



Male gender, age and low income are risk factors for road traffic injuries among adolescents: an umbrella review of systematic reviews and meta-analyses

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Abstract

Aim The present umbrella review aimed to take stock of the situation on the considerable literature concerning the main socio-demographic risk factors of adolescents involved in road traffic crashes.

Methods The following bibliographic databases were searched: PubMed, Scopus and Cochrane Library. Systematic reviews and meta-analyses published between January 2000 and March 2017 and written in English were included.

Results The search identified 13 systematic reviews and 1 meta-analysis. The papers found general agreements of the socio-demographic risk factors at the international level. Males, especially in Africa, Asia and the Arab World, take more risks related to death and injuries; low socio-cultural status and living in deprived socioeconomic areas were characteristics for being at greater risk of motor vehicle crashes worldwide. No unequivocal conclusion has been reached worldwide on the possible effect of different age subgroups: a significant reduction of the number of crashes was obtained in 16 and 17 year olds in the USA after implementing driver's license testing requirements.

Conclusion The findings clearly showed the need to develop specific injury prevention strategies on the basis of educational level, income and social status. Furthermore these aspects represent the main reasons for inequalities and different levels of efficacy of road safety interventions among the adolescents worldwide.

Keywords Adolescent · Teen · Road traffic injuries · Traffic crash · Umbrella review

Introduction

Road traffic injuries (RTIs) are among the top five causes of death worldwide, for all age groups and genders, and the second cause of illness and disability (WHO and UNICEF 2008).

In particular, the WHO underlines that globally road traffic accidents (RTAs) are a leading cause of death among young people and the main cause of death among those aged 15–29 years (WHO 2015).

The scientific literature indicates that many different factors contribute to teen injuries: gender, age, personal knowledge levels, awareness, skills, experiences as well as the context of the community in which their families live, and the conditions

of the motor vehicle, road and weather (WHO 2014a). These influencing factors can be categorized into two main groups: external and internal factors. The first include structural factors such as the street conditions (e.g., illumination or adequate road signs), weather conditions, motor vehicle code (Krug et al. 2000; La Torre 2003; Nance et al. 2004; La Torre et al. 2007a), characteristics and conditions of the motor vehicles, time of day, various conditions of the community in which teens and their families live, and geographical area (rural or urban) (La Torre et al. 2007b; Kim et al. 2012).

Other influencing factors, called internal factors, concern the conditions of the injured people: teen's socio-demographic characteristics (age, gender, race), attitudes, educational level, driving experience, cultural level, economic status, etc. (Krug et al. 2000; Braver 2003; Hyder et al. 2006b; Zhu et al. 2013).

Certainly the control of some of these factors (internal and external) might be very effective in reducing road injury rates (Duperrex et al. 2002).

It is important to say, however, that adolescence is a particular phase of life, which could affect road use, too. In fact, it is

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known that during adolescence engaging in risky behavior is easier than for children or adults: adolescents are more likely than older or younger individuals to be involved in fatal or serious automobile crashes, the majority of which are caused by risky driving: driving under the influence of drugs or alcohol (Steinberg et al. 2008) or not correctly recognizing their own sleepiness and fatigue (Lucidi et al. 2006; Masullo et al. 2014).

Promoting educational interventions in teenagers is strategic because this group is more affected by road traffic injuries than other unintentional injuries and because they represent future drivers (WHO 2008; Alonge and Hyder 2014; Hyder and Vecino-Ortiz 2014). These interventions have been calibrated, taking into account the main risk factors. Juarez et al. (2006) proposed to “create recommendations for comprehensive intervention strategies that can be used in minority communities to reduce disparities in risk behaviors, injury, disability, and death, such as minority youth, gender.”

The present study aims to provide an umbrella review of systematic reviews and meta-analyses that consider internal risk factors related to road traffic injuries in adolescents, such as age, gender, income and type of residence area.

Materials and methods

Data sources and study selection

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses, PRISMA, checklist (Moher et al. 2009) and the statement published by Aromataris et al. (2015) were followed for the execution and reporting of this umbrella review. The PRISMA Statement consists of a 27-item checklist and a four-phase flow diagram; it is used as a basis for reporting systematic reviews and may also be useful for critical appraisal of published systematic reviews. The statements published by Aromataris et al. aimed to develop a guide for conducting an umbrella review; it is a critical appraisal tool with ten questions to help assess risk of bias in systematic reviews and meta-analyses.

According to the WHO’s “Health for the World’s Adolescents” (WHO 2014b) definition, the study considers adolescents as youth aged between 10 and 19 years.

In this umbrella review, RTIs or road traffic accidents (RTAs) were defined as any crash on a road involving at least one moving motor vehicle irrespective of the event resulting in an injury. This included collisions between a vehicle and/or any non-moving object while driving/riding a vehicle as well as collisions with a moving vehicle while walking/running/standing/sitting on the road or falling from a moving vehicle.

The following bibliographic databases were consulted for the search: PubMed, Scopus and Cochrane Library. A

combination of relevant keywords was used to construct the search strategy (Box 1).

Box 1 Details of the search strategy for the umbrella review

The search algorithm included a combination of these terms:

Outcome: “road traffic injuries,” “road accident,” “auto accident,” “car accident,” “car crash,” “motor vehicle collision”

Setting: “adolescent,” “teenager,” “young,” “youth”

Inclusion criteria for selecting studies for the systematic review:

Study design: systematic reviews or meta-analyses

Studies published in the English language

Exclusion criteria for selecting studies for the systematic review

Adult population (age > 19 years) and child population (age < 10 years)

Crashes not involving any motorized vehicle (e.g., bicycles, skaters, scooters, etc.)

The included studies followed the inclusion and exclusion criteria in Box 1.

Articles published between January 2000 and March 2017 were included in this review. This range was established on the basis that systematic reviews should include articles published after 2000 and their comments and discussions should be focused on more recent road laws and contexts.

For the selection of studies, one author initially scanned the titles and abstracts to remove obviously irrelevant papers. Second, full-text reports on the remaining studies were assessed using a standardized form that listed predefined criteria (see previous exclusion criteria).

Data extraction

Data were extracted from the papers using a standardized data collection form gathering information on:

- (1) year of publication;
- (2) research period;
- (3) electronic database;
- (4) geographical region;
- (5) number of articles included under study in the review/meta-analysis;
- (6) typology of primary studies involved (randomized clinical trial, RCT, observational, other);
- (7) age range considered;
- (8) category of user:
 - a. vehicle occupants = refers to drivers and passengers of motorized vehicles (such as motorcycles, cars, trucks, heavy transport vehicles, buses or other unspecified motor vehicles) injured in a traffic accident;

- b. pedestrians/cyclists = refers to pedestrians/cyclists injured in a traffic collision with a motor vehicle. Pedestrians are those injured on foot as well as on roller skates, skateboards or scooters, or in a pram.
- (9) outcomes examined (mortality, disability, injuries, road safety knowledge);
- (10) risk factors assessed, e.g., age, gender, country, income level (according to World Bank list of economies (The World Bank 2017))
- (11) for meta-analyses, the summary measures (RR, OR, difference in means and confidence interval), measures of consistency and publication bias estimates were reported.

Data extraction was conducted by the first author (AM) and independently verified by a second author (RS).

Data were extracted and entered into an Excel sheet.

Quality assessment

The internal validity of included studies was assessed using the AMSTAR tool (A Measurement Tool to Assess Systematic Reviews) (Shea et al. 2007). It is not designed to assess the quality of individual primary studies, but it determines the methodological quality of systematic reviews by assessing 11 items with “yes,” “no,” “can’t answer” or “not applicable.” These items evaluate the quality of reviews based on the a priori design, duplicate study selection and data extraction, a comprehensive literature search, the use of status of the publication as an inclusion criterion, a list of included/excluded studies, characteristics of included studies, documented assessment of the scientific quality of included studies, appropriate use of the scientific quality in forming conclusions, appropriate use of methods to combine findings of studies, assessment of the likelihood of publication bias and documentation of the conflict of interest.

In this study, the total AMSTAR score was calculated by summing “1” point for each “yes” and “0” points for “others,” including “no,” “can’t answer” and “not applicable.” This resulted in summary scores from 0 to 11. To rate the quality of the reviews, we created the following three categories: a score of 0–4 was classified as a low-quality review, 5–8 indicated one of moderate quality, and 9–11 was regarded as a high-quality review (Mikton and Butchart 2009).

Two authors independently conducted a critical appraisal of the included reviews. Disagreements were resolved by consensus or a third reviewer.

Finally, the assessment of risk of bias of the reviews included has been measured considering whether or not the authors declared and explain it in the methods and results sections.

Data analysis

Data were summarized and synthesized by the category of study design and outcome. The majority of the included studies in this research mainly performed a systematic review and considered descriptive analysis. Therefore, data were synthesized qualitatively and displayed using tables.

Results

Overall, 238 papers were identified. However, 61 studies were duplicates, and 163 were excluded because they did not focus on adolescents and motor vehicle collisions or were neither a systematic review nor a meta-analysis.

The list of the excluded studies is available by contacting the first author.

The remaining 13 (12 systematic reviews and 1 meta-analysis) full-text articles were included in the study. One additional systematic review was obtained by checking the references of the papers evaluated. The flow chart of study retrieval and selection is shown in Fig. 1.

Due to the heterogeneity of the studies identified, the study designs (13 systematic reviews versus 1 meta-analysis), a formal quantitative summary was considered unsuitable.

Study sites ranged from the USA to Canada, South Africa, South Asia, New Zealand and Arab countries. These countries present different income levels: low, middle and high.

The publication period of the primary studies included in the reviews selected was from 1960 to 2015. The type of road users were exclusively vehicle occupants (drivers or not), pedestrians or cyclists, or a combinations of these.

Only 2 articles studied adolescents aged 10–19 according to the WHO definition (Shope 2007; Zhu et al. 2013), whereas the remaining 12 studies considered young people aged ≥ 10 –19 years.

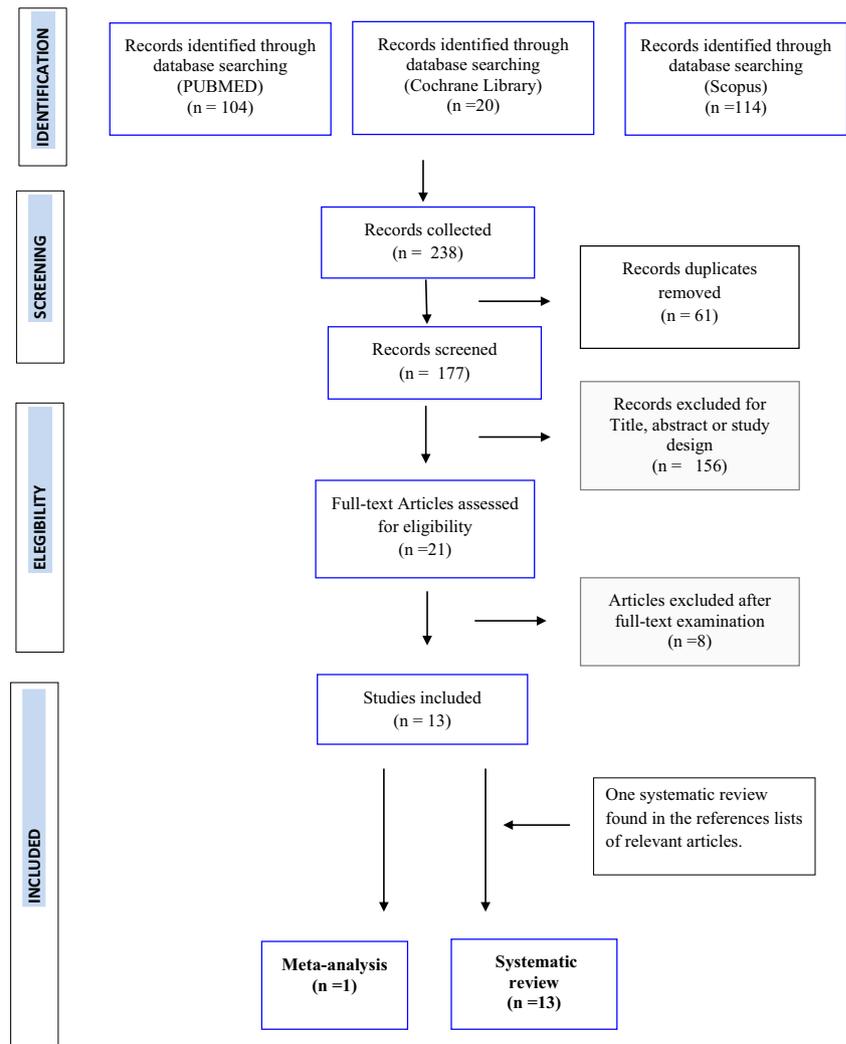
Table 1 shows the characteristics and methodological quality of the 14 included studies.

The methodological quality was generally sufficient: the median was 5 out of a total of 11 points, and 33% of the studies had a value > 6 .

Table 2 contains data regarding the epidemiology of RTI in each study.

The outcomes studied were primarily fatal or nonfatal RTI (Laflamme and Diderichsen 2000; Turner et al. 2004; Hyder et al. 2006a, b; Ameratunga et al. 2006; Shope 2007; Balan and Lingam 2012; Kim et al. 2012; Imamura et al. 2012; Mytton et al. 2012; Zhu et al. 2013; Griffin et al. 2014; Obermeyer et al. 2015).

Fig. 1 Flow diagram of the literature search results conducted until March 2017



Age

The majority of studies considered the possible effect of different age subgroups, often younger than the target age group. Only three studies evaluated the age subgroups according to the WHO definition of adolescents (Shope 2007; Zhu et al. 2013; Obermeyer et al. 2015): two of these papers also evaluated the teen's ability to drive and the third one also recorded mortality and disability rates. From two reviews on the impact of the implementation of graduated driver licensing (GDL) on teen crashes, the authors summarized that particularly the number of those 16 years old is significantly reduced after GDL has been implemented (a 22% reduction in the crash rate of 16 year olds) (Shope 2007; Zhu et al. 2013).

Two moderate-quality reviews (AMSTRAR < 8) quantified the effectiveness of road safety education/community intervention in pedestrians, while the previously reported reviews that focused on the effectiveness of GDL implementation confirmed a reduction of crashes

of approximately 15–40% for adolescents aged 16 years as well as in injuries and fatalities among teen drivers (Shope 2007; Zhu et al. 2013), while in the Obermeyer et al. review the findings stratified by age groups are not given (Obermeyer et al. 2015).

Gender

From the analysis of the articles, RTIs were common especially in male adolescent road users (Ameratunga et al. 2006; Hyder et al. 2006b; Imamura et al. 2012).

The authors agreed that boys have different opportunities than girls in countries such as Africa, the Arab World and Asia (more freedom, employment and outdoor activities), but the difference may also be related to the notion of masculinity. In addition, male children take more risks and are more impulsive than girls. Culturally, too, boys are given relatively greater freedom to explore their environment (Hyder et al. 2006a; Balan and Lingam 2012; Kim et al. 2012).

Table 1 Characteristics of the 14 included studies

Ist Author	Year of publication	Search period	No. databases searched ^a	Geographical area	Income level country ^b	No. art included in the review	Type of studies considered	Quality ^c	Assessment of risk of bias ^d
Obermeyer et al.	2015	2005–2015	1	Arab countries	HM	NS	NS	2	No
Griffin et al.	2014	1960–2011	10	New Zealand, US	H	5	Retrospective case series	7	No
Balan and Lingam	2012	1990–2011	0	Asia, Africa, Western Pacific region, Mediterranean	L	29	Reviews /observational studies	3	No
Mytton et al.	2012	1990–2011	6	Canada, Europe, Asia, USA, South America	HM	31	NS	6	Yes
Kim et al.	2012	1970–2011	9	USA, Canada	H	13	Cross-sectional/population survey	11	Yes
Imamura et al.	2012	2001–2011	3	Ww	LMH	NS	Community-based case series	5	No
Zhu et al.	2013	1991–2011	4	US	H	24	NS	7	Yes
Shope	2007	2002–2007	7	US, Canada	H	21	Pre/post comparison; time series	5	No
Hyder et al.	2006a, b	1980–2004	3	South Asia	LM	26	Prospective hospital/community-based case series; retrospective hospital/ambulance/police records;	5	No
Hyder et al.	2006a, b	1980–2003	3	Sub-Saharan Africa	LMH	31	Prospective hospital-based case series; retrospective mortality data or hospital records; cross-sectional; population-based survey	4	No
Ameratunga et al.	2006	NS	4	Ww	LMH	NS	NS	3	No
Turner et al.	2004	Until 2003	3	Ww	H	4	RCT (intervention: community-based programs and/or road safety)	6	No
Duperrex et al.	2002	1980–2000	8	Ww	H	14	RCT (intervention: direct or indirect education provided by teachers or parents)	7	No
Lafiamme and Diderichsen	2000	Until 1997	13	Ww	H	21	NS	2	No

Bold: meta-analysis

NS, not specified; RCT, randomized clinical trial; Ww, worldwide

^aHealth science database: i.e., PubMed, Scopus, EMBASE, ISI (i.e., not included in Google, Google Scholar)

^bWorld Bank list of economies: H = high income; M = middle; L = low

^cAMSTAR checklist: score from 0 (minimum quality) to 11 (maximum quality)

^dPresence of “assessment of risk of bias” in methods and results

Table 2 Characteristics of RTIs studied in the 14 included studies

1st Author	Age population	Outcome	Type of users ^a	Risk factors considered	Conclusions on risk factors
Obermeyer et al. 2015	10–24 years	Mortality and disability rate	NS	Age, gender, behaviour (drinking, low compliance to comply laws, e.g., speed and motorcycle helmets)	Young Arab males are at greater risk than females (it may be because males generally report a higher frequency of driving than females)
Griffin et al. 2014	0–15 years	Mortality and injury rates	Pedestrians	Age, areas of residence (urban vs. rural)	Not providing sufficient evidence on risk factors
Balan and Lingam 2012	0–17 years	Mortality and disability rate	Pedestrians, cyclists	Age, gender, income level	Most studies show a higher injury prevalence among boys (maybe related to males taking more risks and being more impulsive than females)
Mytton et al. 2012	0–19	Mortality and injury rates	NS	Age, gender, ethnicity, income level	7 out of 31 studies reported rising or variable RTI mortality, and 3 were in 15–19-year-old adolescents
Kim et al. 2012	< 18 years	Rate ratio of injury	Vehicle occupants, pedestrians and cyclists	Residence area urban vs. rural	Rural children are at higher risk of overall motor vehicle injury than occupants, as passengers, as cyclists or in vehicles. No evidence as pedestrians
Imamura et al. 2012	< 15 years	Mortality rate	Vehicle occupants, pedestrians	Country, age	Adolescents 10–15 years involved as pedestrians injured in traffic accidents aren't at greatest risk. Adolescents aged 10–14 years in low-/middle-income countries have greater risk of mortality from RTIs than those in high income countries
Zhu et al. 2013	New drivers and learners, 16–18 years	Mortality and rate ratio of injury drivers	Drivers	Age	Poolled RR for traffic crashes before and after GDL passage was 0.78 for those aged 16 years 95% CI(0.72–0.84), RR = 0.94 for those 17 years 95% CI(0.93–0.96) and for those 18 years not significant
Shope 2007	New drivers and learners: 14–19 years	Mortality and rate ratio of injury	Vehicle occupants	Age, gender	Teen crashes, particularly involving 16 year olds, are considerably reduced after GDL implementation
Hyder et al. 2006a, b	0–19 years	Mortality and injury rates	Pedestrians/cyclist, passengers	Gender	Incidence of road traffic injuries is twice more in males than females; one-third of child and adolescent traffic victims were pedestrians
Hyder et al. 2006a, b	0–19 years	Crash-related injuries and fatal crashes	Pedestrians/cyclist, passengers	Age	Children between 10 and 14 years constitute the group most frequently involved in road crashes
Ameratunga et al. 2006	NS	Crash-related injuries and fatal crashes	Pedestrians, vehicle occupants	Gender	Predominance of males in road injuries
Turner et al. 2004	< 14 years	Injury rate, traffic volume and behaviour	Pedestrians, drivers	Age	Studies that used injury as their outcome measure found a reduction in childhood pedestrian injuries (12%, 45 and 54%), and the study improved traffic control at child pedestrian sites (9% reduction in traffic flow) and sustainable community safety promotion activity
Duperrex et al. 2002	0–55 years	Knowledge, attitudes and behaviour	All	Age	Safety education improved pedestrians' attitude and intentions (with a standardized mean difference

Table 2 (continued)

Ist Author	Age population	Outcome	Type of users ^a	Risk factors considered	Conclusions on risk factors
Laflamme and Diderichsen 2000	0–20 years	Crashes and fatal crashes	All	Socio-demographic characteristics and economic status	ranging from 0.17 to 1.28) and their knowledge about road safety when outcomes were measured before and after intervention (standardized mean differences from 0.16 to 2.39) Children from lower social positions and in more deprived socioeconomic areas are quite consistently more at risk than others

Bold: meta-analysis

NS, no specify

^a Occupants refers to motor vehicle drivers and passengers

Socio-cultural status

Laflamme and Diderichsen (2000) and Mytton et al. (2012) showed that the social gradient reflects a differential exposure of children to the risk of RTI. The major risks are those associated with low environmental factors, but there are also risks related to low socioeconomic status: pedestrian injuries had a particular spatial pattern often peaking in zones with high population density, fast-moving traffic and absence of parks or playing areas; children from lower social positions and in more deprived socioeconomic areas were consistently more at risk than others. Kim et al. (2012) underlined these concepts in particular when considering the comparison between rural and urban areas: rural children sustain a higher rate of overall injury than urban children. The authors summarized this evidence based on eight studies (Esposito et al. 1995; Muelleman and Mueller 1996; Miller and Kaufman 1998; Agran et al. 1998; Mitchell-Taverner et al. 2003; Sharpe and Hardt 2006; McCowan et al. 2008; Alaghebandan et al. 2010); the disparities were attributable, in the majority of the cases in rural areas, to hazardous environmental conditions, different driving speeds, and delayed access to and lower usage of trauma care centers.

Quality

Eight reviews of 14 were of moderate quality (Duperrex et al. 2002; Turner et al. 2004; Hyder et al. 2006a; Shope 2007; Imamura et al. 2012; Mytton et al. 2012; Zhu et al. 2013; Griffin et al. 2014). Only one review was of good quality (Kim et al. 2012). They dealt with different topics and, as such, it was not possible to combine results: one study focused on GDL, one on the comparison between rural and urban children’s road injury rates, one on unintentional injury with a focus on RTIs, one on low-speed runovers and finally two focused on pedestrian injury prevention programs as presented previously.

The assessment of the risk of bias was found in 3 of 14 studies (Table 1). The presence of risk of bias was underlined by Kim et al. (2012), and in particular it was related to the fact that the primary studies used statistical approaches without controlling for potential confounders, whereas Zhu et al. (2013) analyzed the publication bias and declared that there was none in their meta-analysis.

Discussion

This umbrella review underlines that the most investigated risk factors for RTI among adolescents were gender, age and socio-cultural context.

These aspects, in combination with country and income, could increase the risk of RTIs in adolescents.

Concerning gender, the predominance of boys in road traffic injury statistics can be partially accounted for by differences in exposure to risks, assuming that males are more likely to spend more time than females driving or in outdoor activities. Among young drivers, and for younger age groups, male drivers are more likely to be involved in a fatal crash (per km driven) than female drivers, even taking into consideration their increased exposure levels. Factors thought to contribute to this difference may include increased risk-taking and sensation-seeking (WHO and UNICEF 2008; Balan and Lingam 2012; Ministry of Transport 2015; Obermeyer et al. 2015).

Poorer families are more vulnerable and exposed to hazards both in and outside the house, thus increasing their vulnerability to injury among them and their children (Balan and Lingam 2012). In particular, demographic, social and economic disparities can affect behaviors and ultimately the incidence rate of road accidents in children or young adults: pedestrian injuries were common especially among children of low socioeconomic status and living in rural areas or in low-income countries (Laflamme and Diderichsen 2000; Kim et al. 2012; Zhu et al. 2013). The systematic reviews also showed controversial evidence to support undertaking childhood pedestrian injury prevention programs. The authors underline that the success of any community-based program is proportional to the complexity of the strategies implemented, which in turn relies on the number of resources available, time scale of implementation, and the commitment of the organizations and individuals involved. However, Duperrex et al. (2002) supported the hypothesis that community-based interventions are effective in reducing the incidence of childhood pedestrian injury, improve children's knowledge and change their observed road-crossing behavior.

Limitations

It is important to recognize that the definition of outcome varies considerably from review to review. In fact, countries still do not have a common definition of road traffic-related death in use in police databases. Research for this report revealed that 100 countries now use a 30-day definition for their official road traffic fatality data, representing progress since 2010 when only 92 countries applied this definition to their fatality data (WHO and UNICEF 2008). The most commonly quoted definition of a road traffic fatality is: "Road deaths are defined as any person killed immediately or dying within 30 days as a result of an injury accident, excluding suicides" (United Nation Economic Commission for Europe et al. 2009; European Environment Agency 2010; Ronan 2015). However, studies and the WHO have collected considerable variations of this working definition. For example, in the European Union, Greece, Portugal and Spain use a time span

of 24 h, France uses 6 days, and Italy uses 30 days (Mackay 2003; WHO 2009). There is also no consensus on the definition of injury severity: the AIS (Abbreviated Injury Scale) and an its revisited version, MAIS (Maximum Abbreviated Injury Scale), represented approaches to define the level of severity recommended by WHO (Goris 1983; Association for the Advancement of Automotive Medicine 2016).

The absence of the assessment of the risk of bias in all reviews considered may limit the validity of the results. In those that consider the risk of bias, the authors found that the majority of the primary studies applied descriptive rather than analytical statistics by calculating injury rates without controlling for potential confounders (Kim et al. 2012; Mytton et al. 2012).

In addition, certain methodological issues could have an important bearing on the validity of the present findings. In particular, publication and selection biases may have resulted in the over-representation of studies showing or promising intervention effects: three databases were consulted and only the English language was considered. Furthermore, an umbrella review was a review of reviews; therefore, the primary studies of reviews might be included in more than one review (overlapping of the primary studies), and this may further emphasize evidence leading to biased overview results.

There were some sources of heterogeneity, which made it more difficult to combine the results, such as country income, period of study and age group of adolescents. In particular, many articles included age groups not often comparable to each other and not completely included in the target age of the present umbrella review.

Furthermore, the validity of the results from any systematic review of reviews depends on the quality of the primary studies, and in this case 8 out of 14 studies were of poor quality (under AMSTAR's 6 points). Finally, the study sites were described as covering all areas of the world, but the primary studies were probably conducted in a limited number of countries.

Nonetheless, some recommendations and important points emerged from this review:

- fight inequalities so that road safety interventions and educational programs can have the same efficacy for young users from different backgrounds or geographical areas;
- target populations with calibrated programs on injury prevention, in particular considering gender differences in adolescents (WHO and UNICEF 2008; Tozzo and Caenazzo 2015; Obermeyer et al. 2015);
- two different typologies of child/adolescent victims of road accidents were studied: they were either occupants of automobiles or pedestrians (passive victims, or riders, actively causing the accidents), and this implies different approaches to controlling and targeting RTIs;

- independent of the year of publication and the geographical area studied, the same risk factors for adolescent road injuries were reported, namely the predominance of boys and low socio-cultural status.

Future research is required to improve strategies that address the issue of road accidents among children/adolescents starting from these known and accepted risks factors. Only a few reviews have been found on strategies for preventing injuries, and one such review concluded that there is no “reliable evidence supporting the effectiveness of pedestrian education for preventing injuries in children” (Steinberg et al. 2008).

In conclusion, the findings indicated quite clearly the need to develop specific injury prevention strategies on the basis of educational level, income and social status. Furthermore, these aspects represent the main reason for inequalities and different levels of efficacy of road safety interventions in adolescents worldwide.

Compliance with ethical standards

Ethical approval None sought.

Disclosure statement No potential conflict of interest was reported by the authors.

References

- Agran PF, Anderson CL, Winn DG (1998) Factors associated with restraint use of children in fatal crashes. *Pediatrics* 102:E39
- Alaghebandan R, Sikdar KC, MacDonald D et al (2010) Unintentional injuries among children and adolescents in aboriginal and non-aboriginal communities, Newfoundland and Labrador. *Canada Int J Circumpolar Health* 69:61–71
- Alonge O, Hyder AA (2014) Reducing the global burden of childhood unintentional injuries. *Arch Dis Child* 99:62–69. <https://doi.org/10.1136/archdischild-2013-304177>
- Ameratunga S, Hajar M, Norton R (2006) Road-traffic injuries: confronting disparities to address a global-health problem. *Lancet Lond Engl* 367:1533–1540. [https://doi.org/10.1016/S0140-6736\(06\)68654-6](https://doi.org/10.1016/S0140-6736(06)68654-6)
- Aromataris E, Fernandez R, Godfrey CM et al (2015) Summarizing systematic reviews: methodological development, conduct and reporting of an umbrella review approach. *Int J Evid Based Healthc* 13:132–140. <https://doi.org/10.1097/XEB.000000000000055>
- Association for the Advancement of Automotive Medicine (2016) AIS 2015 Released. In: Assoc. Adv. Automot. Med. <https://www.aaam.org/ais-2015-released/>. Accessed 23 Nov 2017
- Balan B, Lingam L (2012) Unintentional injuries among children in resource poor settings: where do the fingers point? *Arch Dis Child* 97:35–38. <https://doi.org/10.1136/archdischild-2011-300589>
- Braver ER (2003) Race, Hispanic origin, and socioeconomic status in relation to motor vehicle occupant death rates and risk factors among adults. *Accid Anal Prev* 35:295–309
- Duperrex O, Bunn F, Roberts I (2002) Safety education of pedestrians for injury prevention: a systematic review of randomised controlled trials. *BMJ* 324:1129
- Esposito TJ, Maier RV, Rivara FP et al (1995) The impact of variation in trauma care times: urban versus rural. *Prehospital Disaster Med* 10:161–166 discussion 166–167
- European Environment Agency (2010) Transport accident fatalities. In: Eur. Environ. Agency. <https://www.eea.europa.eu/data-and-maps/indicators/transport-accident-fatalities>. Accessed 23 Nov 2017
- Goris RJ (1983) The injury severity score. *World J Surg* 7:12–18
- Griffin B, Watt K, Kimble R et al (2014) Systematic literature review of incidence rates of low-speed vehicle run-over incidents in children. *Worldviews Evid-Based Nurs Sigma Theta Tau Int Honor Soc Nurs* 11:98–106. <https://doi.org/10.1111/wvn.12014>
- Hyder AA, Vecino-Ortiz AI (2014) BRICS: opportunities to improve road safety. *Bull World Health Organ* 92:423–428. <https://doi.org/10.2471/BLT.13.132613>
- Hyder AA, Amach OH, Garg N, Labinjo MT (2006a) Estimating the burden of road traffic injuries among children and adolescents in urban South Asia. *Health Policy Amst Neth* 77:129–139. <https://doi.org/10.1016/j.healthpol.2005.07.008>
- Hyder AA, Labinjo M, Muzaffar SSF (2006b) A new challenge to child and adolescent survival in urban Africa: an increasing burden of road traffic injuries. *Traffic Inj Prev* 7:381–388. <https://doi.org/10.1080/15389580600942965>
- Imamura JH, Troster EJ, de Oliveira CAC (2012) What types of unintentional injuries kill our children? Do infants die of the same types of injuries? A systematic review. *Clin Sao Paulo Braz* 67:1107–1116
- Juarez P, Schlundt DG, Goldzweig I, Stinson N (2006) A conceptual framework for reducing risky teen driving behaviors among minority youth. *Inj Prev J Int Soc Child Adolesc Inj Prev* 12(Suppl 1):i49–i55. <https://doi.org/10.1136/ip.2006.012872>
- Kim K, Ozegovic D, Voaklander DC (2012) Differences in incidence of injury between rural and urban children in Canada and the USA: a systematic review. *Inj Prev J Int Soc Child Adolesc Inj Prev* 18:264–271. <https://doi.org/10.1136/injuryprev-2011-040306>
- Krug EG, Sharma GK, Lozano R (2000) The global burden of injuries. *Am J Public Health* 90:523–526
- La Torre G (2003) Epidemiology of scooter accidents in Italy: the effectiveness of mandatory use of helmets in preventing incidence and severity of head trauma. *Recenti Prog Med* 94:1–4
- La Torre G, Van Beeck E, Bertazzoni G, Ricciardi W (2007a) Head injury resulting from scooter accidents in Rome: differences before and after implementing a universal helmet law. *Eur J Pub Health* 17:607–611. <https://doi.org/10.1093/eurpub/ckm028>
- La Torre G, Van Beeck E, Quaranta G et al (2007b) Determinants of within-country variation in traffic accident mortality in Italy: a geographical analysis. *Int J Health Geogr* 6:49. <https://doi.org/10.1186/1476-072X-6-49>
- Laflamme L, Diderichsen F (2000) Social differences in traffic injury risks in childhood and youth—a literature review and a research agenda. *Inj Prev* 6:293–298
- Lucidi F, Russo PM, Mallia L et al (2006) Sleep-related car crashes: risk perception and decision-making processes in young drivers. *Accid Anal Prev* 38:302–309. <https://doi.org/10.1016/j.aap.2005.09.013>
- Mackay M (2003) National differences in European mass accident data bases. In: Gennarelli TA, Wodzin W (eds) Contemporary injury severity and outcome issues. Lisbon Portugal, pp 51–55
- Masullo A, Feola A, Marino V et al (2014) Sleep disorders and driving licence: the current Italian legislation and medico-legal issues. *Clin Ter* 165:e368–e372
- McCowan CL, Swanson ER, Thomas F, Handrahan DL (2008) Outcomes of pediatric trauma patients transported from rural and urban scenes. *Air Med J* 27:78–83. <https://doi.org/10.1016/j.amj.2007.10.001>

- Mikton C, Butchart A (2009) Child maltreatment prevention: a systematic review of reviews. *Bull World Health Organ* 87:353–361
- Miller ME, Kaufman JD (1998) Occupational injuries among adolescents in Washington state, 1988–1991. *Am J Ind Med* 34:121–132
- Ministry of Transport (2015) Risk on the road drivers and their passengers. Ministry of Transport, New Zealand. <https://www.transport.govt.nz/assets/Uploads/Research/Documents/Risk-2015-drivers-and-passengers-final.pdf>. Accessed 31 May 2018
- Mitchell-Taverner P, Zipparo L, Goldsworthy J (2003) Survey on speeding and enforcement. https://infrastructure.gov.au/roads/safety/publications/2003/pdf/Speed_Risk_4.pdf. Accessed 31 May 2018
- Mohr D, Liberati A, Tetzlaff J et al (2009) Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med* 6:e1000097. <https://doi.org/10.1371/journal.pmed.1000097>
- Muelleman RL, Mueller K (1996) Fatal motor vehicle crashes: variations of crash characteristics within rural regions of different population densities. *J Trauma* 41:315–320
- Mytton JA, Towner EML, Powell J et al (2012) Taking the long view: a systematic review reporting long-term perspectives on child unintentional injury. *Inj Prev J Int Soc Child Adolesc Inj Prev* 18:334–342. <https://doi.org/10.1136/injuryprev-2012-040343>
- Nance ML, Hawkins LA, Branas CC et al (2004) Optimal driving conditions are the most common injury conditions for child pedestrians. *Pediatr Emerg Care* 20:569–573. <https://doi.org/10.1097/01.pec.0000139736.00850.da>
- Obermeyer CM, Bott S, Sassine AJ (2015) Arab adolescents: health, gender, and social context. *J Adolesc Health Off Publ Soc Adolesc Med* 57:252–262. <https://doi.org/10.1016/j.jadohealth.2015.01.002>
- Ronan (2015) International Traffic Safety Data and Analysis Group (IRTAD). In: ITF. <https://www.itf-oecd.org/IRTAD>. Accessed 23 Nov 2017
- Sharpe A, Hardt J (2006) CLSL. Five deaths a day: workplace fatalities in Canada, 1993–2005. <http://www.csls.ca/reports/csls2006-04.pdf>. Accessed 31 May 2018
- Shea BJ, Grimshaw JM, Wells GA et al (2007) Development of AMSTAR: a measurement tool to assess the methodological quality of systematic reviews. *BMC Med Res Methodol* 7:10. <https://doi.org/10.1186/1471-2288-7-10>
- Shope JT (2007) Graduated driver licensing: review of evaluation results since 2002. *J Saf Res* 38:165–175. <https://doi.org/10.1016/j.jsr.2007.02.004>
- Steinberg L, Albert D, Cauffman E et al (2008) Age differences in sensation seeking and impulsivity as indexed by behavior and self-report: evidence for a dual systems model. *Dev Psychol* 44:1764–1778. <https://doi.org/10.1037/a0012955>
- The World Bank Country and Lending Groups – World Bank Data Help Desk (2017) <https://datahelpdesk.worldbank.org/knowledgebase/articles/906519>. Accessed 23 Nov 2017
- Tozzo P, Caenazzo L (2015) Ethical reflections of gender equality and equity in adolescence medicine. *Clin Ter* 166:170–175
- Turner C, McClure R, Nixon J, Spinks A (2004) Community-based programmes to prevent pedestrian injuries in children 0–14 years: a systematic review. *Inj Control Saf Promot* 11:231–237. <https://doi.org/10.1080/156609704233289751>
- United Nation Economic Commission for Europe, International Transport Forum, EUROSTAT (2009) Glossary of transport statistics, 4th edn. <http://ec.europa.eu/eurostat/documents/3859598/5911341/KS-RA-10-028-EN.PDF/6ddd731e-0936-455a-be6beac624a83db4>. Accessed 31 May 2018
- WHO (2008) The global burden of disease: 2004 update. http://www.who.int/healthinfo/global_burden_disease/GBD_report_2004update_full.pdf?ua=1. Accessed 31 May 2018
- WHO (2009) Global status report on road safety time for action. http://apps.who.int/iris/bitstream/handle/10665/44122/9789241563840_eng.pdf;jsessionid=2AF7E2CA0EC14322D5562F75984BA58C?sequence=1. Accessed 31 May 2018
- WHO (2014a) Health for the world's adolescents. A second chance in the second decade. <http://apps.who.int/adolescent/second-decade/>. Accessed 31 May 2018
- WHO (2014b) WHO | WHO calls for stronger focus on adolescent health. In: WHO. <http://www.who.int/mediacentre/news/releases/2014/focus-adolescent-health/en/>. Accessed 23 Nov 2017
- WHO (2015) WHO | Global status report on road safety 2015. In: WHO. http://www.who.int/violence_injury_prevention/road_safety_status/2015/en/. Accessed 23 Nov 2017
- WHO, UNICEF (2008) World report on child injury prevention. http://apps.who.int/iris/bitstream/handle/10665/43851/9789241563574_eng.pdf?sequence=1. Accessed 31 May 2018
- Zhu M, Cummings P, Chu H et al (2013) Graduated driver licensing and motor vehicle crashes involving teenage drivers: an exploratory age-stratified meta-analysis. *Inj Prev J Int Soc Child Adolesc Inj Prev* 19:49–57. <https://doi.org/10.1136/injuryprev-2012-040474>