International Symposium on Safety of Vulnerable Road Users

25-26 March 2019
Changsha, China

Proceedings

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Acknowledgement
Independent Council for Road Safety International (ICoRSI) is supported by the Tata Education and Development Trust, Mawana Sugars, Tata Sons and individual donors.

The International Symposium on Safety of Vulnerable Road Users in Changsha, China, was supported by the University of Chicago, Beijing Center.

Declaration
The papers presented at the International Symposium on Safety of Vulnerable Road Users represent the views of the authors and the contents may be published separately after discussion at the symposium. All papers will also be available at www.icorsi.org after the symposium.

Suggested citation
ICoRSI (2019). Proceedings. *International Symposium on Safety of Vulnerable Road Users, Changsha, China, 25-26 March. Independent Council for Road Safety International, https://www.icorsi.org/icorsi-pblications.*

Progress in Pedestrian Safety Research

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Abstract
This study looks at the pedestrian safety issue and the research that has followed to understand and solve the problem of pedestrian safety in the last 120 years - since the time of the first reported pedestrian fatality in the US. Researches have studied the epidemiology of pedestrian crashes, pedestrian behaviour, pedestrian movements and pedestrian flows. The suggested strategies to reduce pedestrian crashes have ranged from controlling vehicular speeds to controlling pedestrian behaviour. This study presents a summary of the progress we have made in understanding pedestrian crash patterns. Pedestrian behaviour observed in different regions of the world tend to have similarity in terms of gap acceptance, preferences of route choice and location for crossing roads. High income countries (HIC) have reported reduction in pedestrian fatalities as compared to low- and middle-income countries (LMIC), however pedestrian trips have also reduced in these countries leading to concerns about effectiveness of "known" strategies. Speed control through active measures has been found to have maximal benefit and education and training program the least. Low and middle income countries face pedestrian exposure on high speed roads. New research efforts are required address pedestrian safety in HIC and LMICs both.

Keywords: Pedestrian safety, pedestrian risk, traffic risk, pedestrian behaviour

1 INTRODUCTION
Henry Bliss was America's first recorded pedestrian fatality. On September 18, 1899, The New York Times headline read "fatally hit by automobile". Henry Bliss was hit by an electric taxi as he was alighting from a street car (1) . Since then in US alone more than 300,000 pedestrians have died in traffic crashes. Historical records show that the first ever recorded pedestrian fatality was a British woman Bridget Driscoll more than 120 years ago[2]. Bridget Driscoll was hit on the grounds of Cristal Palace by an experimental vehicle-a horseless car-the experimental automobile which could go at a maximum speed of 8 mph (13 km/h).

In the years to follow, automobiles and other forms of motorized vehicles grew all over the world. In some parts of the world more than the others. Today we have countries labelled as motorized countries and less motorized countries. Less motorized countries are the low and middle-income countries (LMIC) having different traffic patterns and crash patterns (2).

Road traffic fatalities continued to rise all over the world for the next 70 years since the first reported road traffic fatality. However, motorized countries started reporting reduction in RTIs 1970 onwards. The rate of traffic fatalities have stabilized, however, the number of road traffic deaths continues to increase, reaching 1.35 million in 2016 (3). The WHO report on Road Traffic Injuries notes that "progress has been achieved in important areas such as legislation, vehicle standards and improving access to post-crash care. This progress has not, however, occurred at a pace fast enough to compensate for the rising population and rapid motorization of transport taking place in many parts of the world" (3). Most motorized countries have reported reduction in fatalities, less motorized countries continue to report increase in road traffic fatalities.

However, pedestrian safety has been a difficult issue in all countries. European Union countries report "Deaths of unprotected road users have been decreasing at a slower rate than those of vehicle occupants. In the last ten years deaths among pedestrians decreased by 41%, those among cyclists by 37% and those among power two wheeler (PTW) users by 34% compared to a 53% decrease for vehicle occupants." (4). NHTSA report stated for USA "Although pedestrian deaths were 20 percent lower in 2017 than in 1975, they have increased 45

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[2] Fatal crash with self-driving car was a first — like Bridget Driscoll's was 121 years ago with one of the first cars. https://www.washingtonpost.com/news/tripping/wp/2018/03/22/

percent since reaching their lowest point in 2009".[3] Low income countries continue to report increase in traffic fatalities and proportion of pedestrian fatalities have remained high (3).

This study looks at the pedestrian safety issue and the research that has followed to understand and solve the problem of pedestrian safety in the last 120 years. Section 2 presents number of pedestrians lost in different regions of the world. Pedestrian fatalities have reduced in high income countries, however at the same time number of pedestrians, school going or to work, have also reduced. Section 3 presents summary of research studies since 1950 that focused on understanding pedestrian behaviour. Section 4 presents a comparison of pedestrian crash patterns observed in earlier studies to what is observed in recent studies from different regions of the world. Section 5 summarize the suggested strategies to reduce pedestrian crashes which have ranged from controlling vehicular speeds to controlling pedestrian behaviour. Final section discusses the challenges to address pedestrian safety and new research areas.

2 NUMBER OF PEDESTRIANS LOST IN ROAD TRAFFIC CRASHES

In terms of pedestrian crashes on a worldwide scale, over 400,000 pedestrians die every year with over half of these deaths occurring in low-income countries (3). This may be an under estimation by at least 20 percent (5, 6). The latest WHO Global Status Report on Road Safety (3) has listed road traffic crashes (RTC) as the leading cause of death for the age group 5-29 years. With progress made in reducing deaths from communicable diseases, proportion of deaths from non-communicable diseases-injures has increased. Large variation has been observed in fatality rates amongst different regions of the world. Low and middle-income countries continue to report high fatality rates as compared to high income countries. The variation in death rates observed across regions and countries also corresponds with the differences in types of road users most affected (3). Globally pedestrians and bicyclists comprise of 26% of all road traffic deaths and MTW comprise of 28%. The report states 44% pedestrian fatalities in Africa and 14% for South East Asia. These numbers are based on government statistics. Bhalla, Khurana (6) have highlighted the underreporting of pedestrian crashes in India in government statistics. Other detailed studies (5) have reported at least 35% pedestrian share in fatalities in India. It is possible that the pedestrian deaths have higher underreporting as compared to other road users in other South Eastern countries too.

Around 138,400 pedestrians and cyclists lost their lives on EU roads between 2001 and 2013. 7,600 were killed in 2013 alone (4). Pedestrian and cyclists together accounted for 29% of the road traffic deaths in EU countries in 2016 (4). Pedestrians killed represent 21% and cyclists 8% of all road deaths. But big disparities exist between countries. ETSC reports that there is a high level of underreporting of collisions involving pedestrians and cyclists.[4] ETSC reports show concern over the slow pace of decrease in the deaths of unprotected road users as compared to that of vehicle occupants. In the last ten years deaths among pedestrians decreased by 41%, those among cyclists by 37% and those among power two wheeler (PTW) users by 34% compared to a 53% decrease for vehicle occupants.

US reported an average of 6,000 pedestrian fatalities in 2016-17. The proportion of pedestrian fatalities increased from 14% in 2008 to 19% in 2017. The proportion of people killed "inside the vehicle" (passenger car, light truck, large truck, bus, and other vehicle occupants) declined from a high of 80% in 1996 to 67% in 2017. Conversely, the proportion of people killed "outside the vehicle" (motorcyclists, pedestrians, pedalcyclists, and other nonoccupants) increased from a low of 20% in 1996 to a high of 33% in 2017).[5]

3 PEDESTRIAN CRASH INVESTIGATIONS AND RESEARCH METHODS

First reported pedestrian crash of Bridget Driscoll was not a road traffic crash. It was in an exhibition ground. However, it was so unusual that the incident was sent to the Coroners court for full investigation. The investigation included the testimonies in the court of various witnesses. The witnesses were questioned and reported their observations about the vehicle speed "Florence Ashmore, a domestic servant who had witnessed the crash, said the vehicle had come on "at a tremendous pace, in fact, like a fire engine". [6] The perception speed of this witness is interesting to note because the vehicle was designed for a maximum speed of 8 mph (13 km/h) and for demonstration the speed had been restricted to 4 mph (6.5 km/h).

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[3] 2017 Fatal Motor Vehicle Crashes Overview, https://www.nhtsa.gov/press-releases/us-dot
[4] ETSC Report: Making Walking and Cycling on Europe's Roads Safer, www.pacts.org.uk/.../
[5] U.S. DOT Announces 2017 Roadway Fatalities Down | NHTSA, https://www.nhtsa.gov/press-releases/
[6] Fatal crash with self-driving car was a first — like Bridget Driscoll's was 121 years ago with one of the first cars. https://www.washingtonpost.com/news/tripping/wp/2018/03/22/

There were statements about the driver's abilities and training, "Witnesses testified that Edsall had been driving for all of three weeks time and had not even been told which side of the road he should stay on. (Perhaps unsurprising, he also had no license.)". Driscoll's daughter testified that he (the driver) didn't seem to know what he was doing — that he had zigzagged toward her mother and her — just before the crash. Witnesses were questioned whether the public had been given enough warning about the demonstration vehicle. John Wood, a foreman for workers at the Crystal Palace, testified that there were sufficient public notices in the area warning people of the automobile demonstration.[7] The driver testified that he was going less than 4 mph (6.5 km/h). When he saw the lady in the path of the vehicle he had shouted "Stand back!", while ringing the car's bell. The vehicle hit the lady and the blow knocked Bridget Driscoll down, inflicting a fatal head injury. The driver right away hit the brakes. The jury deliberated for six hours and concluded that this was an "accidental" incident and hoped that this would not be repeated in future.

The framework of the investigation of this first pedestrian crash influenced the process of investigation for many years. Researchers and policy makers focused on "investigating" the role of driver, skills of driver, and "awareness or information" given to the road users to induce safe behaviour on the road. Some other observations from this incident included the possibility of fatality even at a low speed, consequences of head hitting a hard surface. For the next sixty years the role of speed, environment around the road user and road user behaviour after knowing the "correct information" continued to be ignored by most researchers.

Since 1950s some original experimental studies were done to understand pedestrian behaviour on the road (7, 8). Cohen, Dearnaley (8) observed the behaviour of pedestrians in the face of oncoming traffic. Measurements were made between the time elapsing between the pedestrian first observed the oncoming vehicle and the arrival of the vehicle at the crossing. The researchers studied the differences in crossing behaviour with age and sex. Haddon Jr, Valien (9) studied adult pedestrians who were fatally injured by motor vehicles in New York. The study was published in 1961 and it reported that of all the people who died in road traffic crashes in New York city in the years 1955-59, seventy percent were pedestrians. The study focus was to find out the characteristics of pedestrians who are involved in fatal crashes as compared to the ones who were not involved in such events though were similarly exposed. The study also noted that "despite this lack of scientifically gathered information large sums are spent annually throughout the United States in 'pedestrian control' programs, public exhortations, and other measures which though often reasonably have not been the subject of adequately designed evaluations. To the contrary, much has been made of short term fluctuations in incidence, both as evidence of the efficacy of such measures where the changes have been downward and, where the reverse has been the case, as evidence for their need."

The study was based on the premise that it was more important to understand the pedestrian characteristics and socio economic status of the pedestrian rather than the "pedestrian actions" (for example, 'disobeying given traffic regulation') which had been the focus of discussion for pedestrian safety. The study included investigation of post-mortem records of pedestrians involved in fatal crashes controlling for age. A control group was obtained by visiting the accident site on the same day of the week and as close to the time of reported crash to interview similar age people present on the location. Breath samples were also taken of the persons who were interviewed. The study resulted in a control or comparison group of 200 individuals. The results included purely descriptive and controlled observations. The study had noted the time period when majority of the crashes were taking place, weather was not found to explain the differences in patterns of the case and the control group, and presence of alcohol was more in the case group. Neither commuters nor visitors contributed to the fatally injured pedestrians and many of those killed were close to their residence.

These two studies made valuable contribution to the scientific study of cognitive and judgmental factors in traffic crash causation. Cohen, Dearnaley (7) noted the usefulness of models of decision making in risk situations which could help organize many diverse findings concerning individual behaviour in hazardous environment. These studies established methodology of conducting controlled observational studies which approach those of real life situations. The results included maximum risking taking behaviour (no one crossed the road when the vehicle was 1.5 seconds away and fifty percent of the sample crossed when the vehicle was 4.5 seconds away. Similar results have been found in later studies from many other regions of the world (10-12). Ishaque and Noland (13) reviewed a large number of studies of pedestrian crossing behaviour from different regions and different time periods. They conclude "The crossing of streets, which in some cases can be a risky endeavor for pedestrians, is clearly controlled by a consciousness of what those risks are. Gap acceptance rates suggest that pedestrians tend to choose safe crossing gaps and that individual gap acceptance levels are strongly

[7] Fatal crash with self-driving car was a first — like Bridget Driscoll's was 121 years ago with one of the first cars. https://www.washingtonpost.com/news/tripping/wp/2018/03/22/

mitigated by individual capabilities. For example, older people, who walk slower, will select longer gaps. The width of the crossing point also affects gap acceptance rates, clearly showing awareness on the pedestrian's part of the risks they are taking (or in most cases, risks that are avoided through rational decisions)."

In the following decades researchers focused on studying pedestrian risk-taking behaviour by observing pedestrian behaviour while crossing the road (gap acceptance) or interviewing pedestrians regarding the perception of risk at various facilities. Researchers continued to observe pedestrians and young pedestrians (children) behaviour in traffic to suggest how the risk-taking behaviour could be altered. Sandels (14) published a seminal study in Sweden in 1968. This study tried to answer the question "What happens if children are too immature to be able to derive any benefits from the traffic instructions that is given to them?". Sandels attempted to answer this question because "when accidents involving children are discussed it is often said that these accidents are caused by children's carelessness, incautiousness, and rashness,"… "this identification of children with adults has produced the belief that the behaviour of young children in traffic could be made perfect by instruction, ….". The study focused on understanding the cognitive skills of children and limitations of young children. The main conclusion of this study was that children below the age of approximately 10 years do not have sensory or cognitive ability to cope up with modern traffic. Consequently, the remedial measures will have to be aimed primarily at segregating children and traffic. Sweden is the only country at present where children's traffic education is not part of the national traffic safety strategy (15). The finding was accepted and questioned at the same time. Van Der Molen (16) noted in 1981 "children can and do in fact, negotiate modern traffic to a considerable extent and that taking the full consequences of Sandels' solution would be both very expensive and socially disruptive".

Schieber and Thompson (17) reviewed a large number of studies on children's behaviour and traffic focusing on "the developmental attributes affecting the behavior of children that make them more likely to be struck by a vehicle." The study focused on normal developmental stages of children, how children of various ages behave in traffic, what tasks and skills are needed to negotiate traffic successfully and which are deficient, and the effectiveness of school-based methods intended to correct such deficiencies. The authors concluded "For a young child, the act of crossing a street is a conscious, problem solving situation, with each circumstance appearing to be unique". Authors posed the question: "Is a child ready and able to acquire the necessary skills through education or training, or should these approaches be made secondary to efforts designed to change driver behaviour, adult supervision, or the roadway environment?" After considering several factors to answer this question the conclusion was "A developmental perspective suggests that traditional pedestrian traffic education has limited value for young elementary school children, and that most efforts targeting this age group should be directed towards improving the roadway, vehicles, drivers, and adult supervision." The conclusions of this review perhaps have influenced many safe school programs, however attempts to modify education programs and methods to teach school children for improving traffic safety has continued.

With advancements in data collection and statistical techniques, researchers have focused on collecting more data of pedestrian behaviour in different environment and developed models to predict pedestrian risk-taking behaviour. Video cameras have been extensively used to monitor pedestrian behaviour (18-21). Pedestrian movements are being tracked using image processing techniques. Micro simulation techniques have been used to model and predict pedestrian behaviour (22). More advanced microscopic simulation techniques are exploited, namely multi-agent simulation systems, which are based on artificial intelligence concepts. In these systems, pedestrians are treated as fully autonomous entities with cognitive and often learning capabilities (23). Majority of the studies have focussed on pedestrian crossing behaviour in urban settings. Researchers have suggested to combine road crossing behaviour models with route choice behaviour to present a more comprehensive pedestrian behaviour (24-26). In one of the recent studies(27, 28) theory of planned behaviour has been applied to explain the pedestrian route choice behaviour.

Overall data collection techniques have changed, computational techniques and statistical methods have advanced. However, broad understanding of pedestrian behaviour that was reported in 1950-60s and 70s has more or less remained unchanged. More studies continue to be published on pedestrians differentiated by age and gender crossing urban roads.

4 PEDESTRIANS CRASH PATTERNS THEN AND NOW

Pedestrian crashes have been understood as an urban problem primarily. Waller (29) reported injury patterns of pedestrian in US and few other selected countries in 1980 . Pedestrians fatalities represented 18% of the total highway fatalities, whereas same year Kuwait share of pedestrian fatality was 58% , Nigeria 36%, and Malaysia 22%. In contrast to this, Sweden reported 10%. In US, 72% of the pedestrian fatalities were in urban areas. Havard showed that age specific fatality rates per 100,000 inhabitants were highest between age 6 and 9 (29). A

Swedish study found similar results between age 3 and 8 (29). These details were not available for low income countries in 1980.

Waller also reported that the risk of crashes and injuries was highest in dense areas, however, risk of fatal and serious injuries was higher in low density areas (29). This finding has been confirmed by many other researchers thirty years later (30, 31). US data showed in 2007 approximately 73% of pedestrian fatalities occurred in urban areas, largely because of the greater number of pedestrian trips in urbanized areas (32). Similar patterns were observed almost three decades back and reported by Waller (29). Zegeer and Bushell (32) reported although fewer pedestrian fatalities occur in rural areas, pedestrians are more than 2.3 times more likely to die from a pedestrian crash in rural areas than in urban areas. This is because rural areas have higher vehicle speeds combined with fewer separated facilities for pedestrians, such as sidewalks, trails, and paths, compared to urban areas.

In the EU, the risk of being killed as a pedestrian is consistently lowest for children, with 3.4 deaths per million child population, about half that for adults under 50 with 7.5 deaths per million adult population. The greatest risks of being killed as a pedestrian are for people aged 50-64 and especially for those over 65 with 13 and 28 deaths per million population in the age group respectively.

For the EU as a whole, over the period 2011 to 2013, 69% of all pedestrian deaths occurred on urban roads (4, 33). Given the high level of urbanization in Europe and frequent interaction between pedestrians and motorized transport in cities and towns, such a figure is not unexpected. In the EU, another 27% of pedestrian deaths occur on rural roads and 4% on motorways. Pedestrians are legally not allowed to use motorways, so the ones killed might be vehicle users who have left their vehicles for some reason or workers in work zones, along with some individuals who entered the motorway on foot illegally. There is extensive evidence to show that more males than females are being killed in road collisions in Europe which is also the case for pedestrians, but to a lesser degree than for all road users (4).

Large proportion of pedestrian deaths are reported in urban areas in LMICs (3). Unlike North America and Western Europe, pedestrian and motorcyclist involvement in fatal crashes on rural highways is greater than that of other road users.[8] These highway crash patterns are similar to those observed in urban areas.

Some common patterns of pedestrian crashes were identified by Waller (29). These include: a small child darts into the road from between two cars or other obstacles on the road, clustering of fatally injured elderly pedestrians when they have to cross a road for essential shopping, higher proportion of pedestrian fatally injured with high blood alcohol levels. Hunter investigated pedestrian crashes in in 1996 (34). Some of the most frequent pedestrian crash types include dart-out in first half of the street (24%), intersection dash (13%), dart-out in second half of the street (10%), midblock dart (8%), walking along roadway (7.4%), and turning-vehicle crashes (5%). Similar patterns have been reported from China (35), Turkey(36), and Israel (37).

Prato, Gitelman (37) reviewed studies on pedestrian crash patterns in 2012 and reported that the main interest had shifted from analysing child pedestrian and elderly to patterns of pedestrian vehicle interaction. The most common factors used to characterize pedestrian accidents have been age, gender, intoxication of pedestrians by alcohol or drugs, location in urban residential areas, fault of pedestrians and drivers and type of vehicle involved. The study applied neural network technique to find out most recurring patterns in pedestrian crashes. The results showed 72 percent crashes in urban areas in Israel. Five distinct clusters were identified- pedestrian urban elderly, pedestrian two-wheel vehicles, pedestrian rural night, pedestrian youngsters night, pedestrian rural children. The study confirmed the patterns found earlier: (i) elderly pedestrians crossing on crosswalks in metropolitan areas, mostly far from intersections; (ii) pedestrians crossing suddenly or from hidden places and colliding with two-wheel vehicles on urban road sections; (iii) male pedestrians crossing at night and being hit by four-wheel vehicles on rural road sections; (iv) young male pedestrians crossing at night wide road sections in both urban and rural areas; (v) children and teenagers crossing road sections in small rural communities.

Recent studies have reported pedestrians facing high risk near bus stops in urban areas (38-40). Some new emerging patterns of pedestrian crashes which have not been reported in published studies include pedestrian fatalities on access control expressways in India, pedestrians waiting along the shoulder of a high-speed road to board buses.

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[8] Principles for development of safer rural highway systems for conditions prevailing in low and middle-income countries, https://www.icorsi.org/scientific-papers-international-sym

Overall, pedestrian death reduced in the US, EU countries and Australia as compared to LMICs. However, travel surveys from Australia, EU and US also show decrease in pedestrian trips at the same time. School active transport generally declined for males and older female children (19 and 20 percentage points per decade, respectively) between 1985 and 2003 and 2013 in Australia (41). Estimates from the UK suggest that the number of trips on foot per person fell by 20% between 1985/86 and 1997/99 (42). Stewart, Moudon (43) report that active travel to school in the U.S. have declined, from 47.7 percent in 1969 to 12.7 percent in 2009, while rates of students being driven to school in the family car have increased in mirrored proportions. According to US Department of Transportation's 2001 National Household Travel Survey only a small percentage of the population reported any walk trips during the sample day; about 84% listed no walk trips in their daily trip diary. A separate question on the number of walk trips made in the past week revealed that Americans on average take 3.8 walk trips per week (44). The Swedish national travel survey 2015–2016 shows that for all types of travel (business, work and study-related, service and shopping, leisure and other purposes) walking and cycling trips were only 27% of all trips.

Reduction in pedestrian trips is a matter of concern both from lack of active transport resulting in adverse impacts of health (45) and also the effectiveness of strategies which have been implemented for improving pedestrian safety.

5 SUGGESTED STRATEGIES – WHAT HAVE WE LEARNT

5.1 Speed control

Speed is an important factor affecting road accidents both in terms of accident occurrence and severity (46). It seems reasonably safe to assume that increased speed would mean that the accidents that have occurred would be more severe, if other factors (e.g., environment and vehicle design) remain the same. Large number of studies have shown this by both Newtonian physics and empirical data (47-50). Pedestrians, bicyclists and motorcyclists are more vulnerable to impact speeds as compared to vehicle occupants. For many years 30 km/h was considered the safe speed for pedestrians with less than 10 percent chance of fatal injury (51). A recent study analysed Swedish data and reported "the data indicates that fatal accidents (excluding runover accidents) are rare at mean travel speeds below 40 km/h, while severe injury accidents are quite frequent at mean speeds below 35 km/h but rare at mean travel speeds below 25 km/h (51). Therefore, the current speed policies (frequently 30 and 50 km/h speed limits in urban areas) might need revision."

We recall the details of the first reported pedestrian crash where the victim was hit at a speed of 4 mph (6.5 km/h) as reported by the witnesses. Current research shows impact of several other factors such as the vehicle design, impact surface properties, victim age etc. With the increase in the presence of elderly pedestrians on the road, perhaps there is a need to rethink urban speed limits.

5.2 Environmental factors

One of the earliest study on pedestrian crashes reported "Pedestrians are often asked to decide between the easy and quick way to safe way" (29). Repeated empirical studies have shown that pedestrians chose the former. Often grade separation between pedestrian and vehicular movement has been suggested in urban area as well as on highways in LMICs to improve pedestrian safety. This involves constructing foot over bridges or underpasses. Empirical studies have been carried out in different regions and settings to understand pedestrian behaviour at zebra crossings at grade, foot over bridges and under passes. Cantillo, Arellana (52) reviewed a large number of studies on pedestrian crossing behaviour in urban environments and concluded pedestrian crossing behaviour is affected by socioeconomics (e.g. age, gender), traffic characteristics (e.g. speed and flow), the road environment (e.g. crossing walking distance, presence of traffic/pedestrian control devices and signals, presence of crossing facilities), and subjective factors (e.g. perceptions and attitudes). This study found that additional walking distance to cross the road over the pedestrian bridge is less appealing than using a zebra when available; even if it is less attractive when compared to crossing directly somewhere on the road. This effect could be explained by the additional effort needed to climb and descend stairs in a pedestrian bridge. Cantillo, Arellana (52)reported that "the respondents state a general dislike to walk additional distances to cross the street using the 'safer' alternatives (i.e. pedestrian bridge and crosswalk at the intersection). To some extent, respondents prefer to walk towards an intersection rather than going towards a pedestrian bridge to cross." Model results suggest that pedestrians are willing to take less risk when traveling with a minor. The presence of a minor increases the probability of using safer crossings; in fact, the direct crossing alternative became less attractive. The probability of being delayed also has an important effect on the decision. Pedestrians are more prone to use the alternative route involving less walking distance (crossing directly). The authors concluded that "…a largest distance diminishes the probability for the individual to choose safer alternatives. It is observed that

this effect is more relevant for the case of the pedestrian bridge than for the signal crossing, which may be explained by the extra effort involved in climbing stairs. This finding suggests that pedestrian bridges should only be considered in extreme cases, as they seem to be a non-effective crossing facility. To solve conflicts between traffic and pedestrian flows it is preferable to propose at level signalized crossings along with underpass/overpass roads, when necessary."

The conflict of pedestrian and vehicular traffic on high speed roads observed in LMICs and also the presence of pedestrians along the high speed roads require further research and understanding for a successful strategy.

5.3 Training and education

Several detailed studies have repeatedly highlighted the limitation of school education and training programs, yet a 2004 report prepared by EU experts (15) noted "Traffic and pedestrian safety education were a part of the school programs for children (ongoing throughout their school years) in some of these countries, and government-sponsored marketing and safety education campaigns were a high priority. In countries like England, traffic safety campaigns are unified under a single national brand for numerous safety focus areas." Pucher and Dijkstra (53) examined safety trends in both the Netherlands and Germany and came to a similar conclusion; both of these nations provide very successful examples that strict traffic law enforcement and rigorous traffic education for drivers and pedestrians can increase pedestrian and bicycle safety dramatically. The report also mentioned long list of measures which were implemented to create safe infrastructure in these countries, active traffic calming measures introduced to control speeds of vehicular traffic. Separate impact of different measures on safety outcome is not discussed and it is difficult to make a case for prioritizing different measures as required by most LMICs due to limited resources. In fact, education and training is often considered as a low hanging fruit requiring less resources and becomes the priority for many national strategies (32).

There are few attempts to add qualifiers to the success of training strategies and therefore the importance of education and training programs.[9] The WHO manual on pedestrian safety mentions "Changing the attitudes and behaviour of drivers and pedestrians is a complex, long-term undertaking that requires a variety of interventions to be implemented. Measures commonly used to raise awareness and modify behaviour are discussed in the following sections. These measures are most effective when implemented alongside other measures described in this module such as speed management and reducing pedestrian exposure to vehicular traffic".[10]

The limitations of human cognitive skills and capability of judging risk was established almost fifty years back (7, 8, 14). Recent studies have mentioned the limitations and effectiveness of education programs. However, researchers and policy makers continue to include education and training as a possible strategy to reduce pedestrian crashes.

6 CHALLENGES

Much progress has been made in understanding pedestrian behaviour and risk that pedestrians are exposed to in traffic, however not enough success has been achieved in reducing pedestrian crashes both in motorized as well as less motorized countries. Motorized countries continue to report high proportion of pedestrian fatalities in urban areas. These patterns have not changed since 1970s. There is a large body of research available on understanding pedestrian behaviour and exposure to risk from these countries. Researchers made valuable contribution in documenting characteristics of pedestrians, and location of pedestrian crashes in urban settings. More importantly, limitations of cognitive skills of children pedestrian and elderly pedestrians were documented. Since 1990 we find similar research studies coming from less motorized countries also. Studies from China, India, Israel show similar results of gap acceptance by pedestrians while crossing the road, reluctance to use grade separated pedestrian facilities. There seems to be little difference in cognitive skills of pedestrians across different regions of the world. There are differences in location of pedestrian crashes in less motorized countries as compared to motorized countries. Pedestrian are fatally injured on highways in less motorized countries in much higher proportion as compared to motorized countries. Presence of pedestrians is much higher on high speed road in less motorized countries.

New research is required to make cities safer for pedestrians in all countries- revisiting current speed limits, lower speed limits, and active measures to control speeds. There is consensus on urban design principles which can lead to safer cities - higher mixed land use density - the condition already present in less motorized

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[9] Pedestrian safety: a road safety manual for decision-makers ..., https://www.who.int/roadsafety/projects/manuals/pedestrian/en/

[10] ibid.

countries. New research is required to get insights from these settings and understanding of barriers to implementation of these principles.

Less motorized countries have to make greater efforts to understand the requirements of pedestrians along high-speed roads and develop new standards for ensuring pedestrian safety in such locations. Despite continuous efforts of over more than a century, the first reported accident of pedestrian continues to pose challenges to the researchers.

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