

Pedestrian Crash Trends and Potential Countermeasures from Around the World

**By: Charles V. Zegeer and Max Bushell
University of North Carolina
Highway Safety Research Center
730 MLK, Jr. Blvd.
Chapel Hill, N.C. 27599-3430**

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Abstract: As automobile transportation continues to increase around the world, bicyclists, pedestrians, and motorcyclists, also known as Vulnerable Road Users (VRU), will become more susceptible to traffic crashes, especially in countries where traffic laws are poorly enforced. Many countries, however, are employing innovative strategies to ensure that road users can more safely navigate the urban landscape. While bicyclists and motorcyclists are important road users, this paper will focus on pedestrian crash problems and solutions. Pedestrians are most at risk in urban areas due in part to the large amount of pedestrian and vehicle activity in urban areas. With this in mind, designing safe, accessible, and comprehensive facilities for pedestrians is vital to reducing pedestrian crashes. This paper will provide some insight into the magnitude of the pedestrian crash problem around the world, and will offer some lessons learned from several countries, particularly in Europe and the U.S., for improving pedestrian safety. Beginning with pedestrian safety statistics at the global, regional, and national levels, this paper will address potential countermeasures and strategies for improving pedestrian safety from an international perspective.

Keywords: Pedestrian Safety; Vulnerable Road Users; International; Pedestrians; Pedestrian Crash Trends; Pedestrian Crash Countermeasures.

INTRODUCTION

As automobile transportation continues to increase around the world, bicyclists, pedestrians, and motorcyclists, also known as Vulnerable Road Users (VRUs), will become more susceptible to traffic crashes, especially in countries where traffic laws are poorly enforced. In particular, nations such as India and China, which have burgeoning populations as well as a growing middle class, will see a substantial increase in traffic injuries and fatalities if strategies are not found to ensure the safety of Vulnerable Road Users. Many countries, however, are employing innovative strategies to ensure that road users can more safely navigate the urban landscape. While bicyclists and motorcyclists are important road users, this paper will focus on pedestrian crash problems and solutions.

Pedestrians are most at risk in urban areas due in part to the large amount of pedestrian and vehicle activity in urban areas. No matter if the primary mode of transportation is the automobile, bicycle, or public transit; people must walk as a part of the trip, such as from their home to the store or place of employment, and/or to the transit stop. With this in mind, designing safe, accessible, and comprehensive facilities for pedestrians is vital to reducing pedestrian crashes. This paper will provide some insight into the magnitude of the pedestrian crash problem around the world, and will offer some lessons learned from several countries, particularly in Europe and the U.S., for improving pedestrian safety. Beginning with pedestrian safety statistics at the global, regional, and national levels, this paper will address potential countermeasures and strategies for improving pedestrian safety from an international perspective.

MAGNITUDE OF THE PROBLEM

According to the Global Status Report on Road Safety: Time for Action, over 1.2 million motor vehicle-related deaths occur per year, and between 20 and 50 million people are injured in crashes annually (2009). To put this in perspective, these fatality rates are comparable to deaths from all communicable disease, which speaks to the necessity of creating safe environments for road users and particularly pedestrians. Of those that are killed on roads across the globe, about half of the fatalities constitute vulnerable road users (WHO 2009).

Even more distressing is the fact that children are particularly at risk in road crashes. Approximately 21% of road traffic deaths involve children, yielding an average of 720 child deaths related to road traffic crashes per day. These crashes are also the leading cause of child disability (WHO & United Nations Children's Fund 2008). Judging by these astonishing statistics, the topic of pedestrian safety is certainly pertinent for planners, engineers, and legislators around the world.

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 (Naci, Chisholm, & Baker 2009). While many countries do have strategies to mitigate pedestrian crashes, it is clear that many low-income countries are lacking in pedestrian safety amenities.

Figure 1 displays the distribution of road traffic fatalities by road user group, differentiating between low-income, middle-income, and high-income countries. This graph clearly illustrates that with greater wealth comes greater motorization and that fatal pedestrian crashes are higher in low-income countries, despite the fact that overall fatal motor vehicle crashes are higher in high-income countries. In order to further refine this analysis, we examine the distribution of crashes by country.

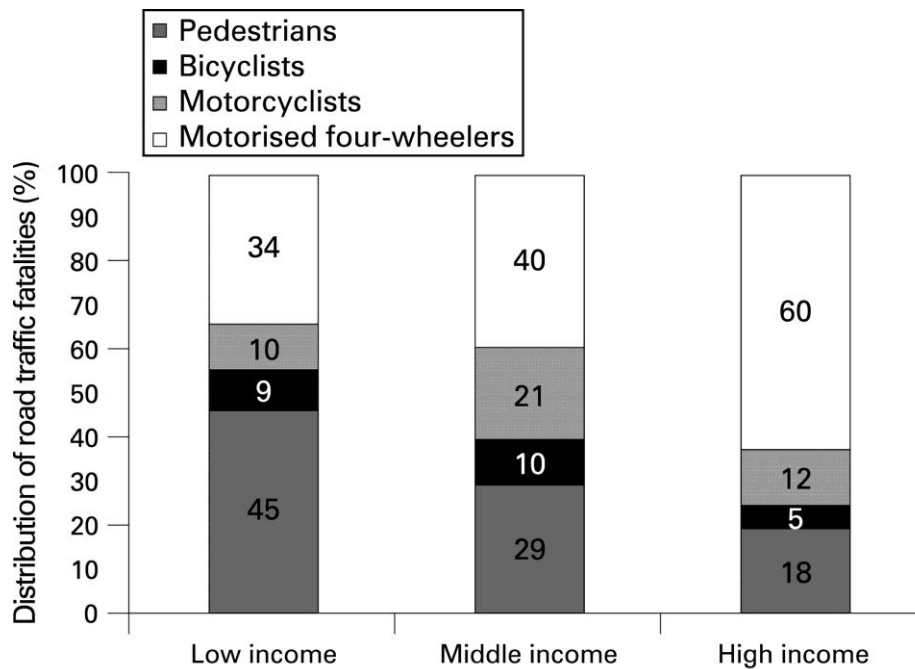


Figure 1: Distribution of Road Traffic Fatalities by Road User Group (Naci et al. 2009)

As expected, more populous countries will have higher absolute numbers of pedestrian deaths with China, India, and the Russian Federation in first, second, and third in that category, respectively.

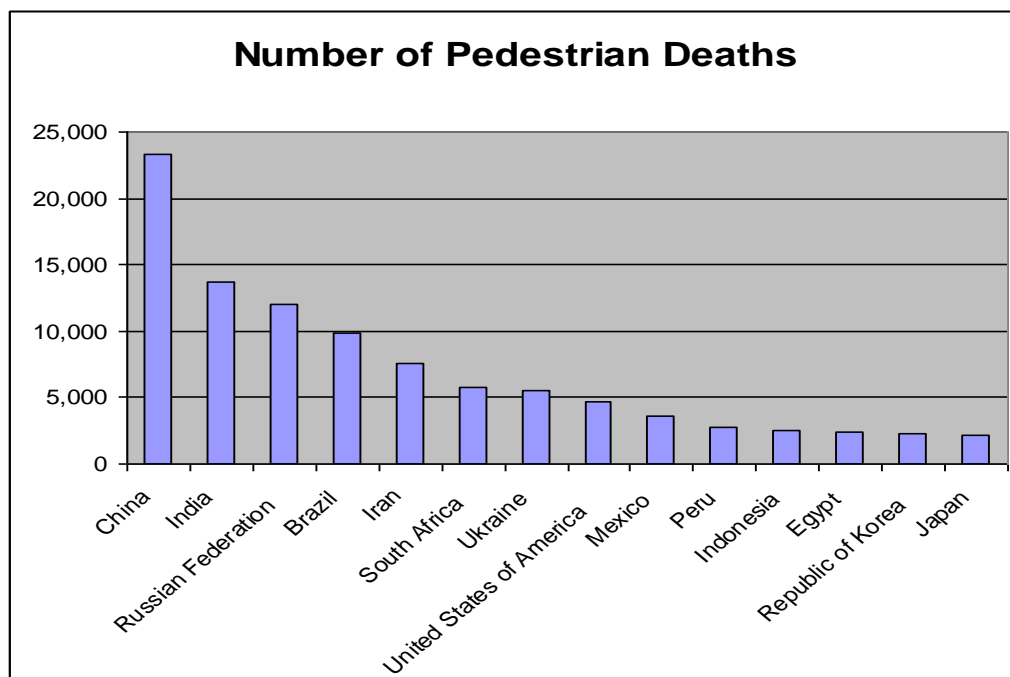


Figure 2: Number of Pedestrian Deaths by Country (WHO 2009)

Making decisions based on the absolute numbers of pedestrian deaths (see Figure 2), however, does not necessarily indicate where pedestrians are most in danger. By normalizing the number of pedestrian fatalities relative to all traffic fatalities, a much clearer picture is generated of where pedestrian safety is a

huge concern. The results are somewhat surprising but support the previous conclusion that in lower-income countries, pedestrian fatalities constitute a greater portion of all fatalities than in high-income countries. Figure 3 is a graphic representation of this information.

Not surprisingly, no high income country is present in the graph of pedestrian death as a percent of total traffic deaths. It is surprising; however, that 78% of overall traffic fatalities in Peru are pedestrians, while Mozambique and El Salvador are both above 60%. With such large percentages of pedestrian deaths, this might be an indication that low-income countries are not able to adequately provide adequate pedestrian facilities for crossing or walking along roadways.

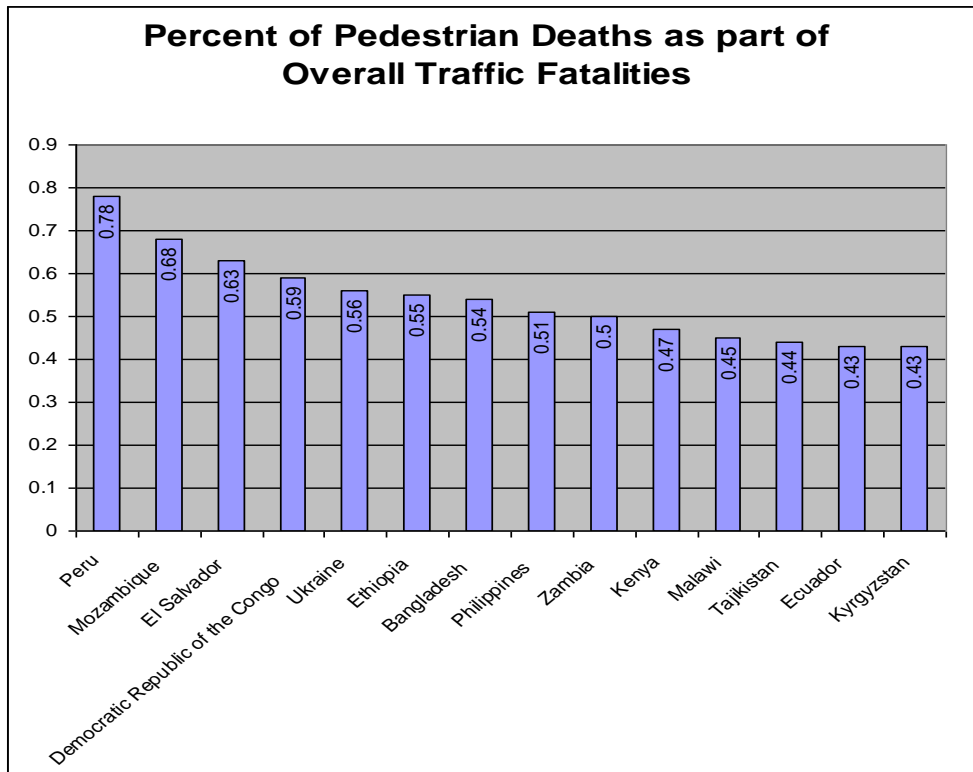


Figure 3. Percentage of Pedestrian Deaths as part of Overall Traffic Fatalities in Some Low Income Countries (WHO 2009)

With these statistics in mind introducing the problem of pedestrian safety on a worldwide, regional, and national scale, the following is a description of pedestrian crash characteristics and trends primarily from the U.S., where pedestrian fatalities constitute approximately 13% of all traffic deaths (FARS 2008). Using the U.S. as a model can help to understand the types of countermeasures that may be effective in reducing the risk of pedestrian crashes and related injuries and deaths. Pedestrian fatal crash characteristics and trends will also be examined for European nations as well as other countries around the world.

PEDESTRIAN CRASH CHARACTERISTICS AND TRENDS

PEDESTRIANS MOST AT RISK

Pedestrian fatal crash trends continue to show greater problems for children and older adult pedestrians. According to Chang (2008), between 1997 and 2006, children under age 15 accounted for about 21 percent of the U.S. population, and accounted for 23 percent of fatal pedestrian crashes. According to Fatality Analysis Reporting System (FARS), children 15 years old or less account for 8 percent of pedestrian fatalities (2008). Pedestrians over age 70 made up about 9 percent of the population but 16 percent of pedestrian deaths in 2007 (Chang 2008).

This trend is not specific to the United States. In the Netherlands almost 50% of the total number of killed pedestrians are over 65 years old, and children under 14 constitute the next most vulnerable group (Hummel 1998). In the state of Andhra Pradesh, India, similar trends have been observed with fatal crashes increasing by 362% and 714% for under-10 year-olds and over-64 year-olds between 2001 and 2006, respectively (Ponnaluri & Nagar 2010). In addition, research in England supports the conclusion that children and older adult pedestrians are most vulnerable (Davies 1999).

In the U.S., males of all ages account for 70 percent of pedestrian deaths and the pedestrian fatality rate was 2.19 (deaths per 100,000 population) for males compared to 0.91 for females (Clifton & Livi 2005). While it has been hypothesized that males may walk more than females, National Household Travel National Household Transportation Survey (NHTS) data from 2001 found that the number of walking trips is roughly similar for males and females. However, there is some evidence that males may in general walk further per trip on average, which would increase their exposure to traffic (compared to females) and partly account for this difference (Clifton & Livi, 2005). Although there has been speculation that males may tend to walk in more dangerous locations or exhibit riskier behavior than females, little information is available to confirm or refute these arguments. There is also evidence that immigrants and minority populations (e.g., Hispanic and African American pedestrians) are over-represented in pedestrian crashes, compared to the size of their population (Chang 2008; NHTSA 2008b; U.S. Census Bureau 2006). Evidence from Peru, at least in terms of children in low income areas, supports the fact that male pedestrians are more likely than females to be involved in a crash (Donroe et al. 2009).

PEDESTRIANS WITH DISABILITIES

Individuals with disabilities may include individuals with mobility disabilities, using wheelchairs, walkers or canes, individuals who are blind or who have impaired vision, individuals with cognitive impairments from developmental disabilities, stroke or brain injury, and others. Individuals with disabilities may be the most vulnerable users of transportation facilities. Many are unable to drive and are dependent on public transit and pedestrian facilities to travel to work and to family, shopping, medical, and recreation destinations.

The safety of persons with disabilities as road users is often dependent on the design of sidewalks and street crossings for usability and safety. Many people change their routes, or use para-transit services, or don't travel at all in response to poor roadway facilities. Safety of persons with disabilities is an essential part of improving roadway safety. In Australia, the safety of persons with disabilities is explicitly addressed in their traffic engineering guide, Austroads (Cairney 1999).

TYPES OF AREAS WITH HIGH PEDESTRIAN CRASH RATES

In terms of the types of areas and locations where fatal pedestrian crashes occur in the United States, in 2007 approximately 73 percent of pedestrian fatalities occurred in urban areas, largely because of the

greater number of pedestrian trips in urbanized areas (NHTSA, 2008a). Research in Europe shows a similar trend with most crash fatalities to pedestrians and cyclists occurring in urban areas (SafetyNet 2009). 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 (Mueller, 1988). 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. Also, pedestrian crashes in rural areas are generally located further from quality emergency care, so more time is needed for Emergency Services to arrive at the scene of a crash (Mueller, 1988).

PEDESTRIAN CRASH TYPES AND BEHAVIORS

Specific pedestrian crash categories or types were defined in the 1970's in a U.S. study to better define the sequence of events and actions by pedestrians and motorists which led to the crashes and for which countermeasures could be developed. In 1996, Hunter et al. applied these definitions to approximately 5,000 pedestrian crashes (and 3,000 bicycle crashes) from six states to update what is known about pedestrian crash types and the roadway conditions where they occur. Some of the most frequent pedestrian crash types include dart-out in first half of the street (24 percent), intersection dash (13 percent), dart-out in second half of the street (10 percent), midblock dart (8 percent), walking along roadway (7.4 percent), and turning-vehicle crashes (5 percent). Computer software and accompanying guide called PBCAT was developed to allow the user to classify (type) their pedestrian (and/or bicycle) crashes and then have a link to corresponding countermeasures. (Harkey et al. 2006).

In examining two junctions in Beijing, China, Chen, Meng, and Wang (2009) found similar crash types including turning-vehicle crashes and midblock crossing crashes. The authors recommend including better facilities for pedestrians and enforcing pedestrian traffic laws as methods to reduce pedestrian crashes at these intersections (Chen, Meng, & Wang 2009).

Also, although it is not a specific crash type, approximately two-thirds of pedestrian fatalities occur at night or under low-light conditions. The reduced ability of a driver to see a pedestrian at night is a contributing factor to several of the pedestrian crash types listed above, such as the "walking along roadway" crash type. It should also be mentioned that the use of cell phones and other distractions, use of alcohol or drugs by drivers and/or pedestrians, and other behaviors can also increase the risks of a pedestrian crash.

VEHICLE SPEEDING

Higher vehicle speeds can increase the risks to pedestrians in several ways. First, vehicle stopping distance increases substantially as vehicle speed increases. Second, the risk of a pedestrian death from a collision with a motor vehicle is much greater for higher vehicle speeds. According to a 1987 study by the U.K. Department of Transport, the probability of pedestrian death is 85 percent when the striking vehicle is traveling at 40 mph. This probability drops to about 45 percent for a 30 mph impact and drops further to 5 percent if the vehicle is traveling at 20 mph at impact. The percent of pedestrian injuries is also shown as a function of vehicle speed at the point of impact (see Figure 4).

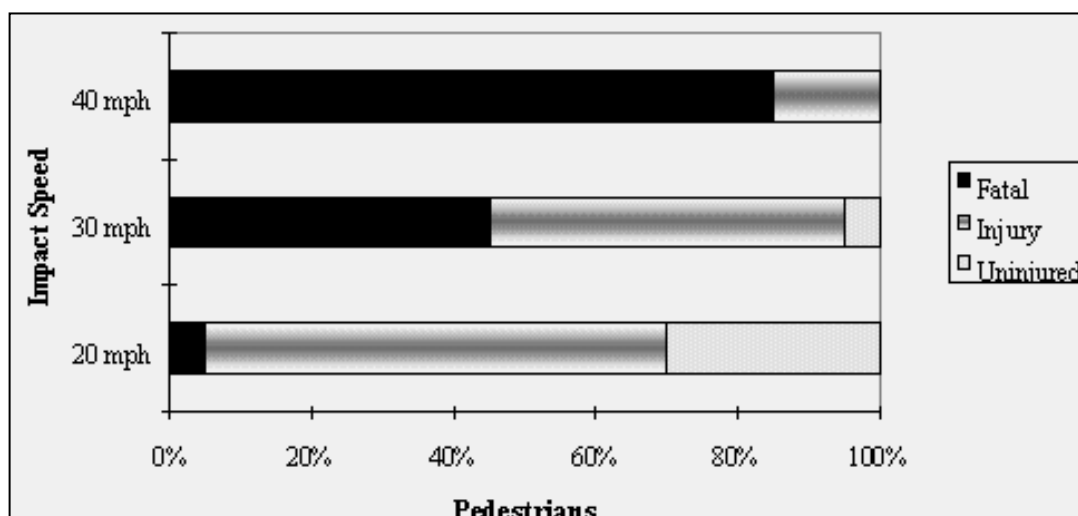


Figure 4: Pedestrian injury severity based on vehicle speed (Source: Traffic Advisory Unit 1993).

ROADWAY FEATURES RELATED TO PEDESTRIAN CRASHES

Based on decades of pedestrian safety research, it is clear that there are many geometric, traffic control, and site characteristics that affect pedestrian safety. For example, Harwood et al. (2008) developed crash predictive models for signalized intersections in Toronto, Canada and Charlotte, N.C. Factors found to be associated with a higher likelihood of pedestrian crashes included higher traffic volume, greater volume of crossing pedestrians, ratio of the average daily traffic (ADT) in the minor road relative to the major road, maximum number of lanes to cross (considering the presence of refuge islands), presence of bus stops within 300m of the intersection, presence of public or private schools within 300m, and number of alcohol establishments within 300m. Chen, Meng, and Wang (2009), in their research in Beijing, China, found that similar factors, including the presence of bus stops and high volumes of crossing pedestrians, lead to increased crash risks for pedestrians.

For unsignalized pedestrian crossings, Zegeer et al. (2005) found that fatal pedestrian crash risk increased for increased traffic and pedestrian exposure, greater number of lanes, lack of a raised median or median island (for multi-lane roads), and for older pedestrians (65 years and older). The presence of a marked crosswalk alone (without other substantial treatments) was associated with higher pedestrian crashes when compared to an unmarked crosswalk, under certain conditions; e.g., multi-lane roads having high traffic volumes (greater than about 12,000 vehicles per day). For these higher-volume, multi-lane road crossings, the authors recommend installing more substantial improvements than marked crosswalks alone, such as raised median islands, traffic and pedestrian signals (if warranted), enhanced nighttime lighting, reducing the number of lanes, etc.

Pedestrian crashes involving “walking along roadway” were analyzed in a case-controlled 2002 study by McMahon et al., in terms of the roadway and socio-economic factors. Physical roadway features found to be associated with significantly higher pedestrian crash risk included higher traffic volume, higher speed limit, lack of a wide grassy walkable area, and absence of sidewalks. Higher risks of such pedestrian crashes were also related to high levels of unemployment, older housing, lower proportion of families within neighborhoods, and more single-parent households.

SUMMARY OF PEDESTRIAN CRASH FACTORS

There are many factors that can affect the risk and/or severity of a pedestrian crash and the discussion above mentions only a few of the relevant factors and issues. These pedestrian-related factors relate to the pedestrian, driver, vehicle, roadway, and/or to a range of social/demographic factors that affect the amount and manner in which people travel. An overview of some of these key factors is given in figure 5, that was part of a recent Pedestrian Safety Program Strategic Plan presented to the U.S. Federal Highway Administration (Zegeer et al., 2010).

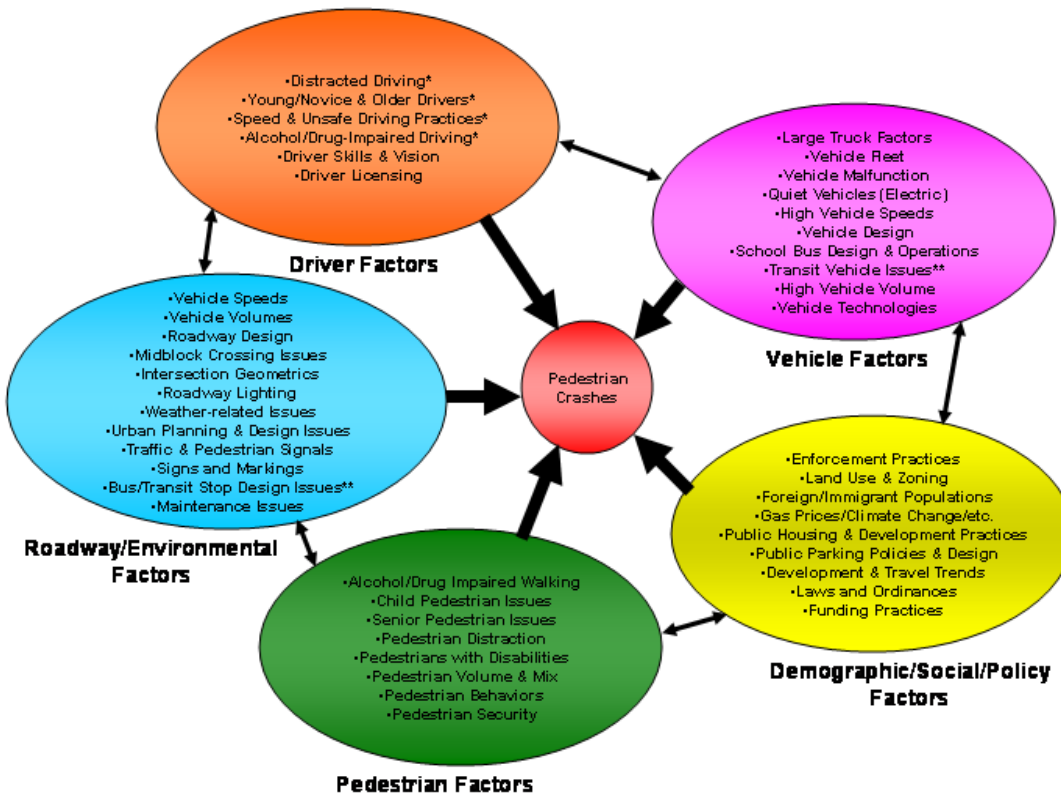


Figure 5. Illustration of factors associated with pedestrian crash risk and/or severity.

LESSONS LEARNED FROM EUROPE

NORTHERN EUROPE

A February, 2010 report entitled “Pedestrian and Bicyclist Safety and Mobility in Europe” was written by a team of 12 transportation professionals from the U.S. based on a technical tour (scan) of practices and policies from five countries: Sweden, Denmark, Germany, Switzerland, and the United Kingdom (Fisher et al., 2010). The purpose of this scan was to identify and assess effective approaches for improving pedestrian and bicyclist safety and mobility. Although the scan focused on identifying strategies that could be applied to the U.S., its authors noted that many of the “lessons learned” from this review and analysis could have applications to other countries throughout the world.

The following is a brief summary of some of the report’s key recommendations regarding methods to improve pedestrian safety, based on experiences from the five European countries cited above. Many general factors were found to contribute to safer conditions for walking (and bicycling). For example, a street hierarchy that gives the highest priority to walking, bicycling, and public transit is an important

factor. Another key factor is that some of these countries have political and public support for favorable walking and bicycling conditions. These countries also have urban land use policies, parking and congestion pricing, and street planning and design practices that support safer travel by foot (or bicycle) (Fisher et al. 2010). Other Federal Highway Administration research corroborates these conclusions, specifically with respect to Sweden and the United Kingdom (Ekman & Hyden 1999, Davies 1999).

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. Routine photo enforcement of motorist traffic laws (to obey the speed limit, and avoid red light running) was common in each country visited (Fisher et al. 2010). Pucher and Dijkstra (2000) 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.

Roadway design and engineering treatments were implemented to address the safety needs of pedestrians. These included the use of low-speed street designs (called home zones which are designed so motorists must travel at near walking speeds), well-designed sidewalks and walkways, short street crossings (where raised crossing islands are common), raised crosswalks at unsignalized pedestrian crossings (at roundabouts, midblock crossings, and traffic-calmed streets), and pedestrian signals which are designed to separate pedestrian and vehicle movements (and to provide for more accessibility for pedestrians with disabilities). Passive detection of pedestrians at crosswalks is used instead of requiring pedestrians to push a button to get a WALK signal (Fisher et al. 2010). These types of treatments are particularly helpful in maintaining low crash rates in cases where walking levels are actually decreasing, as is the case in Denmark (Jensen 1999).

Each of the scan four countries also had promotional programs and activities to encourage and enable more walking (and bicycling). These included well-marked signing and detailed maps on walking routes, web-based walking route planning for pathways (inviting tourists and other users), public-health sponsored wellness and physical activity programs, and personalized travel planning for walking trips. The scan agencies typically develop clear goals for increasing the amount of walking (and bicycling) as well as goals for reducing related crashes and injuries. A performance monitoring and reporting system is regularly used to measure progress toward meeting the stated national goals on the amount of walking and reduction in pedestrian crashes (Fisher et al. 2010).

SOUTHERN EUROPE

While Europe as a whole is often touted as a paragon of multimodal planning with special emphasis on pedestrians (and bicycles), this is not always the case on a country by country basis. In fact, many countries, located primarily in what the European Union (EU) calls the “SEC Belt” or the Southern, Eastern, and Central Europe area, have much higher crash levels than Northern European countries (Avenoso & Beckmann 2005). While the levels of walking are high throughout Europe, they tend to be highest in Northern Europe, in particular in Great Britain and the Netherlands, possibly as a result of their policies towards non-motorized transportation. These policies have also lead to an increase in the perceived safety of walking and bicycling in these countries (SafetyNet 2009).

In a paper on pedestrian safety in SEC Belt countries, Avenoso and Beckmann (2005) provide a series of recommendations on how to mitigate deaths of Vulnerable Road Users in general, and pedestrian deaths in particular. Enforcement measures, most notably raising awareness and implementing more stringent speed limit, helmet, and blood alcohol restrictions, are among the most important recommendations, while education efforts are also highlighted as a primary area for improvement. In addition, infrastructure

is also discussed with a focus on creating more forgiving highways (e.g., free of obstacles); instituting a road hierarchy system, which is lacking in many of the SEC Belt countries; and evaluating and installing pedestrian crossings, which are often nonexistent. These improvements, coupled with the successful implementation of enforcement and education efforts, can have a profound impact on pedestrian crashes. By using the Northern (and Western) European paradigm for pedestrian safety in SEC countries, the EU hopes to reduce pedestrian death rates in the EU overall. In particular, countries such as Denmark, the Netherlands, Norway, and Germany offer successful examples of how engineering and policy changes can improve pedestrian safety (Avenoso & Beckman 2005).

LESSONS LEARNED FROM OTHER REGIONS

AUSTRALIA

In Australia, the crash problem roughly resembles the situation in the United States and in England, at least in terms of crash fatality rates for pedestrians (Cairney 1999). Their policies on signage, crosswalks, and signals are also fairly similar to those of the United States. In terms of medians and pedestrian refuge areas, however, Australian roads are often designed to very generous standards, facilitating the inclusion of medians and refuge islands at a later date. In addition to generous road construction standards, many Australian states and territories have begun to use innovative crosswalk designs and have also included roundabouts in street design (Cairney 1999).

Australia is also innovating in the area of traffic education. By emphasizing traffic safety in early education centers and primary schools, children learn the rules of the road at a young age. Safe routes to school programs supplement these traffic safety courses, while secondary education institutions almost always offer further pedestrian safety training courses (Cairney 1999). In terms of enforcement, however, pedestrian regulations are often a low priority for police in Australia and have “generally not attracted sustained effort on a large scale by police forces...” (Cairney 1999, p. 31).

CHINA

The growth of the economy in China has led to an exponential increase in the middle class, which has, in turn, increased the levels of urbanization. With these changes comes an increasingly chaotic and congested traffic system, which can often lead to pedestrian and vehicle conflicts. In a study conducted in Beijing, Chen, Meng, and Wang (2009) evaluated two interchanges, identified pedestrian (and bicycle) safety issues, suggested countermeasures, and then evaluated their impact. They found that rule violation is high in both areas for pedestrians, bicyclists, and automobiles and that road design is not coordinated with bus stops and bicycle lanes.

In terms of environmental countermeasures, crosswalk striping, bus stop redesign, pedestrian barrier construction, increased illumination, and new signals were introduced at one or the other intersection. While some of these measures did not show drastic safety improvements, the overall reduction in crash frequency demonstrates the effectiveness of these countermeasures. The authors state that with reasonable design solutions for pedestrians and attention to VRU safety, the risks for pedestrians can be reduced in Beijing (Chen, Meng, & Wang 2009).

INDIA

India, like China, has experienced rapid economic growth, which has had the effect of increasing motorization and urbanization across the country. For instance in Hyderabad, the Charminar, an ancient monument, is located in the center of a busy thoroughfare and has become badly damaged by air pollution as a result of the increasing traffic around the building. City officials, over the past 10 years, began the planning process for pedestrianizing the area, both increasing its safety for VRUs and preserving an important historical building. The example of Hyderabad illustrates that cooperation between city

government, private business, and Non-Governmental Organizations (NGOs) can create solutions to the problems of air and noise pollution resulting from increased motorization and also create pedestrian-friendly environments (ITDP 2009).

In the state of Andhra Pradesh (AP), VRU crashes were the highest in India in 2006 and 2007. Ponnaluri and Nagar (2010) argue that despite investment in infrastructure and the development of policy towards preventing fatal pedestrian crashes, little was actually done on the ground to reduce crash frequencies. They highlight that in addition to improving road infrastructure and requiring amenities for pedestrians on new roads, it is important to regulate the operation of vehicles, and educate both drivers and pedestrians to achieve significant crash reductions. This study is one of the very few studies on VRU safety in India and highlights the need for further research, while also illustrating the high risks for pedestrians in Andhra Pradesh (Ponnaluri and Nagar 2010).

Judging by these pedestrian safety initiatives and research, it seems that the safety of Vulnerable Road Users is becoming a more important issue in some low income countries, but may also only be considered as a secondary concern following the mobility of automobiles in some instances.

KEY TRENDS

More highly industrialized nations such as the United States, Canada, Australia, and those in Europe have made progress in pedestrian safety in recent years, although future advancements certainly need to continue in some of these countries. Other lower-income nations, (e.g. China and India) are experiencing growth in terms of economic development and motorization and are also beginning to address pedestrians' safety needs to a larger extent than in the past.

One key trend, which is nearly ubiquitous across countries in the "SEC Belt" and in India, is the lack of adequate traffic safety education, both for drivers and pedestrians (Avenoso & Beckman 2005, Ponnaluri & Nagar 2010). In many of these countries, road safety training is available in schools, but doubts about the quality and frequency of this type of teaching are still present. Driver education is also limited. This problem was highlighted in Australia as well (Cairney 1999).

Another important area, which requires attention in many countries, is enforcement. With stricter penalties for traffic violations primarily for vehicles, massive gains in pedestrian and other Vulnerable Road Users' safety can be realized (Avenoso & Beckmann 2005). As developing countries continue to advance, enforcement will become even more important.

Engineering solutions can also be very successful in mitigating high pedestrian crash levels. Research on improving safety in Beijing, China concludes with the need to implement new signage, signals, and engineering measures, while one recommendation for "SEC Belt" countries is to improve traffic calming measures (Chen, Meng, & Wang 2009, Avenoso & Beckman 2005).

PROPOSED PEDESTRIAN STRATEGIES

Based on a review of a variety of research results and studies from around the world (including the lessons learned from Europe as given above), there is evidence that there are many types of specific safety improvements that can potentially improve pedestrian safety, depending on the country, city, and/or roadway situation. The following is not meant to be a complete compilation of all possible safety improvements, but a list of broad strategies or approaches compiled by the authors, that are believed to have the greatest potential for reducing pedestrian crashes, injuries, and deaths. Certainly, for many of

these strategies it is necessary to have adequate funding and other resources, support from government and various stakeholder groups, and political will at the federal, regional, and local levels.

1. Provide Pedestrian-Friendly Geometric Guidelines

If a country is really serious about reducing pedestrian fatalities, the highway infrastructure and facilities for pedestrians must be handled appropriately. Guidelines should strongly encourage that a “Complete Streets” approach be used for all new roads and for retrofits to existing roads. Such streets could include sidewalks or walkways, better street connectivity for all road users, tighter intersection turning radii, bicycle facilities, and use of 2-lane streets whenever possible (i.e., limiting the construction of the wide arterial streets).

Pedestrians, particularly children, older pedestrians, and those with disabilities, should not have to travel in the street because there is no sidewalk, or because there is no curb ramp to get to the sidewalk. Pedestrian facilities should include well-designed sidewalks, curb ramps at all crosswalks, appropriate cross slopes and proper driveway designs. Particular attention should be focused on facilities near bus stops and transit stations. Raised crosswalks may be appropriate for midblock and roundabout crossing locations. Providing intersection crossing islands at the intersection of arterial streets can reduce pedestrian exposure time in the street.

Some of the geometric treatments reported in the safety literature to significantly reduce various pedestrian crash types include converting unsignalized intersections to roundabouts, installing pedestrian overpasses/underpasses, introducing raised medians or raised pedestrian crossings (refuge islands), furnishing sidewalks, providing paved shoulders (of at least 4 feet), and narrowing the roadway cross section from four lanes to three lanes (i.e., one through lane in each direction plus a center turn lane).

Improved design guidance for pedestrians and other road users should be promoted for new roadways and also for retro-fitting existing roads where feasible. In cases where geometric guidelines are revised to be more pedestrian friendly, an aggressive campaign may be needed to market the new Guide so it becomes a routine part of the engineer’s design work.

2. Implement Effective Traffic Control and Other Pedestrian Safety Treatments

In spite of many years of research and the development of guidelines for signs, signals, and markings by various countries, there are still many situations where pedestrians need assistance related to traffic control devices. Especially in the case of disabled pedestrians, accessible pedestrian signals should be included in street design guidelines. In addition, accessible pedestrian facilities around transit areas are also important.

Although some jurisdictions around the world do a good job of trying to balance the needs of pedestrians with the needs of motorists, this is often not the case. More needs to be done to encourage officials to provide for the safety needs of pedestrians, particularly at signalized intersections and multi-lane (unsignalized) pedestrian crossings.

Numerous traffic signal-related measures have been found to significantly reduce pedestrian crashes. These include improving signal timing and implementing a leading pedestrian interval at some locations (to give pedestrians a “head start” at the start of each signal phase before motorists get the green light). Other potential safety improvements include removing unwarranted signals and protected only left-turn phasing (to reduce the conflict between left-turning motorists and crossing pedestrians).

In addition, certain types of signs, markings, and operational countermeasures can reduce pedestrian crashes. These include adding intersection lighting and lighting along roadway sections, and improving

pavement friction; both of which can reduce vehicle stopping distances. Pedestrian safety can also be enhanced by prohibiting right-turn-on-red at intersections as well as restricting parking near intersections.

It should be understood that not all of these countermeasures are needed or even appropriate at all locations. Each countermeasure needs to be chosen to fit the types of pedestrian crash/safety problems and site conditions. Examples of pedestrian crash reductions from some of these treatments are given by Harkey et al. (2008).

3. Expand Funding and Implementation of Safe Routes to School Programs and Safety Education Programs

Nationally-based Safe Routes to School (SRTS) programs began in Denmark, England, and other European Countries in the 1980s and spread to the U.S. and other countries in the 1990s. The current SRTS legislation in the U.S. provides \$612 million to the states to distribute to communities for providing safer child travel to school by bike or on foot. While this is certainly landmark legislation by the U.S. Congress in an attempt to increase the percent of school trips by bicycling or walking and to also improve safety for the school trip, this amount of funding, after full implementation, is estimated to address the needs of only 7% of elementary and middle schools in the U.S. SRTS programs are fundamental for the safety of children around the world and should be advanced as much as possible.

Pedestrian (and bicycle) safety education has been taught sporadically or not at all in elementary schools in many countries around the world, so it is recommended that nations should develop and implement nationally-accepted, well-coordinated pedestrian safety education programs in schools nation-wide as soon as possible. Australia's programs towards providing safety education at a young age could serve as an example for other countries around the world (Cairney 1999).

Developing a unified safety campaign in appropriate languages (as recommended in the Pedestrian/Bike Scan report) should also be made a part of this overall effort, to benefit not only school children, but all pedestrians (and bicyclists). Education and enforcement should be increased starting with school zones and expanding to other problem areas to help to reduce vehicle speeds and also improve driver awareness of pedestrians in crosswalks and the need to yield to them.

4. Develop and Implement Specific National Guidelines for Safer Bus Stop Design and Placement

Bus stop locations account for a substantial number of pedestrian crashes. This is not only because of the greater volume of pedestrians who cross the street at bus stop sites, but partly because of the behaviors of pedestrians who may cross the street in an unsafe manner to catch the bus and/or leave the bus. In some countries, this is combined with the fact that many bus stops are located along high-speed and high-volume collector and arterial streets, which present a challenge for pedestrians to cross safely, particularly for older pedestrians and pedestrians with disabilities.

Highway and transit agencies should develop guidance for transit stops, which address pedestrian safety needs. Then transit agencies should make sure that their transit stops are in compliance with these guidelines.

5. Promote and Advance the Use of Enforcement

Police enforcement is an important ingredient in an overall program to reduce pedestrian crashes and injuries. Photo enforcement for speeding and red-light running has been used in some industrialized nations, particularly in Europe and Australia, but has been met with considerable resistance in other areas such as in the U.S., for a variety of reasons. Convening an expert panel of interested organizations (e.g. engineers, police officers, policy makers, politicians) to develop a strategy to encourage more and improved implementation of photo enforcement could convince opponents of the legitimacy of

enforcement as a tool to improve pedestrian safety. Also, this strategy could essentially pay for itself from revenue generated by fines from violators.

6. Improve the Reflectorization/Conspicuity of Pedestrians

Because of the high percentage of pedestrian collisions and deaths that occur at night or under low lighting conditions, one of the strategies with a potential to reduce a large number of pedestrian injuries and deaths is to make pedestrians more visible to motorists. Implementing this strategy will require several key activities. Walking in the travel lane or crossing a high-speed street at night while wearing dark clothing and without watching for oncoming motor vehicles creates a high probability of a pedestrian death. Pedestrians need to be made better aware of the fact that they are nearly invisible to drivers when walking in the dark if they are not carrying a flashlight or wearing retro-reflective material/clothing.

Efforts should be made by the local and federal agencies, private companies, and safety organizations to develop high-visibility materials and equipment, such as low-cost reflective vests and flashlights. National transportation and educational organizations should work with such suppliers to provide informational brochures reminding walkers, joggers, and bicyclists to wear retro-reflective vests when walking or running or cycling along roads at night. More public service announcements (PSA's) and other educational messages should be directed to pedestrians and motorists (slow down at night in urban, residential and suburban areas, etc.) and pedestrians (be visible and assume that motorists cannot see you).

7. Develop and Implement Pedestrian-Friendly ITS Vehicle Features

Pedestrian safety cannot be adequately achieved without also considering the potential for improving motor vehicles to make them more pedestrian friendly. Vehicle technology can help to supplement some of the strategies mentioned previously in the coming years:

- Equip electric (or silent) motor vehicles with noise-making equipment, so that pedestrians, particularly those with visual impairments, will be able to hear the vehicles approaching or idling nearby.
- Further develop pedestrian-sensing devices on motor vehicles which would, for example, sense a pedestrian walking in the roadway ahead at night, and alert the driver, so the driver can slow down and take evasive action to avoid striking the pedestrian, or automatically apply brakes if collision is imminent.
- Equip vehicles with pedestrian/object detectors which can detect, for example, a child playing behind a parked car or van in a driveway by sending a warning to the driver (who cannot see the child while sitting in the driver's seat).
- Pedestrian (and bicycle)-friendly front ends of cars and trucks to reduce the injury severity in case of a collision with a pedestrian. Some auto companies and European countries have already begun implementing safer front-end vehicle designs.

Some early technologies by various auto makers have already made progress toward some of these ITS features. Further advancements of pedestrian safety features could help further reduce pedestrian deaths and injuries.

8. Develop a Comprehensive Pedestrian Safety Program

It is recommended that agencies use a comprehensive program of multiple countermeasure options (the five E's) in order to gain the greatest possible safety benefit. One success story of such a comprehensive program is documented in a 2008 report entitled "Evaluation of the Miami-Dade Pedestrian Demonstration Project." The purpose of that study was to reduce pedestrian crashes and related injuries and deaths in a Florida county which was experiencing approximately 1,700 to 1,800 pedestrian crashes

per year. A total of 16 different types of engineering, education, and enforcement treatments were implemented primarily in four high-crash zones and were targeted to address specific high-crash corridors and spots, as well as crash types, and specific age and ethnic groups. The study findings revealed that the program was associated with a significant reduction in pedestrian/vehicle crashes, particularly among children and adults in the targeted zones. A time-series analysis (with three different control groups) revealed crash reductions of 8.5 percent to 13.3 percent, depending on the control group. This translates to a reduction of approximately 180 pedestrian crashes per year as a result of the program, or 360 pedestrian crashes prevented for the first two years after program implementation. Details of the study results can be found at: <http://www.walkinginfo.org/library/details.cfm?id=4295>

CLOSING

Providing a safer roadway system for pedestrians requires that planners and engineers at all governmental and private organizations are familiar with (and motivated to provide) geometric and traffic control measures that balance the safety needs of all road users, including pedestrians. Such knowledge has not been widely provided at the college and university level to date, so professional training is needed to reach safety professionals with the latest research-based information possible on how to reduce pedestrian crashes through roadway improvements. As a part of this effort, there should also be efforts to closely monitor pedestrian crashes, injuries and deaths in each country, region, and town/city with resources in place to target pedestrian training and/or other resources to selected cities and states to counter pedestrian crash problems.

In support of the training and technical assistance activities discussed above, an aggressive, on-going pedestrian safety research program is needed by university and other research agencies to continually evaluate potential measures to reduce pedestrian crashes under a variety of site conditions. The results from this research should be immediately incorporated into the training and technical assistance to cities and into new versions of the geometric and traffic control guidelines.

There are many types of driver, pedestrian, roadway, and other factors that contribute to pedestrian deaths and injuries, and it often takes a combination of engineering, enforcement, and education measures to be effective. The “broad brush” strategies presented in this paper represent some of the best opportunities to reduce pedestrian deaths and serious injuries in the foreseeable future in many countries throughout the world. However, it will also take many dedicated professionals, local, regional, and national pedestrian safety champions, funding partners, and other stakeholders to work together to make a real difference.

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