# Toward a Shared Understanding of Pedestrian Safety

## An Exploration of Context, Patterns, and Impacts

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Pedestrian and Bicycle Information Center
www.pedbikeinfo.org

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# Introduction

## Document purpose

Communities across the United States (US) are contending with population growth, constrained resources, emerging mobility options, and demand for environments that support aging in place, opportunities for active travel, and more equitable and sustainable forms of multimodal transportation. Creating safe environments for all people to walk is a national priority, critical to addressing multiple converging health, social, environmental, and economic challenges. Numerous strategic plans and partnerships—orchestrated both by US transportation agencies as well as non-governmental coalitions—are underway to advance pedestrian safety. The goal of this document is to provide context on pedestrian safety issues, crash patterns and contributing factors, and resulting impacts that may help orient readers from diverse sectors—including advocates, roadway owners and operators, legislators and law makers, real estate developers, businesses and private industries, public health practitioners, researchers, educators, enforcement officers, and others—to identify shared concerns and opportunities to make a difference. It is not intended to provide policy or infrastructure recommendations but does provide a summary of key references and additional resources.

## Why walking matters

Walking, including walking with the assistance of a mobility support device, is a universal activity and a key feature of what makes us human. Babies learn to walk to pursue freedoms and desires beyond their reach as quadrupeds. Anthropologists recognize bipedalism as a marker of human intelligence, differentiating us from the animal kingdom. Philosophers[1] from Rousseau to Thoreau and beyond have established the connection between walking, thinking, and wisdom. Beyond simply a mode of travel, the act of walking is used regularly in social, cultural, spiritual, and political activities of all types, such as pilgrimages to sacred sites and demonstration marches. Walking is the most prevalent form of recreational physical activity in the US, as well as a key form of transportation for everyday trips.

**Figure 1.** A person uses a mobility assistive device to cross the street in downtown Chicago, Illinois. Source: www.pedbikeimages.org / Dan Burden.

**Figure 2.** People walk and children bike on a rural greenway in Lehighton, Pennsylvania. Source: www.pedbikeimages.org / Laura Sandt.

The ability to walk brings important benefits to individuals and communities, some of which are more measurable than others. Doctors prescribe walking to patients with any number of ailments, given the large body of science showing the benefits of walking for prevention of diseases from cancer to heart disease to diabetes. In fact, the US Surgeon General produced a Call to Action to Promote Walking and Walkable Communities[2], recommending walking as a key public health strategy. Comfortable and accessible pedestrian environments offer opportunities for interaction between community members that can strengthen relationships and contribute to a healthy sense of identity and place. In a growing number of communities, the amount of pedestrian activity is considered an indicator of a community's livability—a factor that has a profound impact on attracting residents, businesses, workers, and tourists.

For many people, walking offers an affordable form of transportation that is critical to accessing jobs, schools, health care services, and other fundamental opportunities. Residents that cannot afford a car; have suspended or revoked driver's licenses; or have physical, medical, or mental conditions that limit their ability to operate a vehicle often rely on walking as a primary form of transportation. Many more people actively choose to walk for health or environmental reasons.

Walkable urban places have been shown to decrease combined household and transportation costs and mitigate the impact of rising housing costs in most growing metro areas.[3] And in all areas, including rural communities, trails may be beneficial in promoting physical activity among segments of the population at highest risk for inactivity.[4] At the same time, high "walkability" has sometimes been associated with high costs of living, and a growing body of research points to disparities in who benefits from walkable neighborhoods and pedestrian facilities, a concern that must be addressed for walkable places to flourish.


**Figure 3.** People walk in a commercial area on a sidewalk in Charlotte, North Carolina. Source: www.pedbikeimages.org / Laura Sandt.

**Figure 4.** People sit at tables in an outdoor café in an urban area. Source: Federal Highway Administration Pedestrian and Bicycle Transportation University Course, Module 4.

## Systemic barriers to walking

While walking is essential to life and community vitality, walking is often not accounted for in the transportation systems we have designed in the US, particularly in the last 60 years. As historian Peter Norton explains, much of the history of Americans' vocal advocacy for the ability to walk (see Figure 5) has been ignored or lost in the larger conversation about how to design systems to accommodate vehicle-based travel.[5] In many regions, the environment built for travel is not designed for the ability to walk and can be actively hostile toward walking (see Figure 6). Other systems have reinforced an orientation toward vehicle travel over human-powered transportation. Our system of laws, for example, has produced heavy subsidies for vehicle travel while in many cases criminalizing the act of walking, as legal scholar Gregory Shill points out.[6] Our transportation research system is unbalanced with respect to the attention given to pedestrian issues in relation to other forms of travel; the Transportation Research Board, for example, has but one standing committee out of 179 that focuses on walking. Our education system has few formal programs, curriculum, or textbooks dedicated to active travel or even transportation safety.

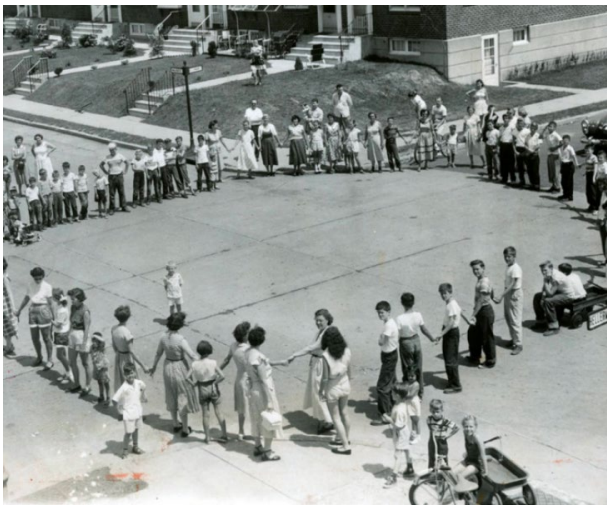

**Figure 5.** Residents block an intersection in 1953. Stop signs were installed the following Monday. Source: CityLab / Philadelphia Evening Bulletin, April 1956/Special Collections Research Center, Temple University Libraries, Philadelphia.

**Figure 6.** Missing infrastructure as a sidewalk ends at a location with high-speed vehicular traffic. There is a "no ped crossing" sign on display. Source: www.pedbikeimages.org / Barbara Gossett.

This background is important context for the pedestrian statistics that follow, which describe the effects of a disturbing trend toward disempowering people from the ability to walk and eroding safe opportunities for walking. The effects of disinvestment and/or systemic de-prioritization of walking in favor of other forms of transportation are felt more heavily in some communities than in others. A brief from Bridging the Gap, for example, found that 90 percent of streets have sidewalks in high income communities, compared to sidewalks on only 50 percent of streets in lower income communities.[7] Several reports have documented the disproportionate impact of crashes on traditionally underserved populations. African Americans and Native Americans are more likely to be killed while walking compared to other groups, according to the 2019 Dangerous by Design report from Smart Growth America.[8] Studies have concluded that neighborhoods with low socioeconomic status or a higher proportion of residents of color have less supportive environmental conditions for walking and other forms of active transportation, which may contribute to lower rates of physical activity and higher rates of poor health outcomes such as obesity, diabetes, and cardiovascular disease.[9]

There are many people and communities that are aiming to reverse these trends by fostering programs, projects, and policies designed to address inequities and support safe walking and travel for all road users. For examples of evidence-based effective practices, see the resources listed at the end of this document. The sections that follow focus on providing additional background and context on what makes pedestrians unsafe and what safety risks, patterns, and gaps in knowledge have been identified to date, to support readers in forming a more shared understanding of the nature of the problem needing to be addressed.

## When Walking, What Makes Us Vulnerable and What Makes Us Safe?

Pedestrians have sometimes been called vulnerable road users, often relative to motor vehicle occupants who have the protection of vehicle safety features in the event of a crash. More broadly, people are considered vulnerable travelers if they are likely to experience unmet needs for safe, comfortable, convenient, and affordable mobility. Vulnerability can stem from perceived or objective lack of mobility or access, exposure to unsafe travel conditions (such as high speed, heavy traffic), inequitable enforcement of traffic laws, or inequitable access to healthcare and resources to mitigate the impacts of a crash. Reducing the inequities that lead to pedestrian vulnerability requires understanding the unique needs and safety concerns of different populations and provision of the appropriate amount of resources. Historically, many low-income communities and underserved populations have been left out of conversations about transportation planning, and this has led to heightened vulnerabilities and pedestrian crash rates amongst traditionally underserved groups.

An equitable transportation system[10] that fosters fairness helps facilitate access to opportunities for all community members and reduce disparities in pedestrian crashes. Pedestrian crashes (and severe and fatal injuries) typically arise from a complex set of factors, where the roadway and vehicle environment, weather, road user behaviors, and other issues may combine to produce a life-threatening event. While crashes are complex, it is not necessary to understand all factors involved in every crash in order to prevent future pedestrian crashes. A focus on eliminating or minimizing population-wide exposure to crash risks and addressing systemic inequities, rather than focusing on individual protective measures, has been shown to be the most effective approach to prevent injuries (see Figure 7). [11,12]

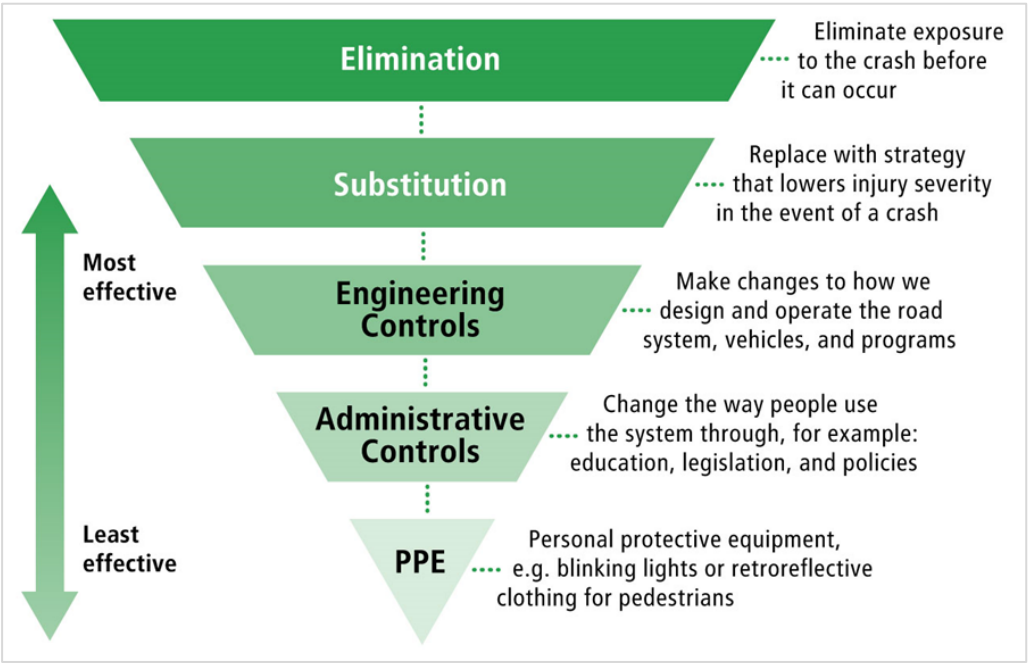


**Figure 7**. Hierarchy of controls for traffic safety. Source: adapted from the 2019 Washington State Strategic Highway Safety Plan and the 2017 National Institute for Occupational Safety and Health to include considerations for pedestrians in the Hierarchy of Controls.[11, 12]

## Pedestrian Fatality Trends over Time

Pedestrians, along with motorcyclists, bicyclists, and other non-vehicle road users account for a growing share of all US roadway fatalities (see Figure 8). According to the Fatality Analysis Reporting System (FARS), pedestrian fatalities increased by 53 percent from 2009 to 2018, while other traffic deaths increased by only 2 percent. The trends in pedestrian crashes observed to date also vary substantially over time and by region. Sunbelt states with growing populations, warmer year-round climates, and typically post-1950s roadway designs (i.e., wider streets accommodating higher proportions of larger vehicles) appear to be most impacted by the epidemic in pedestrian fatalities observed since 2008 (see Figure 9). Five states that make up a third of the US population (California, Arizona, Texas, Florida, and Georgia) account for 46 percent of pedestrian deaths.[13]

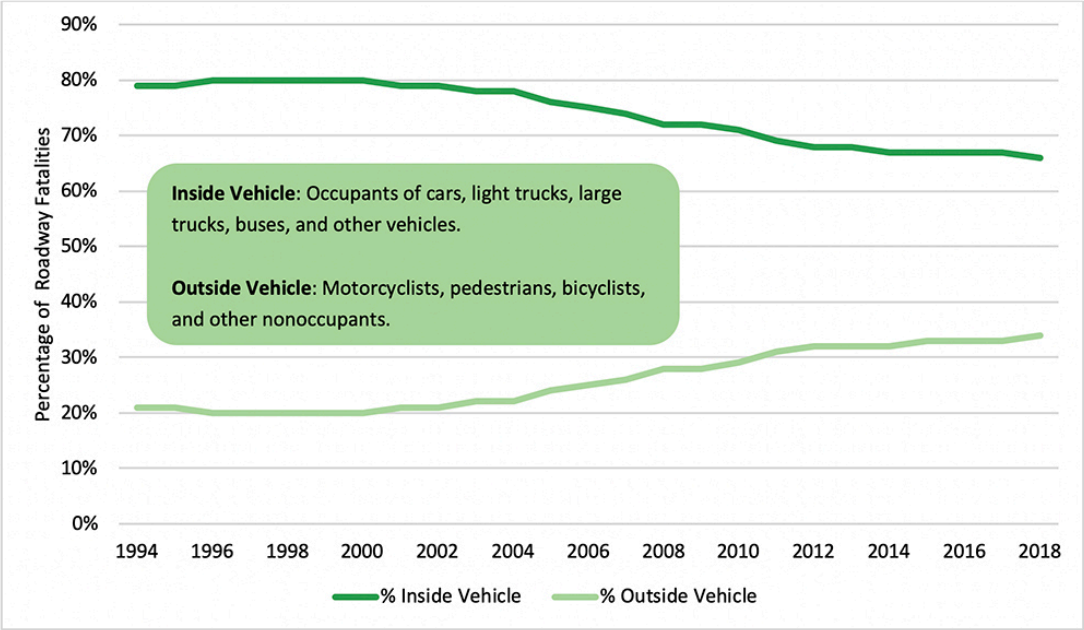


**Figure 8.** Proportion of fatalities inside/outside vehicle, 1994-2018. Source: PBIC with data from FARS.

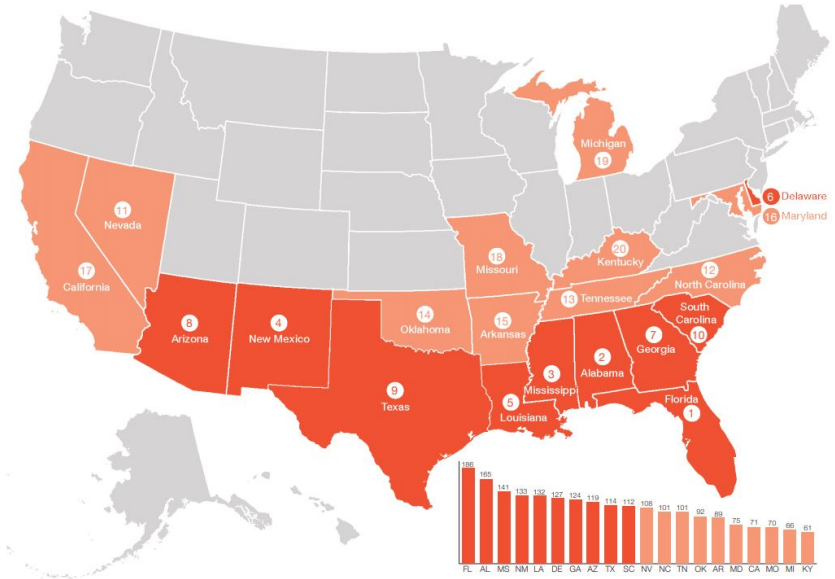


**Figure 9.** The top 20 most dangerous states for pedestrians, according to Smart Growth America's (SGA) Pedestrian Danger Index, a metric that considers population and walking mode share for commuters alongside pedestrian fatalities. Source: SGA.[14]

While rural areas continue to experience an increase in pedestrian fatalities, the largest growth in fatalities in recent years is occurring in more urbanized locations (see Figure 10). See page 18 for more discussion of crash contexts.

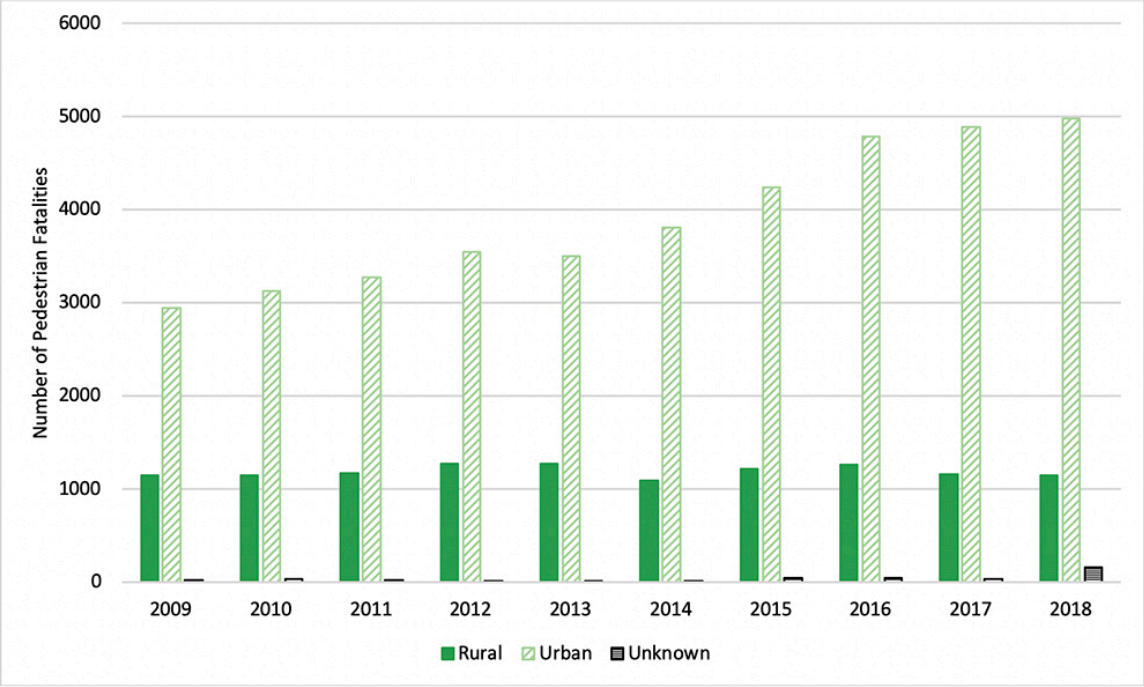


**Figure 10.** Ten-year trend in US rural and urban pedestrian fatalities; N = 51,307 pedestrians in fatal crashes. Source: PBIC with data from FARS.

At the same time, the absence of crashes and fatalities cannot be interpreted as the presence of safety. Low crash figures in an area may be a result of actual or perceived danger that dissuades people from walking. See the next section for more on walking rates and relation to safety.

## Trends in Walking and Measuring Exposure

A missing piece to estimate and monitor pedestrian safety is a lack of data measuring how often people are exposed to the risk of a crash, or "exposure data." It can be collected in different ways, such as manual or automated counts of people using roadway facilities; travel surveys measuring trips, time spent walking, or miles traveled (such as is periodically collected by the National Household Travel Survey (NHTS) and the Census survey on work-based travel); and there are increasingly options for device-based, crowd-sourced data. While there are many pedestrian measurement options, guidance tools,[15] and national consensus recommendations for pedestrian injury surveillance,[16] funding for pedestrian count programs (including staff, infrastructure, software, data management, etc.) remains elusive. There are no pedestrian exposure measurement systems in place at a statewide or national level that meet even the most basic data quality standards for road safety: timely, accurate, systematic, accessible, and complete.

Of the limited options available to help understand pedestrian exposure trends, the NHTS provides the most information at the national level. Researchers of one study[17] examined walking trends in the US from 2001 to 2017 and found that national rates of daily walking rose slightly amongst people age 16 to 44, but rates of walking decreased for ages 5 to 15. There is a growing body of research showing an association between high walking mode share (or, the

percentage of a community's trips taken on foot) and low rates of pedestrian fatalities. This relationship is sometimes attributed to theories that there is safety in numbers (due to higher driver expectation/awareness of pedestrian activity and possibly demand for higher quality infrastructure), but there is no convergence on an estimate of this relationship or the mechanisms underlying it (see Figure 11).

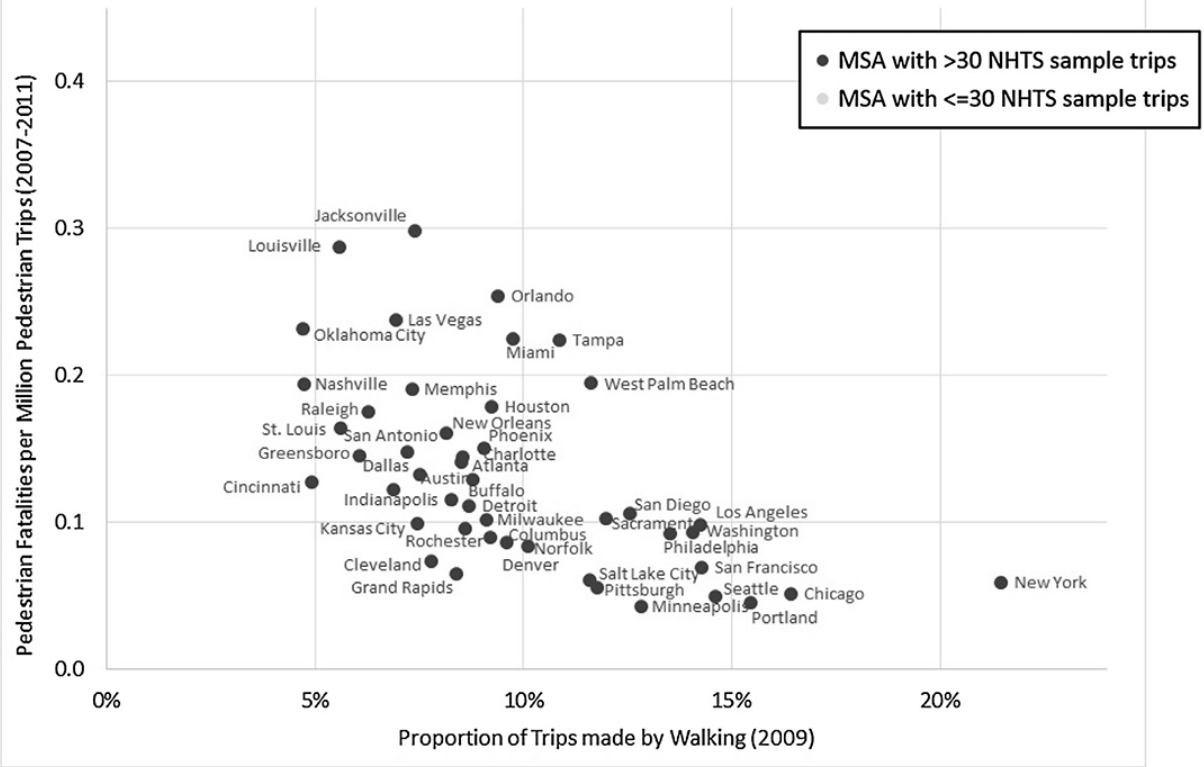


**Figure 11.** Trip-based pedestrian fatality rate vs. pedestrian trip mode share (2007-2011). Source: Schneider et al.[18]

The complex relationship between crashes and pedestrian walking activity or exposure highlights the fact that the absolute number of crashes is often an imperfect indicator of danger for pedestrians and thus, why strategies focused on increasing pedestrian mode share and improving safety are often considered in tandem.

## Pedestrian Injury Patterns and Treatment

According to the Centers for Disease Control and Prevention (CDC), each year, hundreds of thousands of pedestrians are treated in emergency rooms for non-fatal injuries resulting from motor vehicle crashes.[19] Researchers focusing on pedestrian injury data found that, in one state, for every pedestrian killed, approximately 10 other pedestrians may be treated in the hospital.[20] Pedestrian injuries range in severity and can include fractures, head injuries, dislocations, sprains, and injuries to internal organs. Children, likely due to their shorter stature, are most likely to experience a head injury or traumatic brain injury, which may lead to lifelong health and cognitive impacts. Older adult pedestrians hit by vehicles, compared to other age groups, also have a higher incidence of head injuries as well as fractures (see Figure 12, from an ongoing study[21] that is specific to data from the State of North Carolina but may reflect national trends).

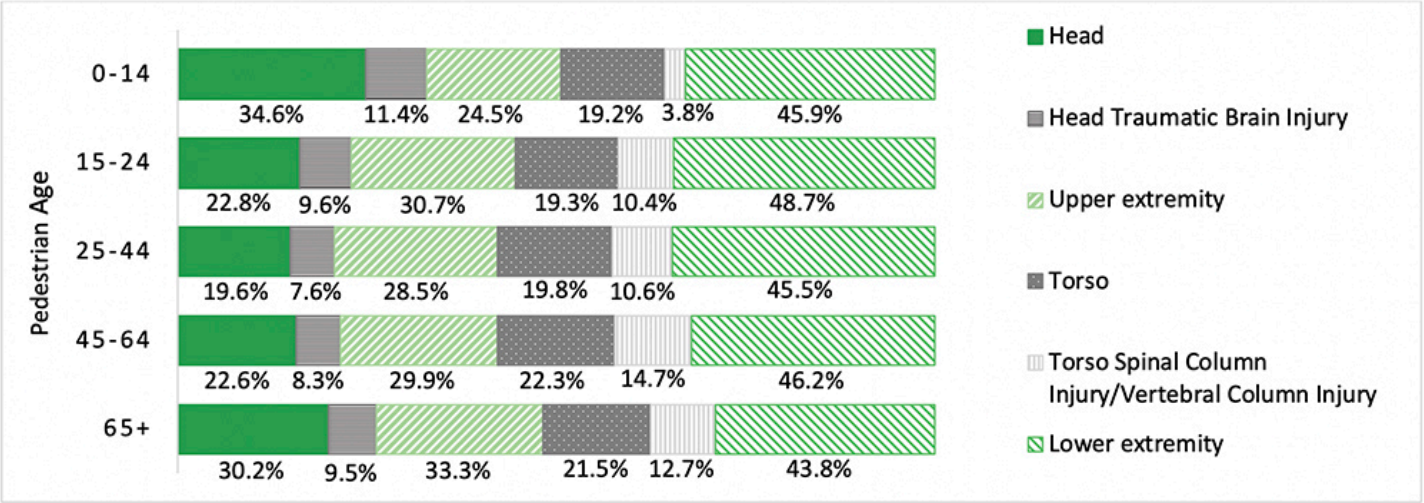


**Figure 12.** Location of injuries by age group for pedestrians struck by vehicles and treated in North Carolina emergency departments, October 1, 2010 – September 30, 2015. Source: Harmon et al.[21]

Age, other health factors, and access to treatment can affect the way in which pedestrian injuries can be treated. For example, a recent study utilizing hospital encounter data[22] found that one in six pedestrian crash victims treated at an emergency department was admitted to a hospital, and of those admitted, more than half stayed more than four days. The study also found that pedestrian hospital admission increased with age, with 38 percent of pedestrians age 80 and older being admitted to the hospital for treatment of pedestrian injuries. Furthermore, approximately 19 percent of fatal pedestrian crashes involve hit-and-run events,[23] in which the response time to injured pedestrians may be substantially longer.[24] Driver impairment and invalid driver's license are common characteristics of hit-and-run crashes.

## Older adults

Older adults are overrepresented in pedestrian fatalities and the proportion of fatalities involving pedestrians age 65 and older has been increasing (see Figure 13). The rise in crashes involving older pedestrians likely reflects the fact that the US population is aging: between 2012 and 2050, the number of Americans age 65 and older will almost double.[25] The growing population of older adults affects communities and planning decisions for transportation and recreation. Many older adults prefer to age in place (remaining in their homes instead of moving to a new location) yet face physiological changes that can present mobility challenges. Older adults may choose or need to stop driving and instead rely on alternative modes of transportation such as walking. Walking may introduce new mobility challenges for older adults due to decreased response time, vision issues, reduced muscular range of motion, and risk of falls. Sidewalks, pathways, and crossings that can be easy for a younger person to navigate may prove hazardous for an older person. Traffic signals may not provide sufficient time to cross at an intersection and cracks in sidewalks can introduce tripping hazards. At the same time, communities can prioritize the mobility and safety of older adults beyond their driving years. Physical activity, like walking and bicycling, can help prevent feelings of social isolation; build and maintain strength, balance, and physical endurance; and make it possible to access destinations without relying on a motor vehicle. The challenge for communities is to provide transportation networks that accommodate the needs of an aging population.

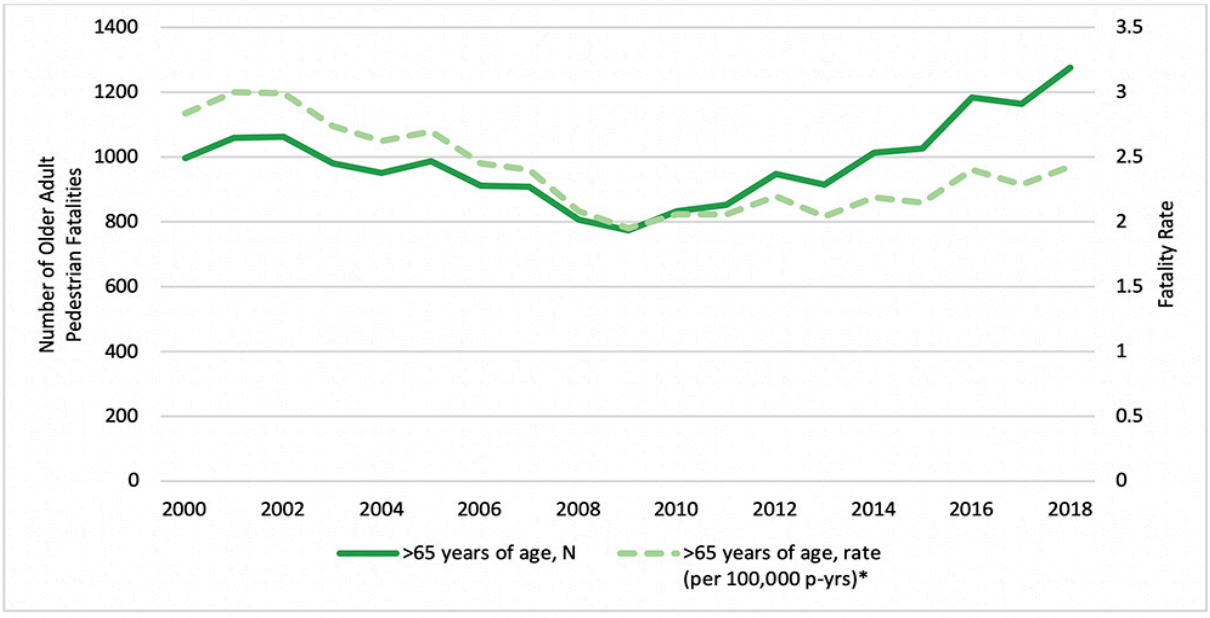


**Figure 13.** Older adult pedestrian fatalities and rate per 100,000 person years, 2000-2018. Source: PBIC using FARS and Census data.

## Marginalized populations

Marginalized populations or historically underserved communities also experience a disproportionate share of crashes (see Figure 14) while simultaneously experiencing conditions less favorable for walking. According to the 2019 Dangerous by Design report, "drivers strike and kill people of color, especially Black or African American and American Indian or Alaska Native people, at higher rates compared to White, Non-Hispanic, and Asian or Pacific Islander people."[8] A report by Urban Land Institute found that Latinos, African Americans, and millennials are more likely to report that crime or traffic in their neighborhood makes it unsafe to walk.[26]

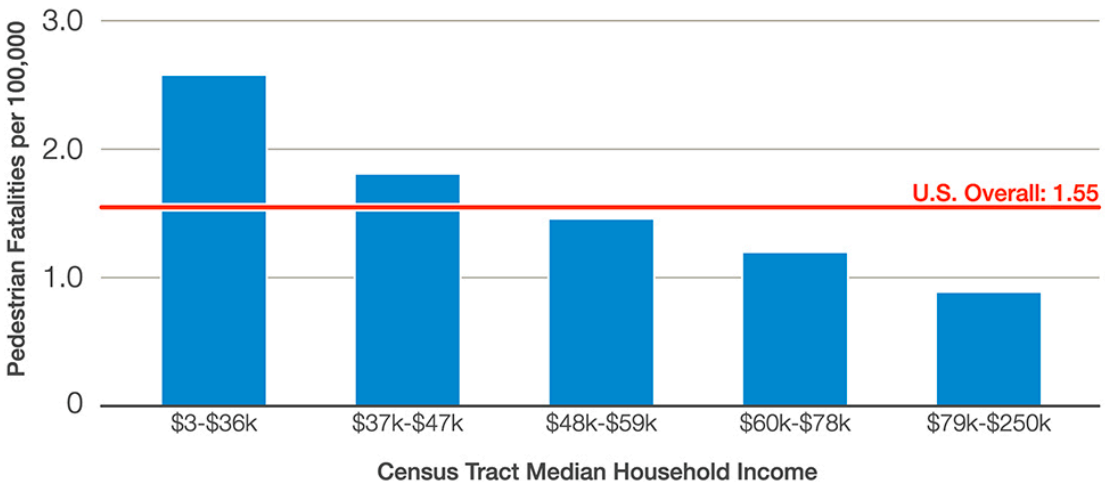


**Figure 14.** Per capita rate of pedestrian fatalities by neighborhood income, 2008 to 2017. Source: SGA.[8]

Americans with veteran status may also be considered to have heightened risks for pedestrian injury and fatality. In one study utilizing death certificate data to examine pedestrian fatalities, it was determined that veterans were over-represented in the state's pedestrian deaths (10.6 percent of all pedestrian fatalities)[27] in relation to their makeup in the population (6.4 percent).[28] In another study linking police-reported crashes to healthcare data,[21] 10.9 percent of injured pedestrians were found to also have a documented serious chronic health condition (e.g. chronic obstructive pulmonary disease, or COPD), 6.8 percent had a documented substance use disorder, and 5.5 percent had a documented mental health disorder. Underlying health issues, which affect roadway behaviors for both drivers and pedestrians as well as crash survival, are an understudied issue.

Targeting specific groups with individual-level interventions can be stigmatizing and ineffective in changing population-level pedestrian crash and injury rates, but gaining a better understanding of the different experiences of pedestrians and underlying risks is critically important to developing evidence-based approaches. How pedestrians experience injuries resulting from different crash scenarios is an under-studied issue, as very few states in the US actively link police reported crash data (which includes descriptive information about the crash location and pre-crash actions) with healthcare data (which contain important details about the nature and location of injuries, other health indicators, treatment, and cost). In 2018, the National Transportation Safety Board (NTSB) prepared a Pedestrian Safety Special Investigation Report based on forum discussions with federal and state officials and experts in pedestrian and passenger vehicle safety. As a result of the investigation, and to address the lack of pedestrian injury and/or hospital injury data, the NTSB recommended that the National Highway Traffic Safety Administration (NHTSA) and the CDC "develop and implement a plan for the states to combine highway crash data and injury health data, with the goal of producing a national database of pedestrian injuries and fatalities."[29]

## Economic and Social Impacts of Pedestrian Crashes

When a pedestrian is struck by a vehicle, the impacts are often horrific and immeasurable. Injury from a vehicle-related crash can take a significant amount of recovery time and can lead to secondary health issues and complications, including obesity, trauma-related mental health issues, and even addiction to painkillers prescribed during treatment of the injury. Few studies to date comprehensively capture these effects, but Figure 15 highlights the ripple effects that pedestrian crashes have on families, employers, the medical system, and communities at large.

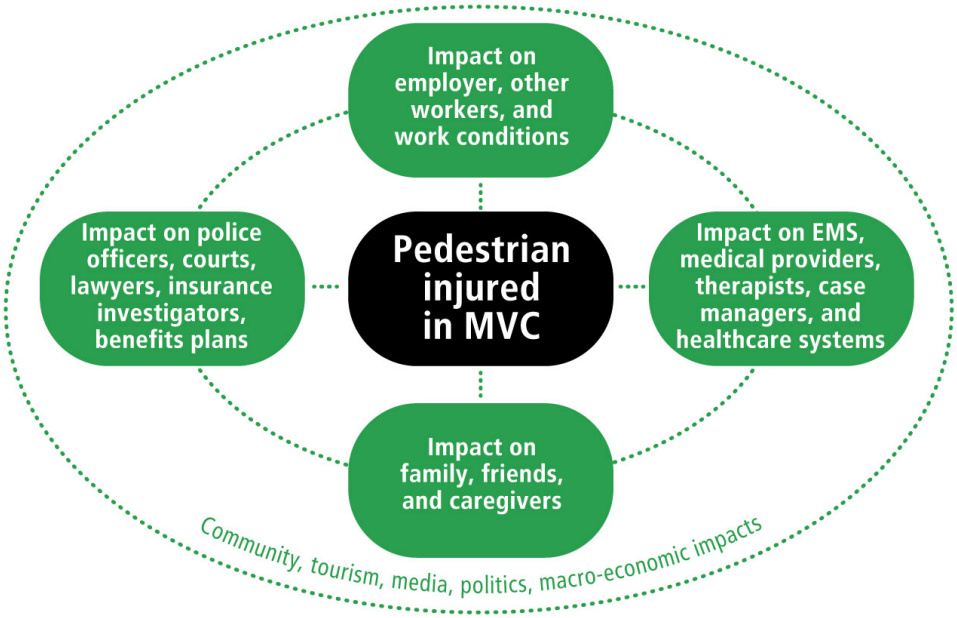


**Figure 15.** Ripple effects that pedestrian crashes have on families.
Source: Adapted from Dembe, 2001.[30]

When standardized crash cost estimates are applied to pedestrian crashes, they estimate a cost of pedestrian fatalities and injuries in the billions of dollars. A large portion of the actual costs of crashes and treatment of injuries are borne by employers, insurance providers, medical providers, and taxpayers at large. As more states work to link their police records of pedestrian injuries with healthcare data, the personal and fiscal impacts of these crashes become clearer. In one state, for example, 55 percent of pedestrian injuries treated in emergency departments were expected to be paid for by Medicaid, Medicare, or self-pay, meaning tax payers and individuals, not private insurance companies, are responsible for the majority of costs associated with pedestrian crashes (see Figure 16).[21] At the same time, dollars are a poor representation of the full impacts on families' quality of life and health after someone is injured while walking.

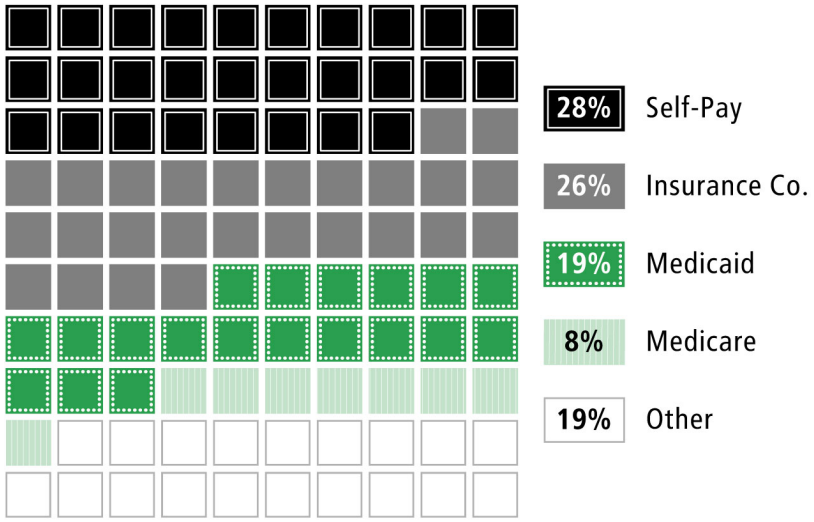


**Figure 16.** Expected source of payment for injured pedestrians treated in North Carolina emergency departments, October 1, 2010 - September 30, 2015. Source: Harmon, et al.[21]

## Driver Involvement in Pedestrian Crashes

Pedestrian crashes are traumatizing events for all parties involved, including drivers. Drivers can be operating in environments beyond their cognitive abilities and may not be prepared or trained to interact safely with pedestrians. Not enough is known about the drivers involved in hitting pedestrians, or how they may differ from drivers that have not been involved in pedestrian crashes. An examination of fatal pedestrian crashes from FARS data shows that, on average, the age of drivers involved in fatal pedestrian crashes has been rising. There has also been a steady increase in the total number of fatal pedestrian crashes involving older drivers (see Figure 17). This may reflect broader demographic changes referenced earlier.

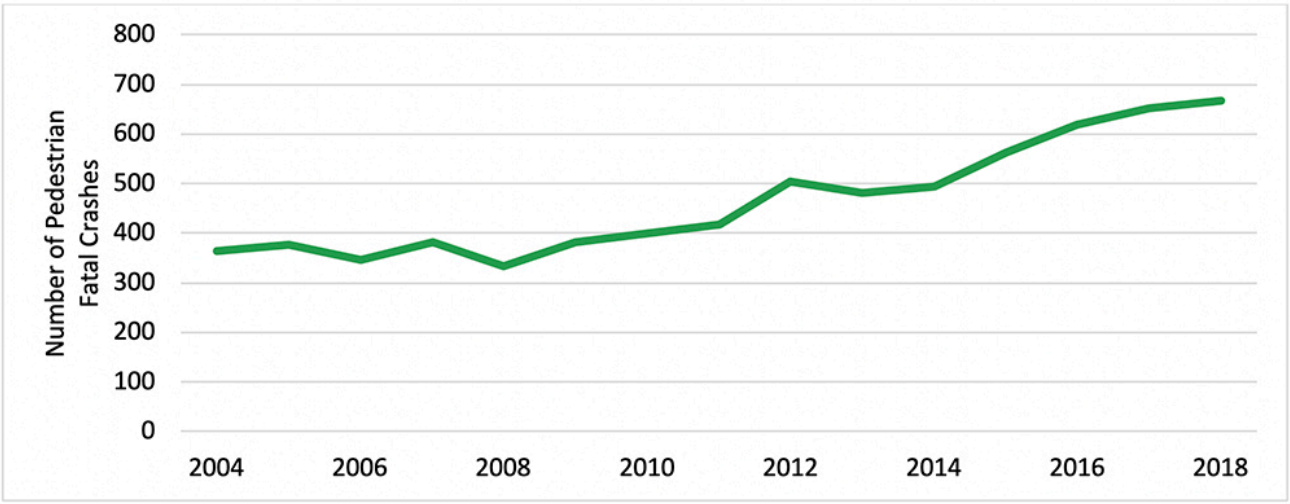


**Figure 17.** Fatal pedestrian crashes involving older adult drivers age 65 and older from 2004-2018. Source: PBIC using FARS data.

A descriptive analysis of pedestrian crashes in one state indicates that younger drivers (those under the age of 25) may be over-represented (in relation to all licensed drivers) in events causing both non-serious and serious injury to pedestrians (Figure 18).

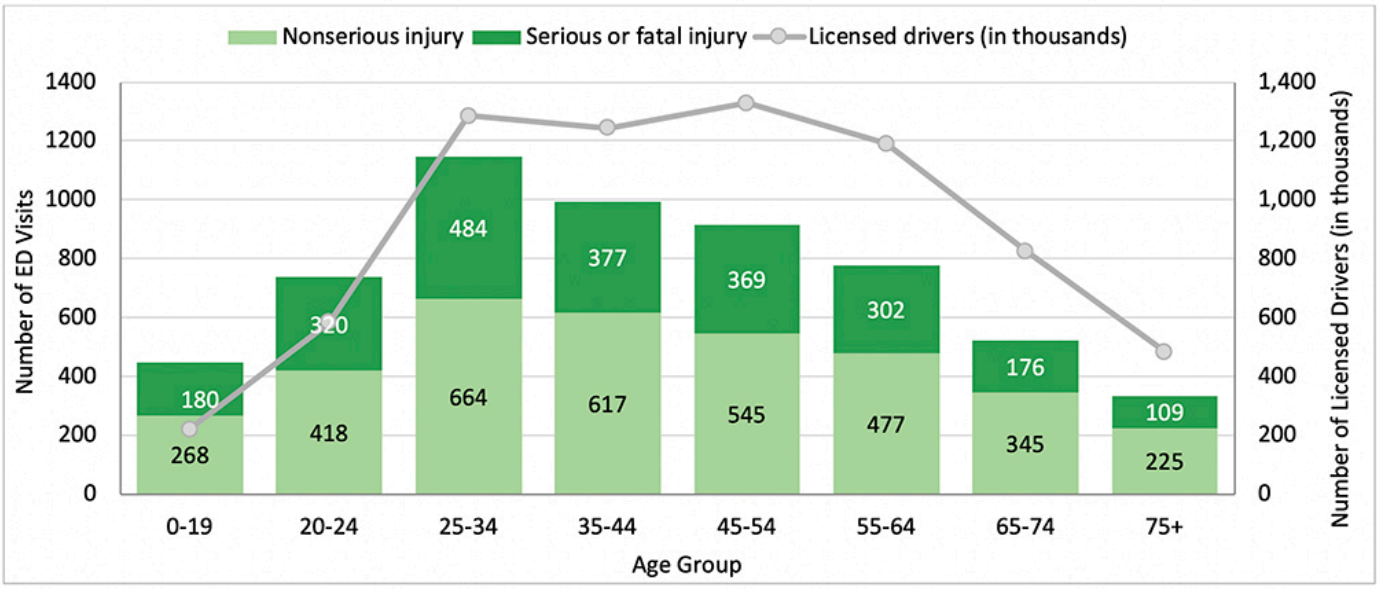


**Figure 18.** Number of pedestrians treated at NC emergency departments by striking driver age group and pedestrian injury severity (n=5,876), displaying number of 2014 licensed NC drivers for comparison (in thousands; N= 7,025,333). Source: Harmon et al.[21]

For drivers across the age spectrum, driver expectations of the movements of other road users may not align with pedestrian's use of the road. Road safety literature on how perception, attention, situational awareness, and inattentional blindness affect motorist behavior is voluminous. Literature has documented drivers' tendency to mentally model the road environment based on several factors, but researchers are increasingly investigating how the exclusion of pedestrians from these sets of expectations may influence unsafe behavior on the part of drivers around pedestrians. More research is needed on how drivers, pedestrians, and bicyclists assess, predict, and respond to each other based on their own expectations and mental models of the roadway environment.

Prescription drugs, fatigue, distraction, and other factors can lead to impaired driving skills that affect ability to perceive and react to pedestrians in shared spaces. In addition, novice drivers may not receive thorough training or experience to safely navigate roads with pedestrians. Risky behaviors like impairment and distraction on the part of the pedestrian may also play a role in crashes. While research has demonstrated that distraction can affect the behavior of pedestrians crossing the street, direct links to pedestrian involved crashes have not been established. As for impairment, there is little research that quantifies the behavior changes in impaired pedestrians (e.g., making the decision to cross the street), but the research is clear that alcohol use is associated with worse injury outcomes for pedestrians.[31,32,33,34]

## The Role of Vehicle Speed and Mass in Pedestrian Crashes

The mass of an object and its speed combine to form its kinetic energy. A crash involves the transfer of kinetic energy from vehicle to person, and the human body can only withstand so much force. Therefore, vehicle speed and mass are consistent primary predictors to determine if a pedestrian will be killed in the event of a collision. Higher vehicle speeds (as measured by posted speed limit or estimated speed at the time of impact) increase not only the likelihood of a crash, but also the severity. Moreover, the increased use of sport utility and larger-sized vehicles, when combined with higher speed, has contributed to the national rise in pedestrian fatalities.[35]

Speeding is linked to 29 percent of total traffic deaths from 2008-2017,[36] though this figure may be underreported due to variation in reporting between states. Many more were seriously injured in crashes related to speeding, but for pedestrians specifically, these figures are largely undocumented or underreported. It is clear why speeding is such a concern for pedestrian safety when one considers the role that higher speeds play in the risk and severity of a crash. Figure 19 illustrates the risk of serious injury or fatality for a pedestrian as vehicle speed increases. It also shows the narrowing visual field and ability for drivers to scan the peripheral for pedestrians as speed increases.

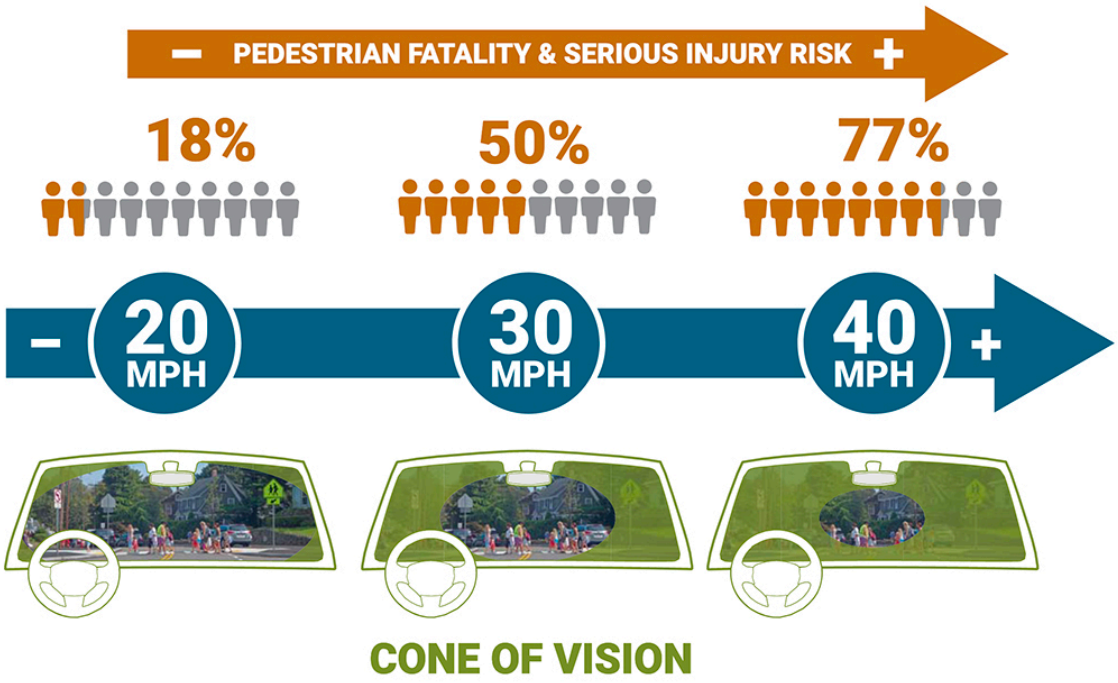


**Figure 19.** Average risk of pedestrian fatalities and injuries at increasing speeds and cone of vision. Source: Porter et al.[37]

To learn more about speed-related pedestrian injuries, researchers are investigating fatality and injury data from emergency departments in the State of North Carolina. Findings show that the number of pedestrians with fatal or serious injuries increase as speed increases. For example, 69 percent of pedestrians struck by vehicles traveling greater than 35 miles per hour sustain serious or fatal injuries, as compared to 24 percent of pedestrians struck by vehicles going less than or equal to 5 miles per hour (see Figure 20). Serious and non-serious injuries documented by emergency departments capture those pedestrians who do not die immediately, but may suffer longer-term consequences.[21]

Pedestrian fatality and injury numbers decrease in areas where posted speed limits are over 40 miles per hour, but this is due in large part to reduced exposure, in that there are fewer pedestrians walking on or along higher-speed roadways.

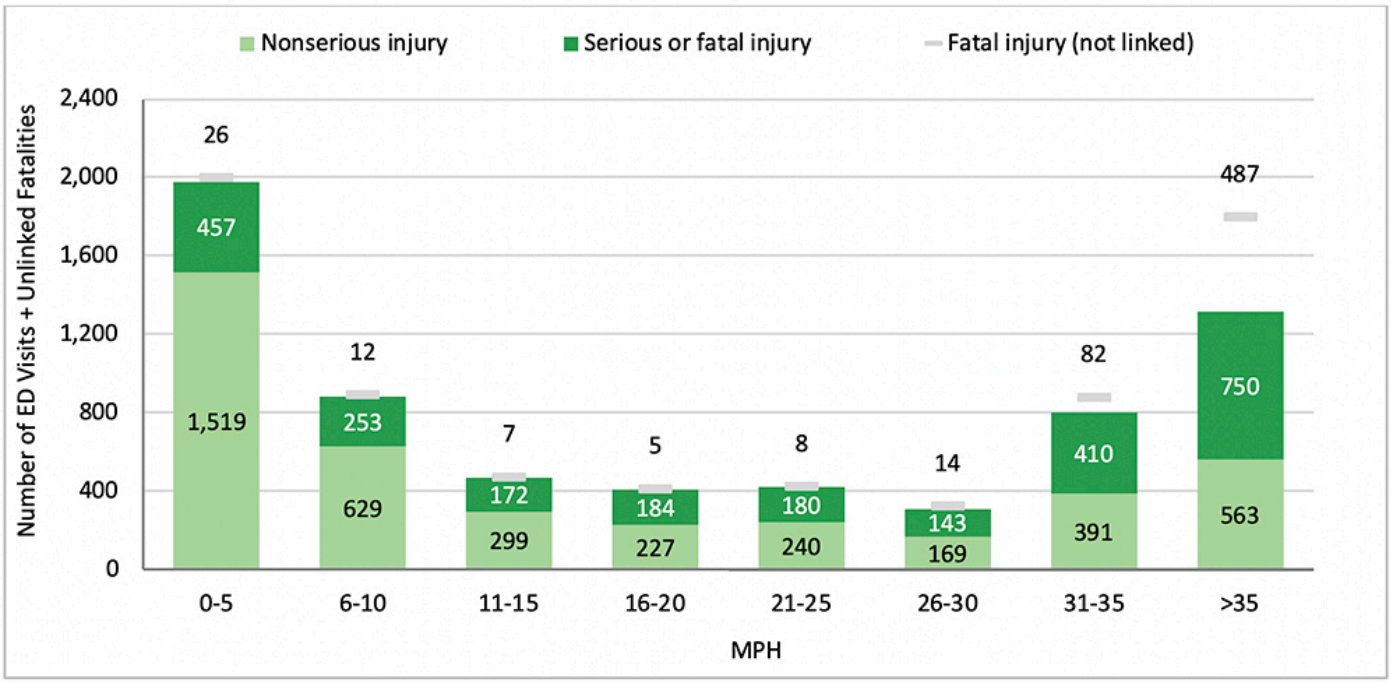


**Figure 20**. Number of pedestrians treated at NC emergency departments, by police-estimated driver speed at impact and pedestrian injury severity (n=6,586)1,2; number of unlinked pedestrian fatalities shown for comparison (n=641). Source: Harmon et al.[21]

Weight and size, and power of vehicles, have been found in several studies to increase the risk of fatality and injury when a pedestrian is struck.[38] Although involvement of all types of passenger vehicles and medium or heavy trucks, which accounted for a majority of pedestrian fatalities, increased from 2009 to 2016, the rate of increase was highest among SUV-class vehicles (81 percent or an average increase of nearly 8 percent per year) compared to minivans and large vans (15 percent), and passenger cars (41 percent).[39] In addition, the power-to-weight ratio increased significantly among all weight classes of passenger vehicles, and pedestrian fatality involvement of pickups, and medium or heavy trucks, each increased by 32 percent.[36] A light truck colliding with an older pedestrian at a higher speed will increase the risk of pedestrian serious injury or fatality, as illustrated in Figure 21.[40] To put further context to the issue, Figure 22 shows sales of light truck retail sales (in thousands) overlaid with pedestrian fatalities from 2000-2016.

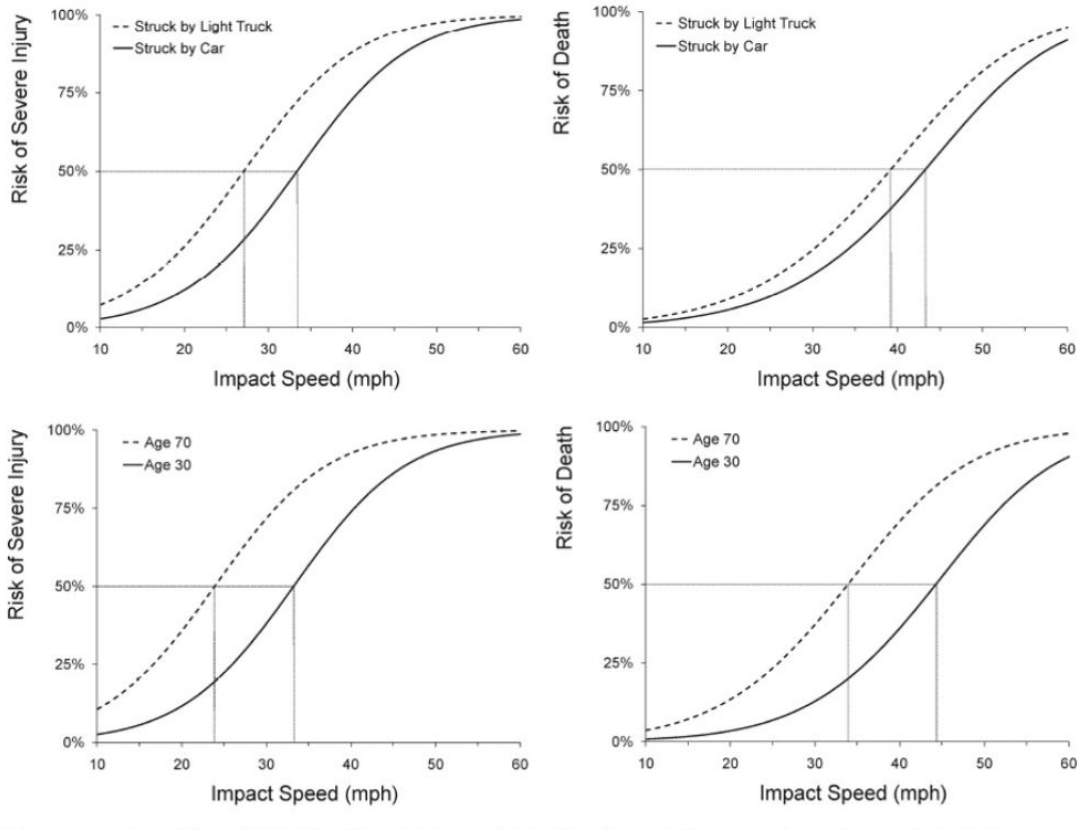


**Figure 21.** Risk of severe injury and fatality in relation to impact speed and type of vehicle. Source: Tefft.[40]

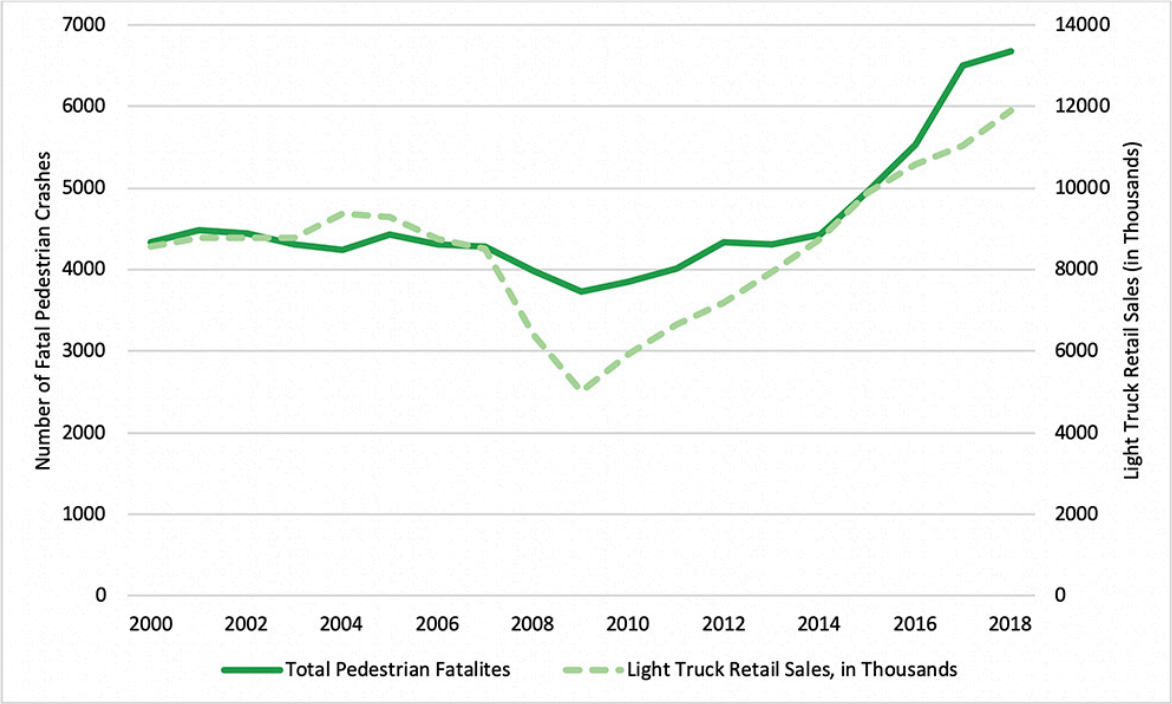


**Figure 22.** Fatal pedestrian crashes (left axis) overlaid against the volume of light trucks sold in the US (right axis), showing a visual correlation between vehicle size/fleet make up and pedestrian fatalities. Source: PBIC, using FARS data and the US Energy Information Administration (EIA).[41]

Speed is a complex issue in traffic safety problems and critical to consider in all aspects of the transportation system. From a Safe System perspective, managing the kinetic energy transfer among all road users is a basic tenet within the approach, and speed is considered as part of an overarching concept that impacts the whole system in a comprehensive way. In a more applied perspective, speed is both a behavioral and an engineering challenge: high-speed travel is inherently risky but speeding, as well as traveling on high-speed roads, are also generally publicly accepted behaviors in the US. There are many roadway design features (such as curb radii, lane width, and presence of medians) as well as vehicle design features (such as speedometer design or warning systems) known to either encourage or mitigate speeding, but roadway design and vehicle-based speed managing features are rarely systematically adopted. More often, targeted enforcement and/or education efforts are employed to combat issues related to speed. Programmatically, managing speed is a key priority for state and local initiatives related to Vision Zero and Safe System efforts. There are some local initiatives to lower default speed limits on city streets, and in particular to reduce travel speeds on residential streets where pedestrians of all ages tend to travel (see Figure 23).[42]


**Figure 23.** Amy Cohen speaking out at a press event and rally for Vision Zero in New York City, New York, held on July 14, 2015. Source: Vision Zero Network.

The NTSB shared findings of a speed-related crash study in a public meeting in 2017, finding that the issue of speeding "as a national traffic safety issue is lower than warranted" given the severity of consequences in higher-speed crashes. The NTSB study identified a need for greater investment at the national level, stating that, "Current federal-aid programs do not ensure that states fund speed management activities at a level commensurate with the national impact of speeding on fatalities and injuries."[43]

## Vehicle Design, Technology, and Testing in Relation to Pedestrians

There is a growing gap between pedestrian safety features and designs on vehicles in the US versus vehicles sold in other parts of the world, which may partially explain why other countries have not observed the same epidemic of pedestrian fatalities that the US is experiencing.[44] For many years, the European New Car Assessment Program (Euro NCAP[45]) has included vulnerable road user ratings, which are not currently included in the US New Car Assessment Program (NCAP). A recent NTSB report[29] identified the need for improved hoods and bumpers for pedestrian safety and adding pedestrian collision avoidance systems to US NCAP. Similarly, the Government Accountability Office recently published a report that examined vehicle design and safety features related to pedestrians and documented data and research limitations.[44] It noted that in 2018, 89 percent (5,602) of the pedestrians included in the study were killed in motor vehicle crashes that involved single vehicles. In those single-vehicle collisions, pedestrians were most likely to be struck by the front of the vehicles. Of fatal pedestrian-vehicle crashes, large truck involved crashes had the highest

percentage of right-side impacts and rear impacts (meaning the pedestrian likely was swept under the vehicle while the driver was turning or was hit while the driver was backing).

Given that upwards of 70 percent of pedestrian fatalities occur in dark/low light conditions (see section on Pedestrian Crash Temporal Patterns), there is a need to consider the role of vehicle headlight standards in affecting pedestrian safety. In October 2018, NHTSA proposed a rule to allow manufacturers to (voluntarily) install adaptive headlights. The proposed rule also established performance requirements for such systems if equipped on newly manufactured vehicles.

In addition to vehicle design approaches (such as bumpers and hoods) that could be used to diffuse energy and mitigate the severity of injury to a pedestrian hit by a vehicle, there is a growing body of technologies aiming to prevent pedestrian crashes altogether. In February 2019, the Insurance Institute of Highway Safety (IIHS) introduced a rating for vehicle-based pedestrian crash prevention technology,[46] designed to detect and brake for pedestrians, and, in some cases, issue a warning to prompt a driver response before automatic braking is engaged. NHTSA has also produced documents describing pedestrian safety features needed.[47]

While advanced technologies to improve detection of pedestrians hold significant potential, preliminary studies have shown that the technology in place to date remains immature, highly variable, and ineffective in many contexts,[48] may take a long period of time to saturate the entire driving fleet, and the potential for unintended consequences such as behavioral adaptation over time (e.g., reduced scanning for pedestrians due to technology reliance) is wholly unknown.

## Pedestrian Crash Context/Environment

A discussion about safety for people walking cannot be separated from a discussion about the role of the physical environment in creating or mitigating risks to their safety. The physical environment in which someone is traveling interacts with their own capabilities to magnify or mitigate the potential for a crash. Designing for the most vulnerable road users translates to safety benefits for less vulnerable road users as well.

Data using varying definitions of “urban” show that a majority of pedestrian fatalities are occurring in developed areas—74 percent of pedestrian fatalities nationwide occurred in urbanized areas and 89 percent in metropolitan statistical areas.[49] As discussed previously and shown in Figure 10, the largest growth in fatalities in recent years has been seen in more urbanized locations. Whether urban or rural (or suburban), most pedestrian fatalities nationally occur at non-intersection locations. In urban areas, 67 percent of pedestrians killed are struck at non-intersection locations; urban non-intersection locations accounted for an average of 49 percent of all fatalities for pedestrians from 2014-2016 (see Figure 24). In rural areas, the proportion of those killed at non-intersection locations was even higher, at 86 percent of those struck (3,240 of 3,755 fatalities, as shown in Figure 17). When considering all pedestrian crashes, not just fatal crashes, there is evidence that non-intersection crashes are more severe. For example, analysis of five years of North Carolina data showed that non-intersection crashes represented 60 percent of all crashes, but 74 percent of fatal and disabling crashes.

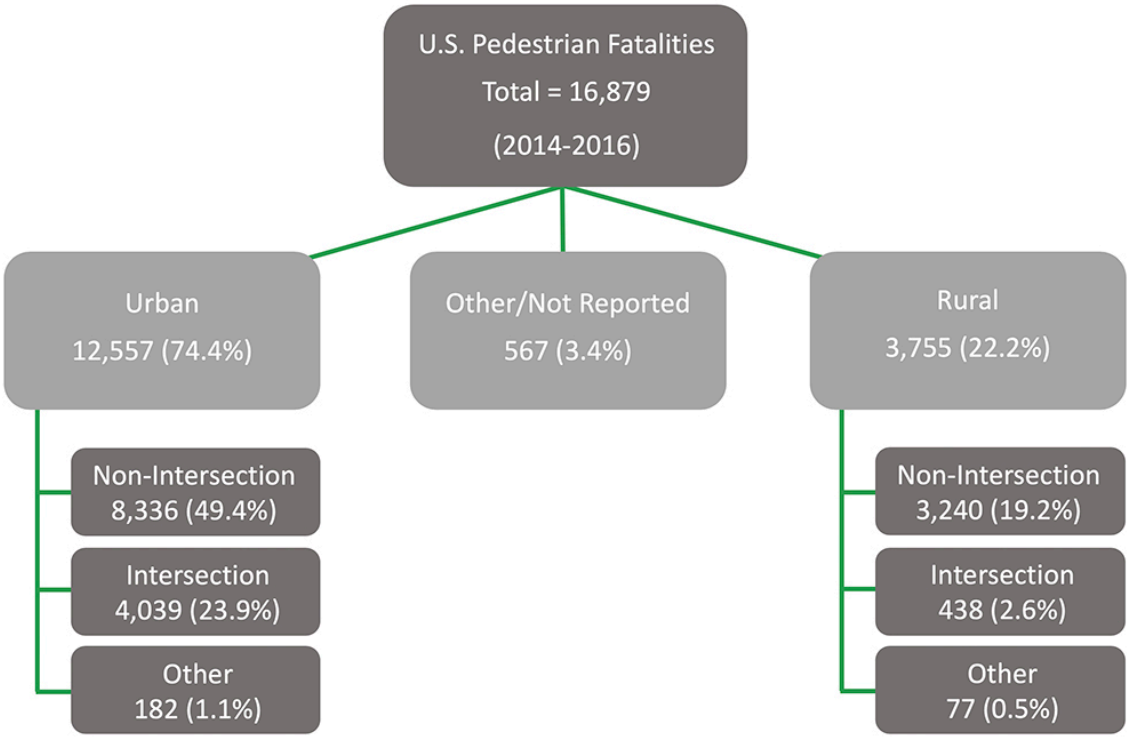


**Figure 24.** US pedestrian fatality distribution by location and intersection characteristics, 2014-2016. Source: PBIC.[50]

Moving beyond consideration of the area type, research has shown that safety and risk are directly related to functional classification,[51] as are safety correlates like walkability.[52] A planned roadway is typically assigned a functional classification which entails certain design considerations based on the prescribed balance between mobility and accessibility. Research has shown that the risk of pedestrian fatality increases as traffic density increases,[52] which is why arterial roadways present significant risk to people walking—they are designed to carry the highest traffic volumes at the highest speeds (with the exception of interstates and other roads that limit pedestrian access).

From 2009 to 2018 the largest increase in pedestrian fatalities have occurred on principal and minor arterial roadways (70 percent and 76 percent increase, respectively), with principal arterials accounting for an average of 36 percent of all pedestrian fatalities (see Figure 25). This trend is troubling, but the fact that most fatalities are occuring on arterials is less surprising if one considers that these roads were designed for motor vehicle travel but include destinations of interest to everyone, regardless of travel mode. The public health community[53] is recognizing that in addition to traffic injuries, arterials have a negative health impact by contributing to water, noise, and air pollution that diminishes the quality of life for residences near the high-traffic enviornments and beyond. Arterials can also be vibrant commercial and cultural resources, but not when they are designed to prioritize motor vehicle throughput above all else.

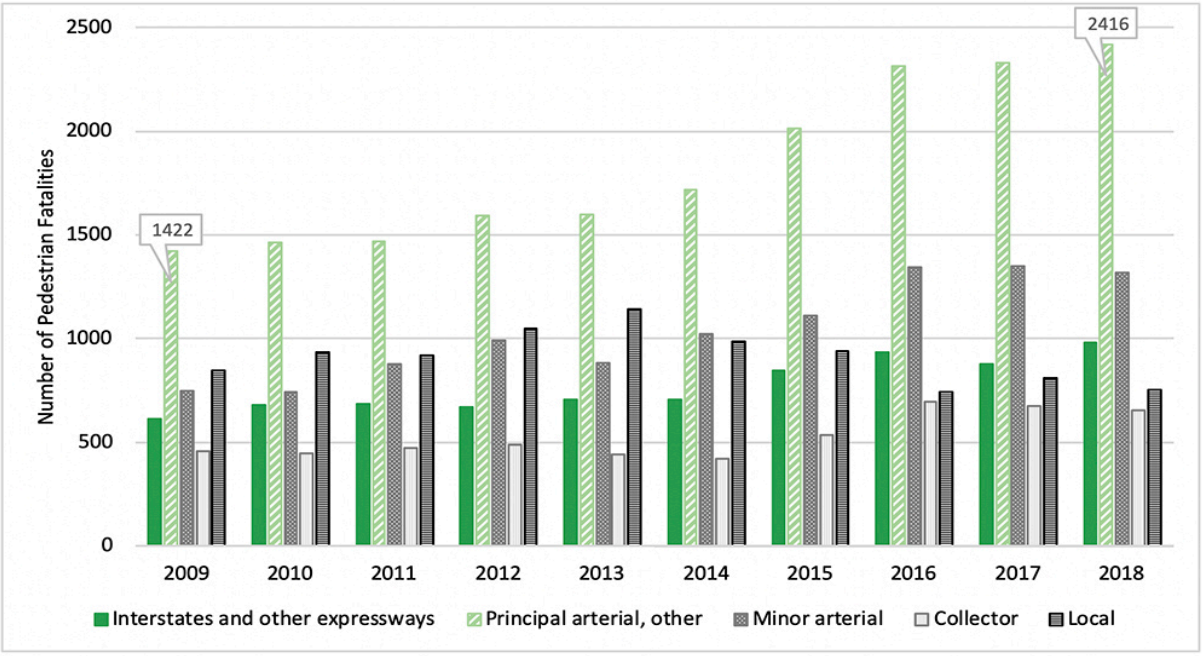


**Figure 25.** Ten-year trends (2009-2018) in pedestrian fatalities by roadway functional class; N = 51,307 pedestrians in fatal crashes. Source: PBIC using data from FARS.

## Pedestrian Crash Temporal Patterns

Lighting and visibility is a key factor in traffic safety, and 75 percent of crashes that resulted in pedestrian fatalities in 2017 occurred in dark conditions.[36] Across the longer term, fatal pedestrian crashes continue to increase at nighttime and in dark conditions (see Figure 26). Pedestrian crashes occurring on weekends between 8pm to 4am are among the deadliest (see Table 1).

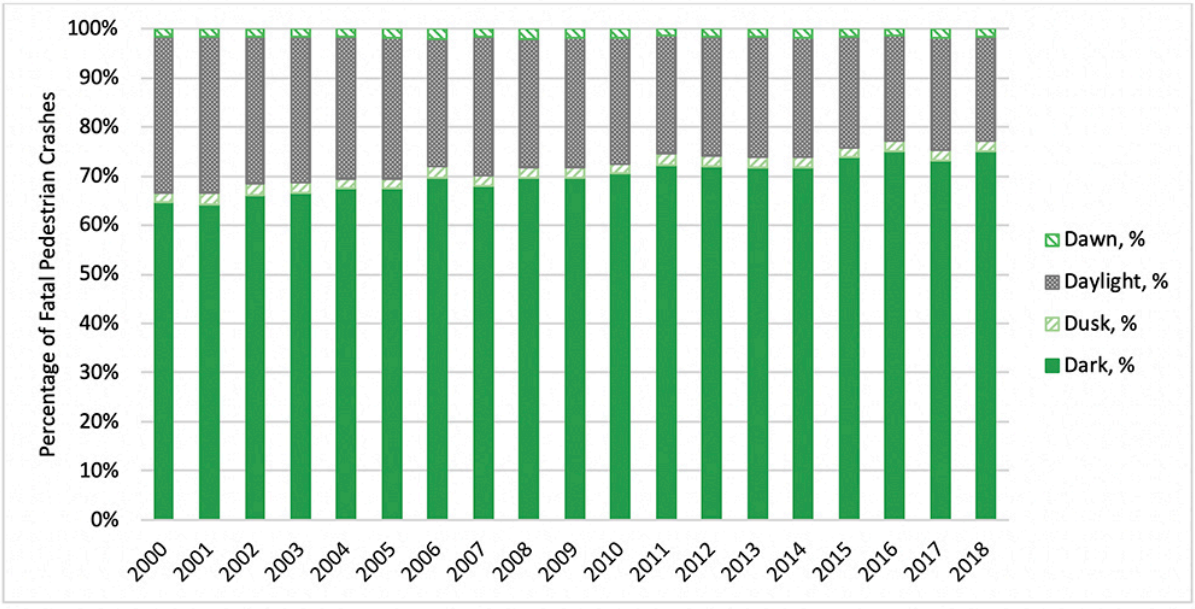


**Figure 26.** The proportion of fatal pedestrian crashes occurring during dark/dusk hours has been steadily increasing as a proportion of all fatal crashes since 2000. Source: PBIC with data from FARS.

**Table 1.** Percentage of pedestrian fatalities by day of week and hour of crash, 2014-2018; n=28,762. Source: PBIC with data from FARS.[54]

| Time | Mon. | Tues. | Wed. | Thurs. | Fri. | Sat. | Sun. |
|---|---|---|---|---|---|---|---|
| 12am-4am | 1% | 1% | 1% | 1% | 2% | 4% | 4% |
| 4am-8am | 2% | 2% | 2% | 2% | 2% | 2% | 2% |
| 8am-noon | 1% | 1% | 1% | 1% | 1% | 1% | 1% |
| noon-4pm | 1% | 1% | 1% | 1% | 1% | 1% | 1% |
| 4pm-8pm | 3% | 3% | 3% | 3% | 4% | 3% | 3% |
| 8pm-12am | 4% | 4% | 4% | 5% | 6% | 6% | 4% |

Generally, nighttime and dark conditions magnify preexisting conditions that may be already challenging for pedestrians, such as poor roadway design. At night and early hours, impairment (of either driver or pedestrian) as well as poor lighting conditions often plays a role. Overall, fewer people are walking at night and drivers are less likely to expect pedestrians on streets. Drivers may also be driving faster because of lack of traffic congestion.

Some cities, such as Austin, Texas, have begun to address these risks by enacting time-based travel bans for cars[55] around key pedestrian nightlife areas to help protect pedestrians from vehicles. Another effort to address crashes at night are reduced speed limits for dark conditions, demonstrated in Tucson, Arizona, and in the states of Montana, Florida, Colorado, and Washington. In New York City, New York, a "Dusk to Darkness"[56] education and enforcement campaign draws attention to the increased risks to pedestrians during the fall and winter. New York Police Department efforts include enforcing speed and failure-to-yield violations and driving while impaired.

Pedestrian-level street lighting offers some mitigation and crash prevention, while also the potential to address comfort and security, but can be slow to implement due to challenges related to cost, multiagency coordination, and concerns regarding light pollution. There is a continued need for research to investigate the performance of lighting, vehicle technology (such as headlamp design), and other roadway features and pedestrian facilities in terms of nighttime safety performance.

## Conclusion

This document was intended to provide a broad landscape of pedestrian safety challenges, known risks, patterns of injuries and other outcomes to stimulate thinking about the nature of the problem and an appreciation regarding the complexities and needs of pedestrian travel. A curated set of additional resources is found below, along with specific works cited in this document. For a more comprehensive set of pedestrian resources, please visit www.pedbikeinfo.org and explore the searchable resource database, topic-specific pages, and webinar library.

## Additional Resources

Pedestrian and Bicycle Information Center (PBIC): Pursuing Equity in Pedestrian and Bicycle Planning provides an overview of transportation equity including definitions of key terms in discussing equity.[10]

PBIC Center Website provides topics pages on older adults, count programs, driver education, safety countermeasure effectiveness, and many others.[57]

Federal Highway Administration (FHWA) Pedestrian and Bicycle Transportation University Course covers pedestrian topics on the university-level and gives a background to relevant issues.[58]

PEDSAFE describes the process for selecting and implementing countermeasures and each includes an interactive selection tool and case studies.[59]

NHTSA: Advancing Pedestrian and Bicycle Safety summarizes promising engineering treatments and behavioral programs and includes a glossary and case studies.[60]

NHTSA: Countermeasures that Work provides guidance for selecting effective, evidence-based countermeasures for traffic safety problem areas including bicycle and pedestrian safety.[61]

Safe State Alliance: ISW8 Pedestrian Injury Surveillance includes 10 recommendations for improving pedestrian injury surveillance, including more comprehensive conceptual and operational definitions and strategies for enhancing pedestrian injury data collection and analysis.[16]

America Walks Fact Sheets offers information on safety, health, social equity, transportation, and economic benefits of walking.[62]

AARP Livability Fact Sheets helps community leaders, policy makers, citizen activists and others to learn about and explain what makes a city, town, or neighborhood a great place to live.[63]

The National Complete Streets Coalition of Smart Growth America serves as a leading organization on the topic of complete streets and hosts a number of resources, tools, and examples to help agencies develop streets that work for everyone.[8]

US Access Board provides guidelines and standards for accessibility in the public rights-of-way and on shared use paths.[64]

Transportation Research Board National Cooperative Highway Research Program (NCHRP) Research Report 893: Systemic Pedestrian Safety Analysis provides a safety analysis method that can be used to proactively identify sites for potential safety improvements based on specific risk factors for pedestrians.[38]

National Transportation Safety Board: Pedestrian Safety investigates pedestrian fatalities and provides recommendation to improve safety.[29]

US Department of Transportation, National Highway Traffic Safety Administration: Traffic Safety Facts- Pedestrians 2017 Data provides information on fatal motor vehicle crashes and fatalities based on data from the Fatality Analysis Reporting System.[23]

PBIC: Lighting Strategies to Improve Pedestrian Safety Webinar offers strategies for lighting improvements and coordination. [65]

PEDSAFE: Lighting and Illumination provides information about lighting as a countermeasure, including considerations, costs, and case studies.[66]

Institute of Transportation Engineers Journal: Speed Kinetic Energy, and the Safe Systems Approach to Safer Roadways discusses the need to address kinetic energy reduction as a central, organizing principle to shift the traffic safety paradigm and put principles into practice.[67]

American Automobile Association (AAA) Foundation for Traffic Safety: Impact Speed and a Pedestrian's Risk of Severe Injury or Death examines how vehicle speed influences the probably that a pedestrian struck by a vehicle will sustain severe injuries or die.[40]

World Health Organization: Managing Speed demonstrates how excessive and inappropriate speed is among the key risks for road traffic deaths and injuries worldwide and illustrates how safe speeds are among main components of a "safe systems approach" to road safety.[68]

FWHA Every Day Counts Safe Transportation for Every Pedestrian (STEP) program provides guidance on implementing speed- and crash-reducing pedestrian safety countermeasures, such as road diets and raised crosswalks.[69]

Speed Management Program Plan advances six inter-related focus areas to manage traffic speeds, including: data and data-driven approaches; research and evaluation; technology; enforcement and adjudication; engineering; education and communications.[70]

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Since its inception in 1999, the Pedestrian and Bicycle Information Center's mission has been to improve the quality of life in communities through the increase of safe walking and bicycling as a viable means of transportation and physical activity. The Pedestrian and Bicycle Information Center is maintained by the University of North Carolina Highway Safety Research Center with funding from the U.S. Department of Transportation Federal Highway Administration.