State-of-the-art review: preventing child and youth pedestrian motor vehicle collisions: critical issues and future directions

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ABSTRACT

Aim To undertake a comprehensive review of the best available evidence related to risk factors for child pedestrian motor vehicle collision (PMVC), as well as identification of established and emerging prevention strategies.

Methods Articles on risk factors were identified through a search of English language publications listed in Medline, Embase, Transport, SafetyLit, Web of Science, CINHAL, Scopus and PsycINFO within the last 30 years (~1989 onwards).

Results This state-of-the-art review uses the road safety Safe System approach as a new lens to examine three risk factor domains affecting child pedestrian safety (built environment, drivers and vehicles) and four cross-cutting critical issues (reliable collision and exposure data, evaluation of interventions, evidence-based policy and intersectoral collaboration).

Conclusions Research conducted over the past 30 years has reported extensively on child PMVC risk factors. The challenge facing us now is how to move these findings into action and intervene to reduce the child PMVC injury and fatality rates worldwide.

INTRODUCTION

The health, social and economic burden of road traffic injuries and deaths is extremely high. Each year there are approximately 1.35 million road traffic deaths worldwide. There is significant variation in rates across countries, however, with low/middle-income countries (LMIC) accounting for 90% of all road traffic deaths according to the 2018 WHO Global Status Report on Road Safety.[1] Vulnerable road users, including pedestrians and cyclists, make up a substantial proportion of those deaths. Efforts to reduce pedestrian and cyclist casualties have been less successful than for motor vehicle occupants.[2]

Child and youth pedestrians (2–20 years) are at particular risk of a pedestrian motor vehicle collision (PMVC) because of their limited developmental capacity to perceive road and traffic threats.[3] Children are also vulnerable to severe injury and fatalities because of their small stature. In 2016, there were approximately 72 000 pedestrian fatalities among children and youth (0–20 years) worldwide.[2]

According to the Global Burden of Disease Study, there has been substantial success in decreasing the population-level rates of child (<20 years) pedestrian fatalities worldwide from 1990 to 2017, calculated in the absence of pedestrian exposure (eg, number of trips, total distance) data.[4] However, there is variation, with greater decreases seen in high-income countries (75% decline from 3.2/100 000 to 0.8/100 000), compared with low-income countries (57% decline from 10.5/100 000 to 4.5/100 000). The rate ratio for child pedestrian fatalities (low-income countries vs high-income countries) has increased from threefold to sixfold between 1990 and 2017. Child pedestrian fatalities as a proportion of all-cause fatalities have also decreased by 42% in high-income countries over the same time period, whereas, it has increased by 15.5% in low-income countries. These data suggest that there may have been greater success in managing other causes of death (other than those due to pedestrian collisions) in low-income countries. Alternatively, these findings may be related to increased levels of motorisation in low-income countries along with a higher proportion of unsafe roadways according to the International Road Assessment Programme.[1] Further, progress in reducing child (<20 years) PMVC in high-income countries has stalled in recent years; 0.89/100 000 in 2012 and 0.78/100 000 in 2017.[4] The burden of child PMVC worldwide highlights the need for a comprehensive review of the best available evidence related to risk factors for child PMVC, as well as identification of established and emerging prevention strategies to reduce the enormous worldwide burden.

Safe System approaches and PMVC

The Vision Zero and Sustainable Safety, also known as Safe System approaches, first introduced more than 20 years ago in Sweden and the Netherlands, respectively, represented a turning point in the way countries and cities viewed road safety.[5 6] As the Organisation for Economic Co-operation and Development (OECD's) International Transport Forum stated in their *Towards Zero* report: 'a Safe System approach implies a greater level of vision, together with a greater level of individual and societal commitment to safety in the road transport system' (p. 111).[7] In fact, while road

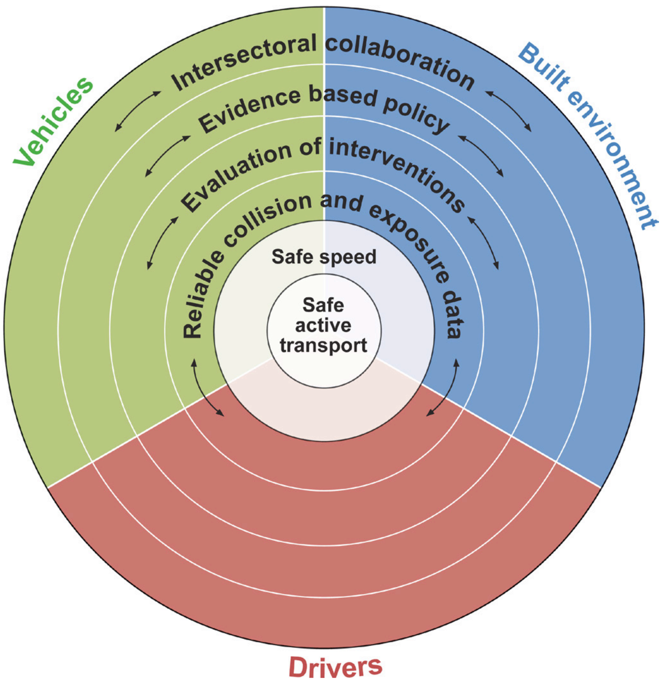

Figure 1 A Safe System approach to child and youth pedestrian injuries.

users—motorists, motorcyclist, cyclists and pedestrians—have long carried the burden of traffic safety, jurisdictions adopting this approach agree that road transport system designers are accountable for the level of safety within the system.[8] This is even more relevant in the case of children and youth, who historically carry this burden inequitably by being blamed for their own injuries and by having restrictions on their independent mobility because of traffic.[9] It aims to reverse the principle of liability in the event of a collision. In other words, road users are responsible for following the rules of the roads, but they may sometimes fail to obey these rules either intentionally (eg, speeding) or due to human error (eg, lack of knowledge or ability). In such situations, the road system should be ready to counteract such human failures and thus help avoid injuries or deaths through design.[10] In short, the foundation of this paradigm shift is to intervene upstream, at the level of the road design, in order to avoid crashes at their source. This approach aims to ensure a safe system for all road users.

Adopting a Safe System approach is especially important for child pedestrians. Children's greater vulnerability due to their size and developmental limitations calls for interventions directed towards pedestrian environments rather than education, that is, transferring the responsibility of road safety from the individual to the transportation system.[11] Figure 1 summarises risk factors and critical issues emerging from the child PMVC literature, adapted from the typical Safe System approach scheme.[12] Safe active transport for children and safe speed are at the centre of this figure given that both are critical to the reduction of child PMVC and both are also influenced by the three main domains: built environment, drivers and vehicles. These domains are also cross-cut by four critical issues (see figure 1). These cross-cutting issues are essential to the prevention of child pedestrian injuries: the availability of reliable collision and exposure data enables the evaluation of interventions, which can then inform evidence-based policy applied through intersectoral collaboration. This article is framed around the figure: background on active transport and speed are presented first, evidence on risk factors and related interventions for child PMVC are reviewed, followed by a discussion of critical issues.

Safe active transport

There has been a recent focus on walking to school and other active modes of transportation as a means to increase physical activity in children. Children who walk to school and use other forms of active transportation have higher levels of physical activity.[13,14] Regular physical activity has established health benefits such as reducing the risk of obesity and other chronic disease conditions.[15] Walking has also been associated with increased cardiorespiratory fitness and healthier body composition.[16] In addition, there are transportation benefits such as less traffic congestion, lower fuel costs, and shorter and more reliable travel times. Despite these established benefits, there have been declining rates in walking or bicycling to school in North America over the last 50 years.[17,18] A recent article examining pedestrian fatality trends over 40 years in the USA (1977–2016) confirms this steady decline in child pedestrian activity in the national travel survey data: pedestrian trips decreased by 48% from 1977 to 1990 (age 5–15), and by 34% from 2001 to 2017 (age 6–15).[19] Only a third of Canadian children use active school transportation modes with declines seen after age 10.[20]

Increased walking, however, leads to increased exposure to road traffic, which must be considered when promoting active transportation. Road traffic exposure is poorly understood as it relates to pedestrian volume and collisions, particularly for children. A 'safety in numbers' effect has been reported in population-based studies of adult pedestrians where higher pedestrian volumes have a protective effect on the risk of PMVC[21,22] and on the number of interactions between child pedestrians and vehicles.[23] In contrast, studies specific to children have shown that more children walking is associated with a higher risk of PMVC, particularly when walking to school.[24–26] This may indicate that environmental conditions that ensure safe walking may be different for children and adults. Optimal conditions for safe walking for children must be defined, because if poorly planned, interventions to increase walking may have the potential to increase the risk of injury in children. This also aligns with research showing that child pedestrian collisions are more strongly associated with the built environment than with volumes of children walking to school. Therefore, safety concerns relate primarily to the built environment and road environment.[27]

Safe speed

Traffic speed has been identified by The WHO as the core of the road traffic injury problem worldwide[28] because of the influence of speed on risk of a crash and injury severity. Once the physical impact occurs, speed determines the energy of the impact that crash participants are exposed to. Greater PMVC impact speed, regardless of the speed limit, increases the risk of pedestrian fatalities: pedestrian fatality risk reaches 10% at 37 km/h, 50% at 59 km/h and 90% at 80 km/h.[29] The ability to stop and avoid a crash is substantially reduced at higher speeds: 13 m is generally required to stop when a car is travelling 50 km/h, whereas only 8.5 m is required at 40 km/h.[30] These statistics are even worse for child pedestrians, with a threefold increase in the likelihood of injury when posted speeds are over 45 km/h.[31,32] Speed limit zones of 20 mph (32 km/h) have shown a 70% reduction in child pedestrian fatalities in the UK compared with higher speed limit zones.[33] A case–control study found that child PMVC was significantly associated with a twofold increase at speeds >50 km/h compared with ≤50 km/h (OR=2.1, 95% CI: 1.3 to 3.2).[34] Addressing the issue of speed through lower speed limits and appropriate road design is critical, especially in areas where there is the potential for many child pedestrian activities, such as around schools and parks. Accordingly, the recent Stockholm Declaration, following the Third Global Ministerial Conference on Road Safety, is calling for default 30 km/h speed limits on urban streets.[35] Parents tend to not allow their children to walk where there are higher speed roadways. Cities have a role to play in this, and the increase of 30 km/h zones (20 mph) around the world is promising.[36]

METHODS

Articles on risk factors were identified through a search of English language publications listed in Medline, Embase, Transport, SafetyLit, Web of Science, CINHAL, Scopus and PsycINFO within the last 30 years (~1989 onwards). Online supplemental table 1 details the search terms for each of the domains. Online supplemental table 2 illustrates the result of the search using a Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram with a total of 9897 documents initially retrieved. After a first screening to remove duplicates, only reviews (including reports, n=14), systematic reviews (n=12) and meta-analyses (n=6) were selected and reviewed, including articles found by hand search in the reference list of the selected papers. No specific quality assessment was done. A few individual manuscripts (n=9) were also assessed when there were limited articles in the domain. A total of 41 articles were reviewed to assess risk factors (RF) and interventions (I) related to child pedestrian characteristics (n=9 RF and n=3 I) and the three domains presented in figure 1: built environment (n=7 RF and n=4 I); drivers (n=6 RF and n=1 I) and vehicles (n=5RF and n=6I). Type, subtopic, age range and main findings of each articles are summarised in online supplemental table 3 (risk factors) and online supplemental table 4 (interventions).

RISK FACTORS AND INTERVENTIONS FOR CHILD PMVC

As presented in figure 1, critical issues related to child PMVC can be grouped under three domains around children's characteristics (including age, sex, socioeconomic status and location of residence): characteristics related to the built environment where the child or youth lives, plays and travels; characteristics related to driver behaviours (including distraction) and characteristics of the vehicle or fleet. Online supplemental table 3 (risk factors) and online supplemental table 4 (interventions) summarise the literature for each of these four domains.

Safe child pedestrians

Risk factors

Children are at higher risk of pedestrian injuries because of their developing cognitive ability and their small size, which makes them both less visible and more vulnerable to injury and death in collisions.[3 31 37] In theory, children 5–9 years are particularly vulnerable, given their emerging independence yet still limited abilities. However, the variability in the populations studied and comparisons between age subgroups across studies currently preclude strong conclusions regarding the relationship between age and child pedestrian injury risk.[19 21] Child pedestrian injuries are more frequent in boys than girls, which may be the result of different risk taking behaviours and exposure to traffic. This may be explained by temperament and personality, but also by gender expectations, including social acceptability of greater freedom for boys to explore their environment.[31 38 39] Similarly, research in social psychology also found that gender differences in risk taking among 12–16 years old pedestrians are due more to sex-stereotype conformity (ie, level of masculinity) than to biological sex.[40 41] Finally, boys may also be more likely to leave the house and travel further for outdoor activities and, in some countries, for work.[39] Indigenous children and those from ethnic minorities also experience higher hospital admissions and death rates, which is likely the result of a variety of social inequities.[42–44] The literature consistently shows that children facing challenging social and economic conditions of life, including low family income, low parental education, crowding, family disruption and sole parenthood are disproportionately represented in child pedestrian injuries.[31 38 44]

Interventions

Many interventions focus on behavioural interventions to improve child pedestrian safety. In a review of 15 randomised controlled trials of safety education programmes for pedestrians, including 13 targeting children between 3 and 13 years old, Duperrex *et al*[45] found that educational interventions can change pedestrian behaviours. Another systematic review by Schwebel *et al*[46] that summarised 25 studies found a relationship between behavioural interventions and pedestrian behaviours, immediately after training and several months later. Individualised or small-group training, outside on the street and sidewalks, tends to be the most effective intervention strategy to change behaviour compared with classroom training, computer-based/virtual reality training, board-games/peer group activities, videos and/or multiple intervention strategies combined.[46] Children's traffic clubs using material to promote parental teaching also seem to change parents' and children's behaviours at least in the short term.[47] However, there is no evidence that education or behavioural interventions carry over to a reduction in actual PMVCs, and such interventions may contribute to a 'victim blaming' narrative where the responsibility for PMVC lies in children's behavioural mistakes rather than on drivers or unsafe street environments. While the literature has identified numerous child PMVC risk factors including sex/gender, age, ethnic minorities and social vulnerability,[48] it is evident from our review of the literature that many of these variables are not addressed in current interventions, which may further limit programme effectiveness even further.

Built environment

Risk factors

Factors related to the environments in which children and youth live, including location of residence (urban, suburban, rural), neighbourhood socioeconomic status, road characteristics and traffic, influence the risk of pedestrian injury.[38] Children living in low-income countries face especially high rates of pedestrian injuries likely due to limited funding allocated for pedestrian infrastructure and law enforcement, which increases the potential for high-speed traffic.[38] Children living in socioeconomically deprived areas are particularly susceptible to child pedestrian injuries likely because of increased exposure.[39 44] In other words, these children often walk more and live in neighbourhoods with more cars on the roads.[24 49] Similarly, neighbourhoods with a high percentage of multifamily dwellings and subsidised housing are associated with increased risk of child pedestrian injuries.[31 44] Rural areas are at higher risk, even more so in LMIC, where more pedestrians face hazardous environmental conditions, higher driving speeds and delayed access to and lower usage of trauma centres.[38] Conversely, high-income countries have identified urban locations as injury creating environments, due to the higher population density, therefore more pedestrians, and increased traffic volume.[50 51] Large and straight roads that make crossing difficult, greater traffic volume, poor visibility and low-light conditions are other road-related characteristics associated with more child pedestrian collisions.[31 38 51]

Interventions

Traffic calming measures are the only built environment factors consistently associated with fewer PMVC in children.[51] Traffic calming measures can reduce traffic speed and volume, which effectively reduces child PMVC. Measures such as speed humps and roundabouts, and reduced speed limits (20 mph or 30 km/h) are associated with both walkability and a reduction in pedestrian injury incidence.[39 44 51–54] However, results related to the presence of parks and playground are contradictory. A recent study found that the risk of child pedestrian fatalities is up to 2.23 times higher around parks than around schools and up to 1.81 times higher around parks than any other citywide crossing.[55] A systematic review on built environment and safe walking, however, found that recreation/parks areas and playground presence were consistently associated with lower pedestrian injury incidence.[51] This finding might be explained by difference in road characteristics within school zones, a common situation worldwide. Appropriate traffic calming measures are necessary in areas close to schools but also in areas where there are many child pedestrians, such as parks and playgrounds, so that the increased exposure to road traffic does not increase injuries.[51] Unfortunately, inequities in terms of the road environment exist, with, for example, lower densities of traffic calming measures found in lower socioeconomic areas.[56]

Drivers

Risk factors

Risky driving behaviours, including impairment, distraction, aggressive driving and speeding, influence road injury risk. However, very few studies have assessed the impact of drivers' risky behaviours on child PMVC. Alcohol-impaired driving is an established independent risk factor for pedestrian-struck incidents[57] and drivers involved in child PMVC are more likely to be under the influence of alcohol at the time of the collision, compared with drivers deemed not-at-fault in vehicle-only collisions.[57 58] Distraction, which can take many forms, including talking on a cell phone, texting or performing other tasks such as eating while driving has also been associated with child PMVC; drivers involved in child PMVC were more likely to be distracted at the time of the collision.[29] In Toronto, Canada, dangerous driving behaviours around schools including double parking and drop-offs on the opposite side of the school were associated with an increase in child PMVC rates (based on child population).[59 60]

Interventions

While vehicle speed, distracted and impaired-driving law enforcement[61] are in place in most countries and have shown to be effective to regulate drivers' risky behaviours, no study has assessed the impact of enforcement interventions on child PMVC. A review of countermeasures included in Safe Routes to Schools programmes in the USA reaches the same conclusion: evaluation of enforcement programmes focuses on behaviour changes such as speeding.[62] A literature review on vehicle travel speeds and pedestrian injuries published in 1999 by the National Highway Traffic Safety Administration (NHTSA) acknowledged that reduction in speed limits and enforcement reduces pedestrian crashes and injuries.[63] However, despite their extensive deployment in cities such as New York as part of their Vision Zero strategy, little is known about the impact of interventions such as automated speed enforcement near schools on child PMVC.[64] Results from a pilot-project in Seattle (USA) are promising, including a reduction in speed violation rates and mean hourly vehicle speeds.[65] Finally, it appears that many education campaigns run by police departments target pedestrians and their behaviours, including distraction, rather than drivers. However, there is no evidence that distracted pedestrians are the cause for the high burden of pedestrian collisions, either for adults or children.[66]

Vehicles

Risk factors

Vehicle design has been recognised to be both part of the problem and the solution when it comes to pedestrian injuries. There is little information specific to child pedestrians regarding vehicle-specific risks, except that children are more vulnerable to head injuries—the usual cause of fatality—because of their shorter stature. Accordingly, light truck vehicles and sport utility vehicles (SUVs) are now under scrutiny for the greater risk they pose to adult pedestrians compared with conventional cars since their mass makes it harder to brake quickly and vehicle height leads to more upper body injuries.[67–69] Of even greater concern, a recent technical report from the NHTSA found that vehicles sold globally (including European and US variants) offer more pedestrian safety than vehicle models marketed only in the USA and that US pickup trucks and large SUV models performed the worst of all vehicles.[70] Connected and automated vehicles (CAV) represent a great opportunity, but also a potential threat to pedestrians. With these newer technologies, collision risk may decrease as the majority of collisions are related to human error. However, recent reviews highlight the great uncertainty related to the interaction of CAV with pedestrians in that the reliability of the technology (sensors, algorithm and so on) has not been firmly established.[71] Both pedestrian reaction to CAVs, given the lack of interpersonal communication with the (non)-drivers, and the drivers' reaction when faced with a pedestrian remain unknown.[72 73] In this era of new mobility technology, there remain more questions than answers.

Interventions

Safety standard improvements around the globe have contributed to the decrease in the burden of car crashes, especially for vehicle passengers. Several passive (eg, front-end design) and active (eg, automated emergency braking system) safety designs are known to prevent pedestrian collisions or decrease the severity of injuries if a crash occurs.[68 74–77] For example, an automatic braking system that engages immediately at a time to collision of 1.5 s may reduce fatality risk by 84% for pedestrians struck in frontal impacts, a scenario that accounts for about 70% of pedestrian fatalities in the USA.[78] Empirical data from non-fatal pedestrian collisions in Sweden suggested that 60%–70% of pedestrian crashes would be avoided if cars had mandatory pedestrian detection and automated emergency braking systems.[79]

CRITICAL ISSUES: RECOMMENDATIONS AND FUTURE DIRECTIONS

This section summarises critical issues related to child PMVC, highlighted by the review of the literature, and suggests future directions.

Reliable collision and exposure data

According to the US Federal Highway Administration, critical data in road safety include crashes, traffic volume and road characteristics.[80] All three represent a challenge when it comes to PMVC.[81] The burden of PMVC deaths and injuries is likely underestimated because of the lack of accurate data. For example, estimating the numerator for rate calculations can be challenging because of limitations in data sources such as misclassification or inaccuracies in crash location and time.[82] Police reports and hospital records are the two main sources of data to measure PMVC, including those involving children. However, under-reporting is well documented for police reports, particularly for collisions involving less severe injuries.[83 84] Moreover, in several jurisdictions, police reports and hospital files do not record the collision location, which is crucial information for prevention.[85 86] The situation in LMIC is even more challenging, with under-reporting of crashes being a major issue: road fatalities are not uniformly reported to official sources for a variety of reasons, including under-resourced police, differing definitions of fatalities, varying legal requirements to report crashes and paperwork and recording issues.[87 88]

Another important data challenge relates to identifying accurate denominators. Pedestrian volume data related specifically to child PMVC rarely exist at the street level and household travel surveys, an alternative source of data for pedestrian volumes, are available only at a larger scale. Vehicle volume and speed data are collected more frequently, but are mostly available at intersections with traffic signals or on major roadways where children tend not to walk.[56] Novel methods for the measurement of exposure data (vehicle and pedestrian volumes) are required to accurately estimate child pedestrian risk. The use of 'big data' may be promising, via GPS data streams as well as artificial intelligence/machine learning algorithms.[89 90] However, these sources need to be further developed to be applicable to child pedestrians.[91] Because of these general data collection issues, exposure to traffic or distance walked (ie, risk per journey) is frequently not considered when assessing child pedestrian injury risk. Instead, area child population is used as the denominator to calculate rates (ie, risk per person). This can result in inconsistencies in research evaluating the scope of the problem or the impact of the road environment. A review of methodological considerations in the context of child PMVC has been published as a companion paper to this review.[91]

Finally, measuring risky driving behaviours including speeding, distraction, and alcohol and drug impairment pose many challenges when it comes to data collection. The lack of social desirability of these behaviours limits the use of respondent surveys, especially around schools where most drivers are parents. Novel methods and standardisation of roadside testing for alcohol and drugs are needed, as are studies assessing the relationship between drug impaired driving and child PMVC, especially given the legalisation of cannabis in some countries. Distraction is not currently evaluated or reported in a standardised way across studies, thus limiting the conclusions that can be drawn. Quantifying distraction properly is particularly challenging, as it relies on surrogates such as visual and cognitive inattention. Surrogate outcomes currently used (eg, decrements in lateral and longitudinal vehicle control for cognitive inattention, glances at roadway vs secondary device for visual inattention) are still poor proxies for relative safety.[92]

Evaluation of interventions

Evaluation of interventions with rigorous study designs is needed to support evidence-based decision-making. Historically, road safety strategies were formulated around the three 'Es' (engineering, education, enforcement). Lately, several other 'Es' have emerged, including 'Evaluation', which has been a much-neglected piece. Road safety strategies must be based on data, but there remains insufficient high-quality systematic evaluation of road safety interventions and their effect on child pedestrian injuries.[93] Although there have been some studies done of the effectiveness of built environment interventions on motor vehicle collisions, few studies have examined the relationship with PMVC and even fewer are specific to environments where there are many child pedestrians.[56]

Rigorous evaluation of built environment interventions examining their effect on both active transportation and pedestrian injuries are needed, such as randomised controlled trials, quasi-experimental and controlled pre-post studies.[38] A recent review found that child transportation injury prevention research is generally observational or descriptive, with only 25% of studies being experimental.[93] Of these experimental studies, the majority evaluated educational interventions, despite evidence that these are largely ineffective in reducing injury. Further research investigating the effect of engineering and enforcement interventions on child PMVC is required. Among built environment interventions evaluated for their effects on adult PMVC, only a few have been evaluated for their specific effects on child PMVC. Results for adults might not be generalisable to children since differences in injury incidence, road knowledge and behaviour between adult and child pedestrians is well-documented.[62]

Evidence-based policies

It is essential that evidence-based policies take a systems approach and consider the interplay between road safety policy, transportation planning, environmental design and health in order to achieve continued progress in child PMVC prevention. As noted earlier, policies to promote walking and those to improve pedestrian safety, should not be enacted in isolation. Interventions need to take an environmental design approach to create 'human error-tolerance in the road system', that is, a road system that is forgiving to human error.[94] For example, presence of playgrounds and recreation areas have been identified as factors consistently associated with both more walking and less PMVC injury.[51 95] Integrating road safety into broader urban policies is essential and should involve collaboration between decision makers, multidisciplinary practitioners and researchers. Decision making related to child pedestrian safety strategies should be both data-driven and evidence-informed. Appropriate governmental organisations should constantly review their policies and guidelines to ensure that they meet the highest standard and take into account recent innovations.[96] Road safety policies should be integrated and take a long-term view involving consultation and consensus with all stakeholders, citizens and governing politicians. However, this long-term goal is often in conflict with the political need for short-term results.

Intersectoral collaboration

Multidisciplinary collaboration between researchers and practitioners is the key to success. As for many other public health issues, collaboration between researchers, decision makers and practitioners is essential to achieve success in injury reduction. Moreover, a Safe System approach requires collaboration across sectors and across disciplines.[97] Broad collaboration is also essential to plan and implement an evaluation process early into intervention projects. However, the decision-making process related to road safety is often heavily influenced by public opinion.

Road safety management will be most effective if policy makers are involved in the research process from the beginning and vice versa. Research on the role of evidence in policy has shown that while evidence is necessary, it is not sufficient to bring about change. Policy makers cite other factors, including having a 'champion for the change', strong relationships with researchers, a united opinion and professional group consultation as being enablers to implement policy.[97]

CONCLUSION

The large-scale nature of the challenge, the breadth and depth of domains, the broad collaboration required, and the political will have to be involved to lower the burden of child PMVC. Success will require political leadership, financial commitment and public engagement. A major impediment to change is the so-called 'war on cars' rallying call, and a vocal resistance to change of 'car-centric' built environments. This rhetoric creates animosity between road-users and impedes the ultimate goal of keeping child pedestrians safe. Since World War II, transportation policies have focused on moving automobiles efficiently and on improvements to the driving environment, with a few exceptions in Europe where the needed shift from a focus on moving cars to a focus on moving people has occurred over the past few decades. The current need is to put the spotlight onto pedestrian health and safety and to refocus road safety on more vulnerable road users.

Many countries have committed to the Vision Zero framework with the goal of zero road traffic fatalities and serious injuries. The Vision Zero framework is fluid in that it is constantly evolving to include new road environment conditions and new areas of focus on transport safety.[98] The ultimate goal of eliminating road traffic fatalities and serious injuries can be achieved by creating a proactive and integrated plan with the aim of protecting vulnerable road users. Child pedestrians and other vulnerable road users should be separated in time and space from motor vehicles, and where this is not possible, traffic speeds should be capped at 30 km/hr reflecting crash survivability. It is now the time for a systematic translation of the evidence on prevention of child PMVC into concrete actions worldwide.

What is already known on the subject

- ► Children are particularly at risk of a pedestrian motor vehicle collision (PMVC) because of their limited developmental capacity to perceive road and traffic threats.
- ► Optimal conditions for safe walking must be defined, because if poorly planned, strategies to increase walking may have the potential to increase injury risk in children.
- ► Many interventions focus on child behavioural interventions to improve child pedestrian safety. Despite some evidence that educational interventions can change behaviours, there is no evidence that this carries over to a reduction in actual child PMVCs.

What this study adds

- ► Adopting a road safety Safe System approach is much needed if we want to reduce the child PMVC injury and fatality rates worldwide while encouraging safe walking.
- ► In addition to known child pedestrian risk factors related to built environment, drivers and vehicles, our state-of-the-art review highlights four cross-cutting critical issues to address: reliable collision and exposure data, evaluation of interventions, evidence-based policy and intersectoral collaboration.

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