mulima G, Kajombo C, *et al*. Adult pedestrian and cyclist injuries in Lilongwe, Malawi: a cross-sectional study. Malawi Medical Journal 2020;32:197–204.
[26] Baru A, Azazh A, Beza L. Injury severity levels and associated factors among road traffic collision victims referred to emergency departments of selected public hospitals in Addis Ababa, Ethiopia: the study based on the Haddon matrix. BMC Emerg Med 2019;19:2.
[27] Kim CY, Wiznia DH, Averbukh L, *et al*. The economic impact of helmet use on motorcycle accidents: a systematic review and meta-analysis of the literature from the past 20 years. Traffic Injury Prevention 2015;16:732–8.
[28] Klinjun N, Kelly M, Praditsathaporn C, *et al*. Identification of factors affecting road traffic injuries incidence and severity in Southern Thailand based on accident investigation reports. Sustainability 2021;13:12467.
[29] Somchainuck O, Taneerananon P, Jaritngam S. An in-depth investigation of roadside crashes on Thai National Highways. Engineering Journal 2013;17:63–74.
[30] Wang S, Dalal K. Road traffic injuries in Shanghai, China. HealthMed 2012;6:74–80.
[31] Kumar P, Srinivasan K. To study the socio demographic profile of road traffic accident victims in district hospital, karimnagar. Int J Res Dev Health 2013;1:136–40.
[32] Cirera E, Plasència A, Ferrando J, *et al*. Factors associated with severity and hospital admission of motor-vehicle injury cases in a southern European urban area. European Journal Of Epidemiology 2001;17:201–8.
[33] Anderson RW, McLean AJ, Farmer MJ, *et al*. Vehicle travel speeds and the incidence of fatal pedestrian crashes. Accident; analysis and prevention1997;29:667–74.
[34] Burden G, Study RF, Metrics H, *et al*. Global, regional, and national incidence, prevalence, and years lived with disability for 301 acute and chronic diseases and injuries in 188 countries, 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet (London, England) 2015;386:743–800.
[35] Vernick JS, Tung GJ, Kromm JN. Interventions to reduce risks associated with vehicle incompatibility. Epidemiologic Reviews 2012;34:57–64.
[36] Mogaka EO, Ng’ang’a Z, Oundo J, *et al*. Factors associated with severity of road traffic injuries, Thika, Kenya. The Pan African Medical Journal 2011;8:20.
[37] Quddus MA, Noland RB, Chin HC. An analysis of motorcycle injury and vehicle damage severity using ordered probit models. Journal of Safety Research 2002;33:445–62.
[38] Rice TM, Peek-Asa C, Kraus JF. Nighttime driving, passenger transport, and injury crash rates of young drivers. Injury Prevention 2003;9:245–50.
[39] Bishai DM, Hyder AA. Modeling the cost effectiveness of injury interventions in lower and middle income countries: opportunities and challenges. Cost Effectiveness And Resource Allocation 2006;4:2; C/E.
[40] Damsere-Derry J, Ebel BE, Mock CN, *et al*. Evaluation of the effectiveness of traffic calming measures on vehicle speeds and pedestrian injury severity in Ghana2019;20:336–42.
[41] Nadesan-Reddy N, Knight S. The effect of traffic calming on pedestrian injuries and motor vehicle collisions in two areas of the eThekwini Municipality: a before-and-after study. South African Medical Journal Suid-Afrikaanse tydskrif vir geneeskunde 2013;103:621–5.
[42] Kamruzzaman M, Haque MM, Ahmed B, *et al*. Analysis of traffic injury severity in a mega city of a developing country. 2013. discovery.ucl.ac.uk