

Consensus Recommendations for Pedestrian Injury Surveillance

March 2017

Report from the Injury Surveillance Workgroup 8 (ISW8)



SAFE STATES



About the Safe States Alliance

The Safe States Alliance is a national non-profit organization and professional association whose mission is to strengthen the practice of injury and violence prevention.

To advance this mission, Safe States Alliance engages in activities that include:

- Increasing awareness of injury and violence throughout the lifespan as a public health problem;
- Enhancing the capacity of public health agencies and their partners to ensure effective injury and violence prevention programs by disseminating best practices, setting standards for surveillance, conducting program assessments, and facilitating peer-to-peer technical assistance;
- Providing educational opportunities, training, and professional development for those within the injury and violence prevention field;
- Collaborating with national organizations and federal agencies to achieve shared goals;
- Advocating for public health policies to advance injury and violence prevention;
- Convening leaders and serving as the voice of injury and violence prevention programs within state health departments; and
- Representing the diverse professionals within the injury and violence prevention field.

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Disclaimer: *The opinions, findings, and conclusions expressed in this publication are solely those of the authors. They do not necessarily represent the official positions of the Safe States Alliance, the National Highway Traffic Safety Administration (NHTSA), or any agencies affiliated with individual authors.*

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Members of the Injury Surveillance Workgroup 8

Since 2001, the Safe States Alliance has convened multidisciplinary groups of experts to recommend improvements to important public health injury surveillance practices. Its eighth group of experts – known as the Injury Surveillance Workgroup 8 (ISW8) – represented organizations from across the United States that research, implement, and/or influence efforts associated with injury surveillance and pedestrian safety. Over the course of three years, members of the ISW8 graciously contributed their time, efforts, and energy to collaboratively develop this report and are acknowledged below.

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Preface

The Safe States Alliance Injury Surveillance Workgroup 8 (ISW8) initiated its work in the spring of 2014. Our goal was to develop a more comprehensive, conceptual and operational definitions related to pedestrian injury, as well as make recommendations for improving pedestrian injury surveillance. This report, along with the surveillance methods and tools contained herein, was designed to support injury prevention professionals across the fields of public health and transportation with standardizing their efforts to conduct surveillance on pedestrian injury and to better equip them to design and evaluate interventions aimed at pedestrian injury prevention.

This consensus report is a result of a fruitful and collaborative effort between pedestrian safety experts across many disciplines and backgrounds. To initiate the process, the ISW8 identified key tasks that were addressed by seven task groups. The task groups held regular meetings, developed content, and reported back to the full ISW8 during all-member calls. As the work evolved, the tasks converged into the text that now comprises this document.

The next phase of the work was to develop consensus recommendations through collaboration, cooperation, and inclusivity. This was accomplished by identifying a draft set of consensus recommendations developed by the task groups and individual workgroup members. The draft recommendations were then evaluated by each member of ISW8 according to an agreed-upon criteria. Based on cumulative evaluations, we refined the set of recommendations that are included in this report.

While the report is not free from limitations,

the ISW8 members and I feel that it makes a significant contribution to pedestrian injury surveillance by providing insights regarding the scope, definitions, and ways to conduct surveillance. We hope this information, along with the consensus recommendations, will provide agencies with the much-needed "traction for action" to accomplish their mission in preventing pedestrian injuries.

I'm grateful for the opportunity to lead this effort, and I'm indebted to the ISW8 members and the Safe States Alliance team for their outstanding contributions.

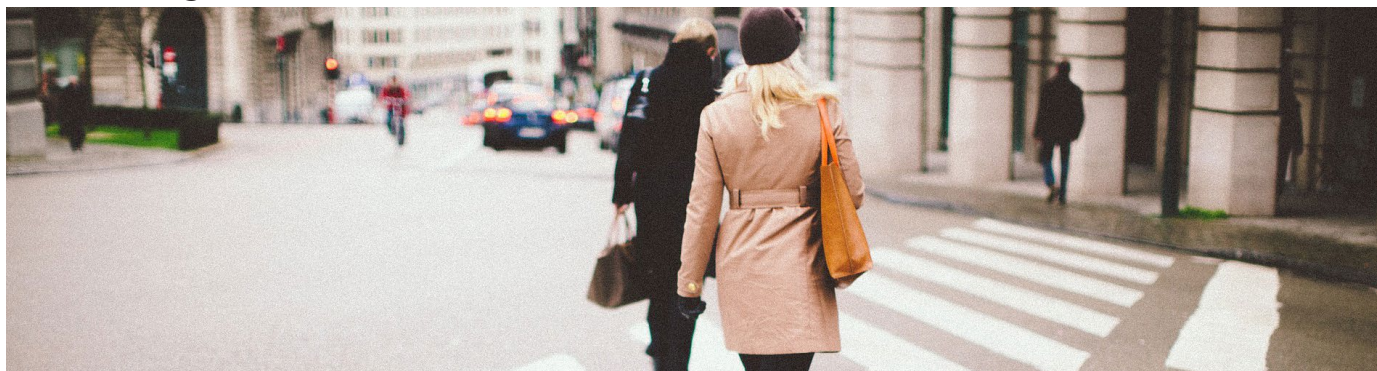


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Executive Summary

Walking is the most fundamental mode of transportation, and at some point each day, everyone is a pedestrian. Walking is always a part of a trip, even if it primarily involves driving, cycling, or using public transportation. However, pedestrians are one of the most vulnerable road users. **Pedestrian fatalities have become an increasingly larger proportion of all traffic fatalities, steadily growing from 11% to 15% of all traffic deaths over the last 10 years (2006 - 2015)** (NCSA, 2016a; NCSA, 2016b).

The immense societal burden of pedestrian injuries and fatalities – coupled with existing gaps in pedestrian injury surveillance – warrant improvements in better defining, detecting, and measuring pedestrian injuries to ultimately prevent these injuries and deaths. **The purpose of this report is to provide practitioners with recommendations for improving pedestrian injury surveillance, data analysis, and reporting.** To this end, this report puts forth a variety of helpful elements, including:

- New consensus definitions of “pedestrian” and “pedestrian injury” for public health surveillance purposes;
- A summary of data sources relevant to pedestrian injury surveillance in the United States, including their strengths and limitations;
- A summary of data sources relevant to the analysis of pedestrian exposure and risk;
- A basic overview of important pedestrian injury and risk variables;

- An overview of methods that can be used to analyze pedestrian injury data, ranging from simple to more complex analyses of pedestrian injury;
- Case studies that demonstrate practical uses of pedestrian injury surveillance data; and
- Consensus recommendations to improve pedestrian injury surveillance.

This report also examines various challenges that may be encountered when conducting pedestrian injury surveillance, including those associated with quantifying pedestrian exposure, working with stakeholders, and interpreting pedestrian injury surveillance data.



New Consensus Definitions of “Pedestrian” and “Pedestrian Injury”

A **pedestrian** is any person on foot, walking, running, jogging, hiking, standing, sitting, lying down, or in a manually or mechanically propelled wheelchair (but not riding in or on a motor vehicle, railway train, streetcar, pedalcycle, animal, animal-drawn vehicle, or other vehicle) on a public road, in the public right of way, or in a parking lot.

A **pedestrian injury** occurs when a pedestrian sustains bodily harm in an unintentional motor vehicle traffic crash with one or more vehicles or pedalcycles.

Summary of Data Sources

Thirteen databases for pedestrian injury (Appendix A.1) and four databases for pedestrian exposure (Appendix A.3) in the U.S. were identified. Detailed descriptions of these databases (e.g., geographic scope, years of data, availability, and contact information) and details of their strengths and limitations are included in this report.

Case Studies

Three case studies are presented as illustrative examples of how pedestrian injury data can be analyzed, using a range of methodological approaches and key variables to inform injury prevention efforts.

Pedestrian Injury and Risk Analytical Methods

The extent of analyses can be shaped by a variety of factors, including the quality and robustness of the available data as well as available time, resources, and capacity. Pedestrian injury surveillance and data analysis are fields that are particularly suitable for interdisciplinary collaboration with respect to data methods and interpretation. This report includes detailed case studies and metrics that should be considered when reporting pedestrian injury and risk.



Consensus Recommendations for Improving Pedestrian Injury and Risk Surveillance



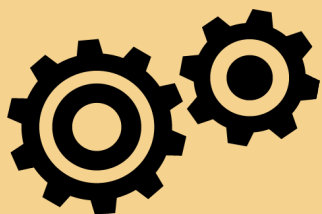
Recommendations for Enhancing Definitions of “Pedestrian” and “Pedestrian Injury”

1. **Use the definitions for “pedestrian” and “pedestrian injury” established by this report.** All state, regional, and local agencies that collect and analyze pedestrian injury surveillance data should use the consensus definitions of “pedestrian” and “pedestrian injury” established by this report.
2. **Train all primary collectors of pedestrian injury data.** To ensure that the definitions of “pedestrian” and “pedestrian injury” established by this report are used consistently, training should be provided to all to primary collectors of pedestrian injury data, including (but not limited to): state and local health departments; state and local transportation agencies; state and local law enforcement agencies; hospitals, emergency departments, and other medical facilities; and federal agencies (e.g., NHTSA and CDC).



Recommendations for Improving Pedestrian Injury Data

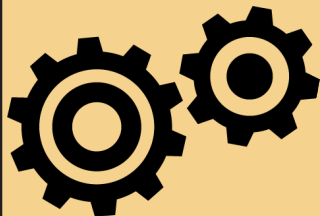
3. **Collaborate to link data across multiple sources.** When possible, primary collectors of pedestrian injury data at state, regional, and local levels (e.g., health departments, transportation agencies, health care organizations, and law enforcement agencies) should work collaboratively to link data across multiple sources (e.g., behavioral surveys, traffic reports, emergency room data, and police reports) to generate a robust and comprehensive dataset of variables to inform pedestrian injury prevention research, programs, and policies.



Recommendations for Utilizing Pedestrian Exposure and Risk Data

4. **Establish working contacts with partner organizations that manage injury and exposure data.** Agencies responsible for conducting pedestrian injury surveillance should establish working contacts with partner organizations responsible for managing injury and exposure data, including (but not limited to): state and federal departments of transportation, law enforcement agencies, metropolitan planning organizations, and public health entities.
5. **Include estimates of pedestrian injury exposure so that risk can be calculated.** To support the comparison of pedestrian injury trends across groups and geographies, injury prevention and traffic safety professionals should include estimates of pedestrian injury exposure so that risk can be calculated. If definitive exposure measures are unavailable, consider using existing, publicly available proxy measures of pedestrian exposure to estimate risk and acknowledge the limitations thereof.

Consensus Recommendations for Improving Pedestrian Injury and Risk Surveillance



Recommendations for Utilizing Pedestrian Exposure and Risk Data (Continued)

6. **Make pedestrian-specific data collection a routine part of transportation data collection.** To increase availability of exposure measures, agencies conducting pedestrian injury surveillance should make pedestrian-specific data collection a routine part of transportation data collection by obtaining funding and/or collaborating with partner agencies that are collecting these data. Examples of data collection tools include: National Household Travel Survey (NHTS) add-ons; travel studies/surveys conducted by Metropolitan Planning Organizations or other regional agencies; count programs (automated and/or manual); and emerging data sources (e.g., app/crowd-sourced data).



Recommendations for Analyzing Pedestrian Injury Data

7. **Collect or access data on variables that describe key characteristics of the injury.** Analysts or teams working on pedestrian injury surveillance projects should collect or access data on variables that describe key characteristics of the injury, including: factors that occur before, during, and after the event; variables that describe pedestrian and driver behavior; and the social and physical environment.
8. **Map and conduct spatial analyses of pedestrian injuries.** To focus prevention efforts, users of pedestrian injury data should map and conduct spatial analyses of pedestrian injuries by city, zip code, corridor, intersection, or other geographic units to determine spatial patterns and clusters of pedestrian injuries.
9. **Collaborate regularly across disciplines to analyze, interpret, disseminate, and utilize pedestrian injury data.** State, regional, and local professionals across the many disciplines responsible for pedestrian injury prevention and safety – e.g., public health, transportation, engineering, planning, law enforcement, education, health care, and public policy – should collaborate regularly to: analyze and interpret pedestrian injury data; disseminate data widely to key audiences; and utilize data to inform and advance prevention efforts.
10. **Publish and disseminate useful approaches to data analysis to inform injury prevention initiatives.** Analysts or teams working on pedestrian injury surveillance projects should publish and disseminate useful approaches to data analysis to inform injury prevention initiatives, such as case studies, to help advance the practical application of surveillance data.

Intended Users of the ISW8 Report

Primary audiences for this report include state and local public health injury prevention professionals (e.g., epidemiologists and program directors) and state traffic safety professionals (e.g., state highway traffic safety offices, state departments of transportation, and local public works departments). Secondary audiences for this document are injury prevention researchers, special interest groups (e.g., livable community groups, pedestrian safety groups, Metropolitan Planning Organizations (MPOs), and safety planning commissions), public health and public safety decision makers, policymakers, and law enforcement agencies.

Primary audiences can use this report to determine the content and quality of pedestrian injury data sources and determine appropriate ways to present and analyze pedestrian injury and risk data for a variety of purposes and for different groups. Secondary groups can also use this document to assist with the interpretation of pedestrian injury data and obtain examples of how to implement surveillance recommendations based on the data availability and findings. Table 1 summarizes the intended users and audiences for of this report.

Table 1. Intended Users: Primary and Secondary Audiences

Intended Users	Primary Audiences
	<ul style="list-style-type: none"> • State and local injury prevention professionals, including: <ul style="list-style-type: none"> ◦ Epidemiologists ◦ Program directors • Traffic safety professionals, including staff at: <ul style="list-style-type: none"> ◦ State highway traffic safety offices ◦ State departments of transportation ◦ State agencies that house traffic data ◦ Local public works departments
	Secondary Audiences
	<ul style="list-style-type: none"> • Injury prevention researchers • Livable community groups • Metropolitan Planning Organizations (MPOs) • Pedestrian safety groups <ul style="list-style-type: none"> ◦ Vision Zero groups • Policymakers at state, regional, and local levels <ul style="list-style-type: none"> ◦ Planning commissions ◦ Public health decision-makers • Law enforcement

Introduction



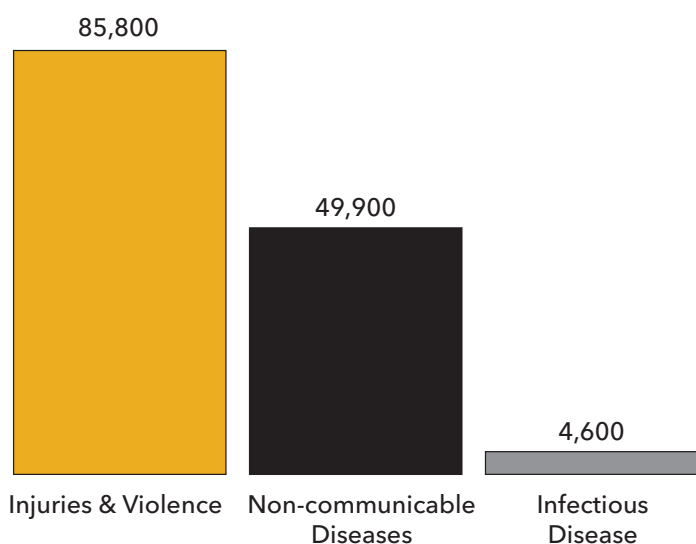
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The Burden of Pedestrian Injury

"Injury" is defined as "bodily harm resulting from severe exposure to an external force or substance (mechanical, thermal, electrical, chemical, or radiant) or a submersion" (CDC, 2007). Injuries can range from minor to fatal and may have consequences that translate beyond the single individual and physical health repercussions. Depending on the severity, injuries may contribute to chronic physical and mental health conditions extending beyond the initial incident. The impact of injuries can extend into multiple dimensions, and can have long-term effects on the quality of life for individuals, families, communities, and society. Injury contributes to and impacts productivity, medical costs, legal and court costs, property damage, emergency services, travel delays, and workplace losses (Chakravarthy, Lotfipour, & Vaca, 2007).

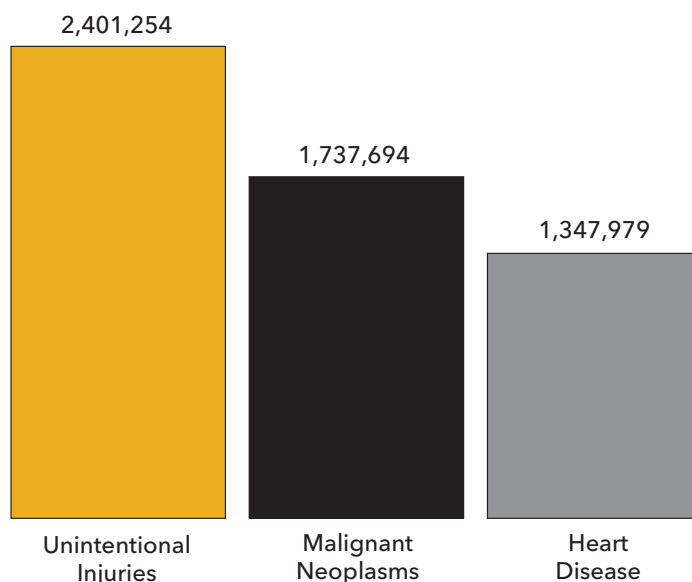
Injuries - including unintentional injuries, as well as those resulting from violence - have been the leading cause of death for persons ages 1-44 in the United States for more than three decades (CDC, 2016a). In 2015, injuries and violence accounted for nearly 86,000 deaths among those ages 1-44 - nearly twice as many deaths caused by non-communicable diseases and nearly 20 times as many deaths as those caused by infectious diseases (Figure 1A) (CDC, 2016a). Injuries from all intents accounted for a total of 2,401,254 years of potential life lost (YPLL) in 2015; by comparison, malignant neoplasms accounted for 1,737,694 YPLL and heart disease accounted for 1,347,979 YPLL (Figure 1B) (CDC, 2016b). As of 2013, the total lifetime medical and work loss cost of injuries and violence in the United States was \$671 billion (CDC, 2016c).

Figure 1A. Injury Deaths Compared to Other Causes of Death for Persons Ages 1-44, United States, 2015



Source: CDC, 2016a

Figure 1B. Years of Potential Life Lost (YPLL) by Cause of Death: United States, 2015



Source: CDC, 2016b

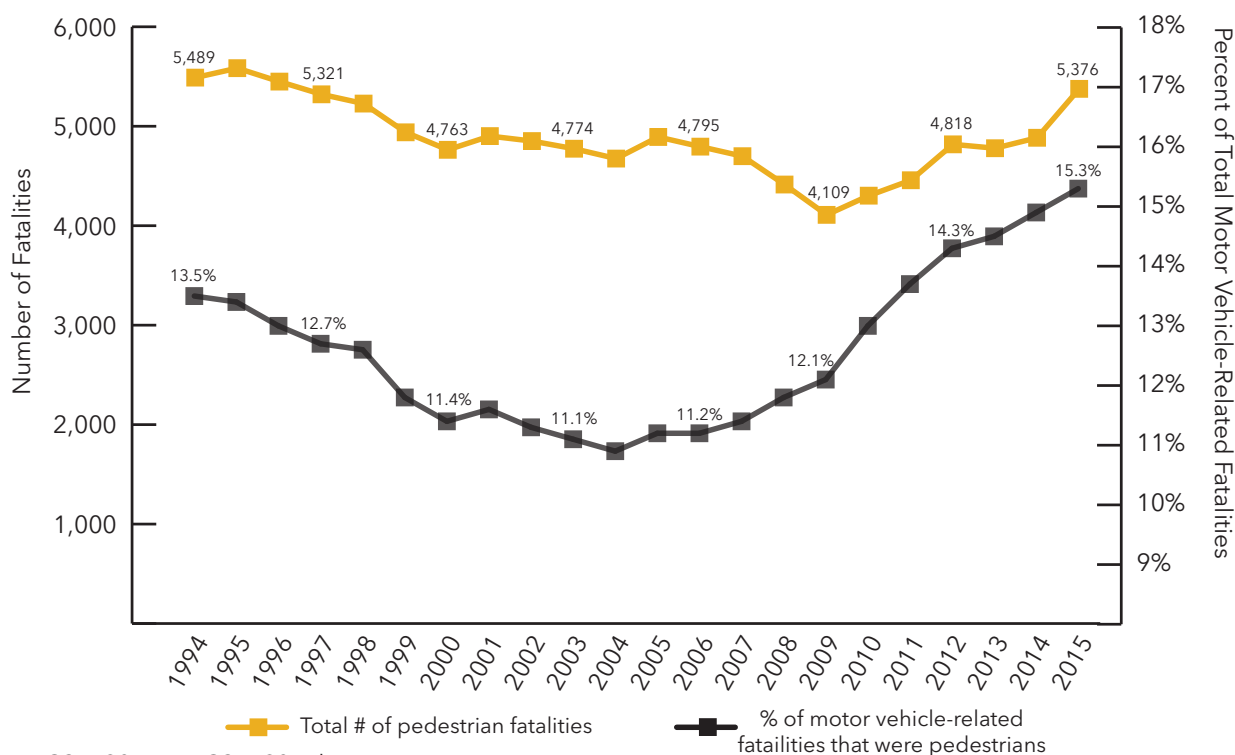
Motor vehicle crashes are a leading cause of unintentional injuries in the United States (CDC, 2016d). In 2015, 35,092 motor vehicle fatalities and an estimated 2,443,000 motor vehicle injuries occurred in the United States (NCSA, 2016a). However, as reflected in Figure 2, pedestrian fatalities have become an increasingly larger proportion of all traffic fatalities. Based on the last 10 years of data from the U.S. National Highway Traffic Safety Administration (NHTSA), pedestrian deaths have steadily grown from 11% to 15% of all traffic fatalities, resulting in the loss of nearly 50,000 lives from 2006-2015 (NCSA, 2016a; NCSA, 2016b). According to NHTSA (NCSA, 2016a), in 2015 alone:

- 5,376 pedestrians were killed and an estimated 70,000 pedestrians were

injured in traffic crashes throughout the United States.

- Pedestrian fatalities increased by 9.5% between 2014 and 2015, resulting in the highest number of pedestrian deaths since 1996.
- On average, one pedestrian was killed nearly every two hours, and one pedestrian was injured nearly every eight minutes.
- The number of pedestrian fatalities in the United States increased by approximately 31% since 2009 - the year that saw the lowest number of pedestrian fatalities from 1994-2015.

Figure 2: Number of Pedestrian Fatalities and Percent of Total Motor-Vehicle Related Fatalities (1994-2015)



Source: NCSA, 2016a; NCSA, 2016b

Despite the significance of these data, pedestrian injuries and fatalities are less meticulously or consistently monitored, recorded, documented, and linked across multiple data sources compared to other traffic-related injuries. Additionally, acquiring information about walking trends, pedestrians' exposure to potential injury, and the severity of pedestrian injuries that occur also remains a challenge. This challenge often leads to underreporting, variations in reporting system definitions, coding errors, and misclassifications across different agencies. For instance, the definitions of "pedestrian" and "pedestrian injury" vary across agencies and organizations. As a result of having different definitions, NHTSA and CDC report different numbers of pedestrian deaths: NHTSA reported that 5,376 pedestrians were killed in the United States in 2015 (NCSA, 2016a); in contrast, CDC reported an additional 1,302 pedestrian deaths in 2015, for a grand total of 6,678 pedestrian fatalities in the U.S. that same year (CDC, 2017a).

Since 1969, the National Household Travel Survey (NHTS), conducted by the Federal Highway Administration (FHWA), has attempted to accurately capture data related to daily personal travels and the various

modes of travel, including walking. The 2009 NHTS indicated that about 41 billion walking trips of all-purpose types were made in a year over the 2008-2009 survey period (Santos et al., 2011). These 41 billion walking trips represent approximately 10% of all transportation mode trips reported, compared to pedestrian fatalities, which represent 15% of all motor vehicle-related fatalities (NCSA, 2016a). Additionally, the perception of unsafe conditions can limit engagement in healthy activities such as walking, thus having further health impact.

There are many challenges to obtaining reliable data that are necessary to fully understand pedestrian injury, risk, travel, and safety. For instance, calculating pedestrian fatality rates (i.e., pedestrian fatalities per number of walking trips or pedestrian fatalities per miles traveled by walking) is extremely difficult due to the inability to systematically collect and consistently measure walking exposure (NHTSA, 2013). Pedestrian injuries and fatalities are one piece of a larger set of issues related to transportation and safety. Interactions between demographic, behavioral, and environmental risk factors all require further study.

Demographic, Behavioral, and Environmental Risk Factors Impacting Pedestrian Injuries and Fatalities

Pedestrian injury and risk have multiple direct and indirect causes. A consideration of demographic, behavioral, and environmental factors is an important starting point to begin to understand pedestrian injury and fatality risk within complex transportation systems. Pedestrian injury and fatality patterns vary depending on a variety of demographic,

behavioral, and environmental factors. These variables highlight key populations, trends, and variations in factors that are important to understanding the underlying demographic and behavioral components of pedestrian fatalities and injuries across all stages of life and subpopulations.

Age

In 2014, nearly one-fifth (19%) of the children ages 14 and younger killed in traffic crashes were pedestrians. On the other end of the spectrum, older adults ages 60-64 had the highest percentage of pedestrian fatalities (20%) within the adult population (NCSA, 2016b). This increased risk may be influenced by older individuals' having slower reaction times, diminished sensory capabilities, and the state of frailty that comes with age. Overall, the pedestrian fatality trend reflects higher rates of fatalities in middle age groups relative to younger age groups. In 2014, the average age of a pedestrian fatality was 47 years of age and of a pedestrian injury was 37 years of age (NCSA, 2016b).

Gender

More than two-thirds (70%) of pedestrian fatalities were males in 2014, with males having an estimated pedestrian fatality rate of 2.17 per year per 100,000 population and an estimated pedestrian injury rate of 22 per 100,000 population. Females are estimated to have a pedestrian fatality rate of 0.91 per 100,000 population and 19 per 100,000 population pedestrian injury rate (NCSA, 2016b).

Ethnicity and Socioeconomic Status

A number of studies have highlighted the overrepresentation of minorities, immigrants, and low-income populations in vehicle crashes involving pedestrians (Anderson, Vaca, & Chakravarthy, 2010; Chakravarthy et al., 2012; Chen, Lin, & Loo, 2012; Murtha, 2005). While identifying causes and contributing factors resulting in these trends require further in-depth analysis, these studies suggest that underlying environmental justice issues

influence pedestrian fatality and injury patterns (Kravetz & Noland, 2012). Oftentimes these populations reside in geographical areas with poor transportation safety infrastructure, high traffic volumes and speeds, and have high rates of transit use and walking, thus increasing their exposure (Cottrill & Thakuriah, 2010).



Alcohol Impairment

Sociocultural risk factors, including alcohol involvement and impairment, are other common trends emerging from pedestrian fatality and injury data. In 2014, nearly half (48%) of all fatal pedestrian crashes involved alcohol use by the driver and/or the pedestrian (NCSA, 2016b). Further disaggregation of the data highlights the fact that alcohol involvement is an important contributing factor for both pedestrians and drivers. In 2014, 34% of pedestrians involved in fatal crashes had a blood alcohol concentration (BAC) of 0.08 grams per deciliter (g/dL) or higher compared with 14% of drivers involved in these fatal crashes. That same year, the pedestrian age groups with the highest percentage of alcohol impairment (BAC 0.08 g/dL and above) that resulted in a fatality included pedestrians aged 35-44 years (49%), 45-54 years (46%), 25-34 years (45%), and 21-24 years (44%) (NCSA, 2016b). Further information is needed to understand trends regarding other impairments (e.g., recreational drugs, over-the-counter drug use), interaction effects between pedestrians and multiple substance abuse, and how this influences pedestrian behaviors and patterns.

Speed

Motor vehicle speed is a key risk factor in all crashes, however, vehicle speed and a pedestrian's risk of sustaining a severe injury or fatality are highly correlated. Several studies have estimated the risk of pedestrian fatality based on driver impact speeds (Leaf & Preusser, 1999; Rosén & Sander, 2009; Tefft, 2011). According to Tefft (2011), a pedestrian struck by a vehicle traveling at 46 miles per hour (mph) or greater will have 90% chance of severe or fatal injury; however, if struck 23 mph or below, the pedestrian's chances of sustaining a severe or fatal injury drops to 10% (Table 2). In addition to the increased fatality risk, as vehicle speed increases, drivers tend to less frequently yield for pedestrians in crosswalks (Gårder, 2004; Bertulis & Dulaski, 2014).

Table 2. Average Risk of Severe or Fatal Injury for Pedestrians Struck by a Vehicle at Various Speeds

	10%	25%	50%	75%	90%
Chance of severe injury for pedestrian struck by a vehicle	16mph	23mph	31mph	39mph	46mph
Chance of fatal injury for pedestrian struck by a vehicle	23mph	32mph	42mph	50mph	58mph

Source: Tefft, 2011

Distraction: Electronic Device Use

The impact of electronic device use by pedestrians on pedestrian distraction has been the subject of limited research. Several studies have investigated the effects of electronic device use on distraction in naturalistic environments. For example, Nasar, Hecht, and Wener (2008) and Hatfield and Murphy (2007) found that cell phone users crossed more unsafely than other pedestrians. Thompson, Rivara, Ayyagari, and Ebel (2013) also found phone use and texting to be associated with slower lane crossing times. In addition, a recent study of pedestrians treated in emergency room departments in New York City found that teenagers were twice as likely to be using an electronic device when struck by a car (Glass et al., 2014). Driver distraction also plays a role in pedestrian crashes. In 2014, 13% of all people killed in distraction-affected crashes were pedestrians (NCSA, 2016c).

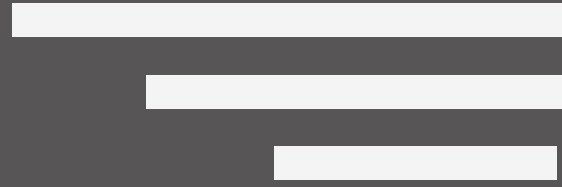
Physical and Built Environments

Environmental and engineering factors also play a critical role in influencing pedestrian behaviors. These environmental factors, including both the physical and built environment, may directly influence pedestrian behaviors.

Brown et al. (2013) found that greater population density is correlated with moderate to vigorous physical activity, which has been linked to a host of health benefits, ranging from reduced risk of chronic diseases to improvements in overall health (CDC, 2017b). However, pedestrian injury is particularly problematic in dense urban environments, with rates proportionate to urban density. Approximately 78% of pedestrian fatalities occur in urban locations compared to rural locations (NCSA, 2016b). In 2014, among

U.S. cities with a population of 500,000 or greater, New York City accounted for the largest proportion of pedestrian fatalities relative to all traffic fatalities at 50.4% (NCSA, 2016b). Traffic density is an underlying urban risk factor that increases exposure to more vehicles (AASHTO, 2010; Bhatia & Wier, 2011); yet, a greater number of vehicles and the accompanying congestion are also associated with decreased speeds. While urban areas may account for the large majority of deaths and injuries, the severity of a pedestrian injury may be greater in more rural areas due in part to higher vehicle speeds, lack of adequate pedestrian infrastructure (e.g., sidewalks) to physically separate pedestrians and cars, and longer distances to emergency care services (Mueller, Rivara, & Bergman, 1988; Harkey & Zegeer, 2004).

Additional environmental risk factors for pedestrian injuries have also been associated with multi-family dwellings (Mueller et al., 1990), lack or scarcity of playgrounds (Backett & Johnston, 1997; Durkin et al., 1999; Mueller et al., 1990), the presence and proximity of major roadways (Pitt, Guyer, Hsieh, & Malek, 1990; Routledge, Repetto-Wright, & Howarth, 1996), and traffic volume (AASHTO, 2010; Bhatia & Wier, 2011).



Enhancing Definitions of "Pedestrian" and "Pedestrian Injury"



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Pedestrian injury surveillance generally involves counting instances of a fatal or non-fatal transportation-related injury. As stand-alone counts, these figures can reveal absolute safety impacts and are the ultimate purpose of such efforts. However, injury counts can also be used to express pedestrian

safety in terms of the rate of injuries per unit of pedestrian exposure, which is referred to as pedestrian injury risk.

This section focuses on the process and outcome of developing definitions to enhance pedestrian injury surveillance.

Definitions of "Pedestrian" and "Pedestrian Injury"

The definitions of a "pedestrian" and a "pedestrian injury" are not consistent across agencies and the corresponding data sources maintained by these agencies. The discrepancies are derived from the functional uses of the data. The table below summarizes

the definitions of "pedestrian" that are found in NHTSA's "Traffic Safety Facts" publications, CDC's Web-based Injury Statistics Query and Reporting System (WISQARS), and the World Health Organization's (WHO) International Classification of Diseases (ICD).

Table 3. Data Sources and Definitions of "Pedestrian"

Source	Definition of "Pedestrian"
Traffic Safety Facts ¹	Any person not in or upon a motor vehicle or other vehicle.
Traffic Safety Facts ²	Any person on foot, walking, running, jogging, hiking, sitting or lying down who is involved in a motor vehicle traffic crash.
WISQARS ³	Pedestrian (struck by or against a vehicle): Injury to a person involved in a collision, where the person was not at the time of the collision riding in or on a motor vehicle, railway train, motorcycle, bicycle, airplane, streetcar, animal-drawn vehicle, or other vehicle. This category includes persons struck by cars, pickup trucks, vans, heavy transport vehicles, buses, and SUVs. This category does not include persons struck by other vehicles such as motorcycles, trains, or bicycles; these cases fall in the category of "other transport."

¹ National Center for Statistics and Analysis (2016). Traffic Safety Facts 2014: A Compilation of Motor Vehicle Crash Data from the Fatality Analysis Reporting System and the General Estimates System. Report no. DOT HS 812 261. National Highway Traffic Safety Administration. U.S. Department of Transportation. Retrieved from <https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812261>.

² National Center for Statistics and Analysis (2016). "Pedestrians."Traffic Safety Facts: 2014 Data. Report no. DOT HS 812 270, May 2016. National Highway Traffic Safety Administration, U.S. Department of Transportation. Retrieved from <https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812270>.

³ Nonfatal data: The National Electronic Injury Surveillance System-All Injury Program (NEISS-AIP) hospitals provide data from about 500,000 injury-related emergency department (ED) cases annually. Fatal data: Death data come from a national mortality database compiled by CDC's National Center for Health Statistics. This database contains information from death certificates filed in state vital-statistics offices and includes causes of death reported by attending physicians, medical examiners, and coroners. It also includes demographic information about decedents reported by funeral directors, who obtain that information from family members and other informants. Definitions for WISQARS "Cause of Injury Categories" and "Subcategories of Transportation-Related Causes" are available from the Centers for Disease Control and Prevention, National Center for Injury Prevention and Control: <https://www.cdc.gov/ncipc/wisqars/nonfatal/definitions.htm>

Source	Definition of "Pedestrian"		
ICD-9 ⁴	Any person involved in an accident who was not at the time of the accident riding in or on a motor vehicle, railroad train, streetcar, animal-drawn or other vehicle, or on a bicycle or animal. It includes a person:		
	1. Changing tire of vehicle 2. In or operating a pedestrian conveyance, defined as any human powered device by which a pedestrian may move other than by walking or by which a walking person may move another pedestrian, including:		
	a. baby carriage b. coaster wagon c. heelies, wheelies d. ice skates e. perambulator	f. pushcart g. pushchair h. roller skates i. scooter	j. skateboard k. skis l. sled m. wheelchair
	3. Making adjustment to motor of vehicle, and 4. Being on foot		
ICD-10 ⁵	Any person involved in an accident who was not at the time of the accident riding in or on a motor vehicle, railway train, streetcar or animal-drawn or other vehicle, or on a pedal cycle or animal. It includes:		
	1. Person: a. changing tire of vehicle b. making adjustment to motor of vehicle c. on foot 2. User of a pedestrian conveyance such as:		
	a. baby carriage b. ice-skates c. perambulator d. push-cart	e. push-chair f. roller-skates g. scooter h. skateboard	i. skis j. sled k. wheelchair (powered)
	Mechanism of pedestrian injury or fatality	Intent of injury or fatality: All injury	Intent of injury or fatality: Unintentional
	<i>Motor Vehicle Traffic</i>	[V02-V04](.1,.9), V09.2	[V02-V04](.1,.9), V09.2
	<i>Non-Traffic</i>	V01, [V02-V04](.0), V05, V06, V09(.0-.1,.3,.9)	V01, [V02-V04](.0), V05, V06, V09(.0-.1,.3,.9)

⁴ Centers for Disease Control and Prevention, National Center for Health Statistics. International Classification of Diseases, Ninth Revision (ICD-9), Volume 1. Retrieved from: http://ftp.cdc.gov/pub/Health_Statistics/NCHS/Publications/ICD-9/ucod.txt

⁵ World Health Organization, International Classification of Diseases, Tenth Revision (ICD-10). "Definitions related to transport accidents." Retrieved from: <http://apps.who.int/classifications/apps/icd/icd10online2006/defs.htm>

Using these foundational definitions, we recommend the following consensus definitions of a "pedestrian" and "pedestrian injury":



A **pedestrian** is any person on foot, walking, running, jogging, hiking, standing, sitting, lying down, or in a manually or mechanically propelled wheelchair (but not riding in or on a motor vehicle, railway train, streetcar, pedalcycle, animal, animal-drawn vehicle, or other vehicle) on a public road, in the public right of way, or in a parking lot.

A **pedestrian injury** occurs when a pedestrian sustains bodily harm in an unintentional motor vehicle traffic crash with one or more vehicles or pedalcycles⁶.

This definition of a "pedestrian" blends those established by experts from the fields of health and transportation. For practical surveillance purposes, this definition is linked with the definitions of "pedestrian injury" used by potential data sources. Users of most pedestrian "conveyances"⁷ – as defined in ICD-9 and ICD-10 – were also excluded from the "pedestrian" definition. The rationale for this decision was two-fold: (1) The needs of individuals using most pedestrian conveyances are often different than the needs of the average pedestrian on foot or in a wheelchair; and (2) Excluding most conveyances allowed the definition of "pedestrian" to be as simple and narrow as possible.

Excluded from the definition of "pedestrian injury," though debated, were non-vehicle related pedestrian injuries (e.g., trips/falls, collisions with another pedestrian). Historically these types of injuries have not been included in any of the data sources commonly used for pedestrian injury surveillance; including them in this definition for injury surveillance purposes, would result in considerable discrepancies between the recommendations in this report and the fields of pedestrian safety

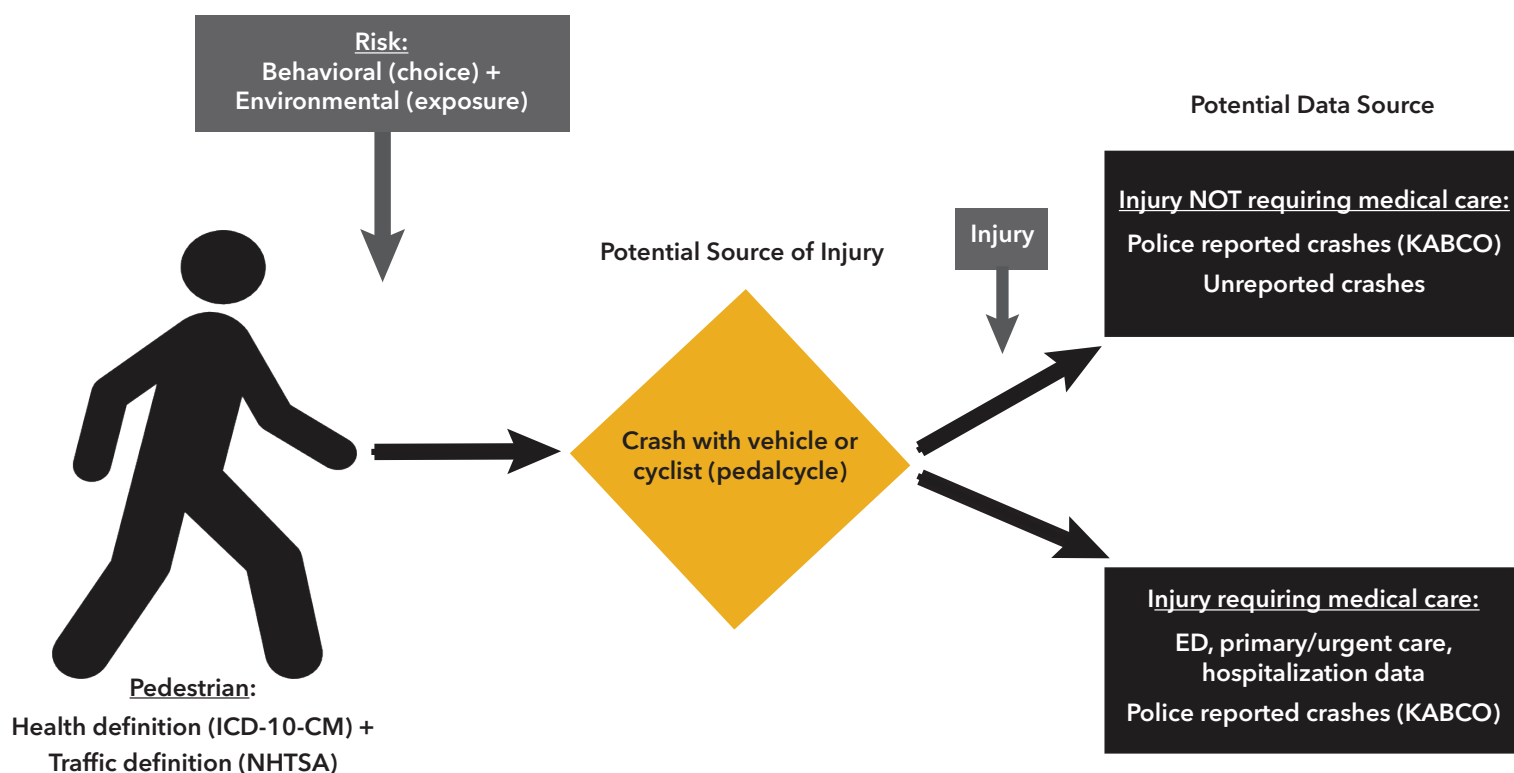
and injury prevention. Moreover, many of the evidence-based strategies for fall prevention (e.g., medication review and strength and balance training) are not part of the inventory of countermeasures available in transportation safety. As the American society ages, this may become an issue with a unique set of countermeasures. However, for the purposes of this report, such non-vehicle related injuries were excluded.

The following diagram (Figure 3) depicts a conceptual model that guided the work of the ISW8. In the model, pedestrian injury results from individual choice (behavioral) in response to exposure to structural conditions ("environment"). These structural conditions, such as sidewalks, crosswalks, and roadway design, encourage a behavioral response by way of their design features. A pedestrian may be exposed to structural conditions that encourage unsafe behaviors. Alternatively, pedestrians may put themselves at risk despite being exposed to safe structural conditions. A "pedestrian injury," for the purpose of this report, results from conflicts between pedestrians and motor vehicles or pedalcycles.

⁶ NHTSA defines "pedalcycles" as "two-wheel, nonmotorized vehicles, tricycles, and unicycles powered solely by pedals" (NCSA, 2016d).

⁷ A conveyance is defined as a "device by which a pedestrian may move other than by walking or by which a walking person may move another pedestrian." (Buck, 2015).

Figure 3. ISW8 Conceptual Model of Pedestrian Injury



A conceptual model of pedestrian injury, including sources of injury and data.

ICD = International Statistical Classification of Diseases; NHTSA = National Highway Traffic Safety Administration; KABCO = KABCO injury scale (K - Fatal, A - Incapacitating injury, B - Nonincapacitating injury, C - Possible injury, and O - No injury); ED = Emergency Department

Pedestrian Exposure and Injury Risk

While the general definition of "injury" has been largely well-understood by practitioners, the concepts of "exposure" and "risk" are much less well-defined. Pedestrian injury surveillance commonly involves counting instances of injury or death. Individually, these figures can reveal absolute safety impacts and are the ultimate purpose of such efforts. However, injury counts can also be used to express pedestrian safety in terms of the rate of injuries per unit of pedestrian exposure, which in the context of this report, is meant as exposure to injury risk. In other words, the

use of exposure allows us to calculate to what extent pedestrians are likely to experience an injury.

"Exposure" is defined as "the condition of being subject to some detrimental effect or harmful condition" (Merriam-Webster, 2017). For transportation applications, the pertinent "condition" is a trip or journey. Several constructs can be used to quantify trip-based exposure to the possibility of pedestrian injury. These include, but are not limited to, the number of walking trips, miles walked, minutes walked, or the count of pedestrians

within the scope of the study (Beck, Dellinger & O'Neil, 2007; Guler & Grembek, 2016).


Accordingly, a corresponding definition of "pedestrian exposure" is as follows:

Pedestrian exposure is an observable period or point during which a pedestrian experiences the possibility of suffering an injury related to the act of being a pedestrian.

Once quantified, the estimated exposure provides the denominator for calculating the rate of pedestrian injury per unit of exposure. This rate also provides an estimate of pedestrian injury risk, which is the probability of injury per unit of exposure (Figure 4). While a linear relationship between outcome and exposure is often assumed, it should be noted that pedestrian injuries per unit of exposure may reduce as the exposure increases and exhibit a non-linear relationship - e.g., the safety-in-numbers phenomenon (Jacobsen, 2003).

Figure 4. Equation for Pedestrian Injury Rate or Risk

$$\text{Pedestrian Injury Rate or "Risk"} = \frac{\text{Pedestrian Injury}}{\text{Exposure}}$$

Recommendations for Enhancing Definitions of "Pedestrian" and "Pedestrian Injury"	
	<ul style="list-style-type: none"> • Use the definitions for "pedestrian" and "pedestrian injury" established by this report. All state, regional, and local agencies that collect and analyze pedestrian injury surveillance data should use the consensus definitions of "pedestrian" and "pedestrian injury" established by this report.
	<ul style="list-style-type: none"> • Train all primary collectors of pedestrian injury data. To ensure that the definitions of "pedestrian" and "pedestrian injury" established by this report are used consistently, training should be provided to all to primary collectors of pedestrian injury data, including (but not limited to): state and local health departments; state and local transportation agencies; state and local law enforcement agencies; hospitals, emergency departments, and other medical facilities; and federal agencies (e.g., NHTSA and CDC).



Improving Pedestrian Injury Data



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There are a variety of pedestrian injury data sources that are useful for public health surveillance of pedestrian injury. These data sources provide absolute numbers of fatal and nonfatal injuries, and can be used as the numerator to calculate pedestrian injury prevalence rates. However, counts of pedestrian injuries and fatalities can be useful without an accompanying exposure measurement. Several cities, for instance, have adopted the goal of zero traffic fatalities through the “Vision Zero” project – a multi-national and multi-city initiative that considers the loss of any life to be unacceptable and aims to eliminate all fatal and serious traffic

crashes (City of New York, 2015; City of San Francisco, 2015; City of Seattle, 2015).

Trends in total counts of pedestrian injuries and fatalities may be useful for allocating emergency response resources or documenting areas where engineering countermeasures are needed to reduce the overall burden of injuries. In these situations, the underlying reason for changes in pedestrian injury is less important than placing resources where they are needed most: areas with high pedestrian injury or fatality counts (Los Angeles Walks, 2015).

Pedestrian Injury Data Sources

Table 4 provides a list of thirteen pedestrian injury data sources. Although comprehensive, this list of data sources (presented alphabetically) is not meant to be exhaustive.

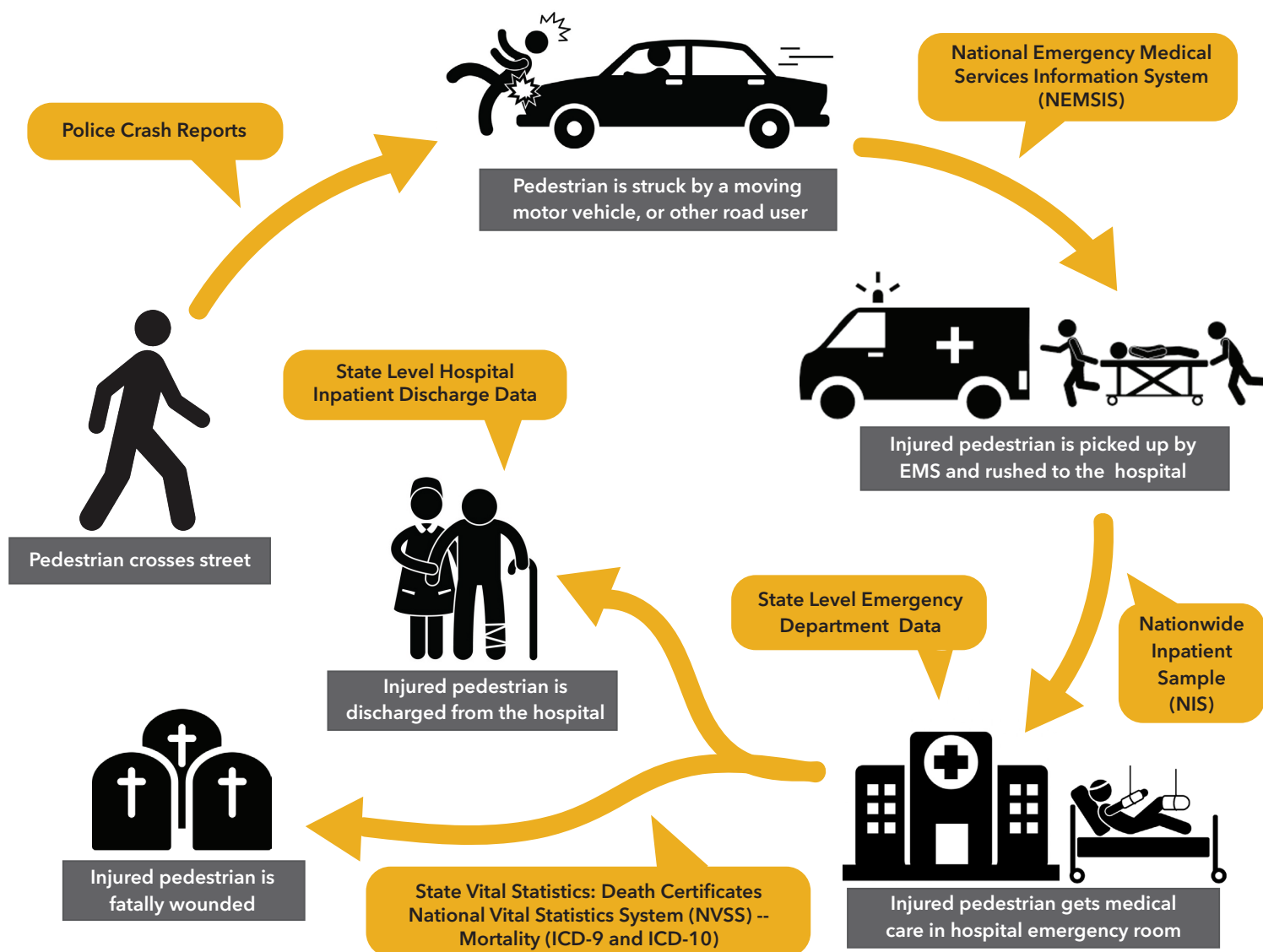
However, these data sources can each provide useful information (as the numerator) to help calculate the burden of pedestrian injuries and fatalities.

Table 4. Sources of Pedestrian Injury Data

1. Fatality Analysis Reporting System (NHTSA)	7. Nationwide Emergency Department Sample (NEDS)
2. General Estimates System (GES) (NHTSA)	8. Police Crash Reports
3. National Ambulatory Medical Care Survey/National Hospital Ambulatory Medical Care Survey	9. State Level Emergency Department Data
4. National Emergency Medical Services Information System (NEMSIS)	10. State Level Hospital Inpatient Discharge Data
5. Nationwide Inpatient Sample	11. State Vital Statistics: Death Certificates
6. National Vital Statistics System	12. WONDER (Wide-ranging Online Data for Epidemiologic Research)
	13. WISQARS (Web-based Injury Statistics Query and Reporting System) (CDC)

Figure 5 illustrates the variety of data sources available for events that occur during and after a pedestrian injury.

Figure 5. Pedestrian Injury Data Sources by Incident Phase



Summary tables in Appendix A.1 provide details regarding all 13 pedestrian injury data sources and include information that can help potential users make an initial determination about the usefulness of the sources to their pedestrian injury surveillance needs.

The following information is provided for each data source in the summary tables:

- Name of the data source or system
- Contact information (website, address or phone number if applicable)
- Data type and purpose
- Geographical area covered by the data
- Data availability (online and/or free to the public)
- Data collection methodology
- Overview of the content of the dataset
- Details regarding demographic information included in the data set
- Years of data availability
- Variables and codes to identify pedestrian injury cases (if relevant)
- Strengths and weaknesses of the data source
- Other relevant information that may help the reader to determine the utility of the data source

Data Linkage

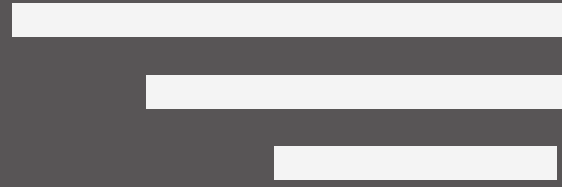
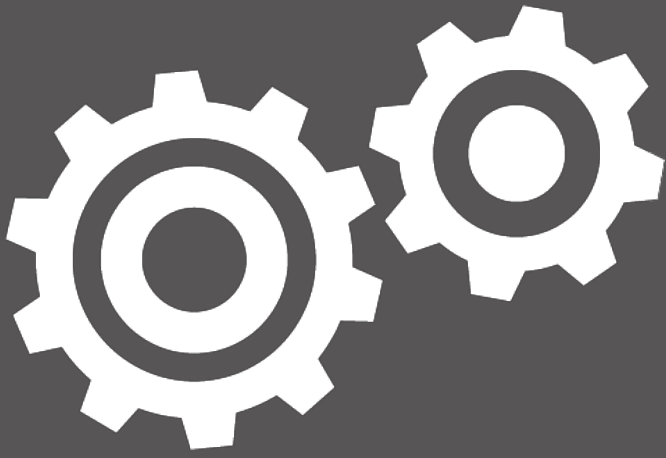
While each data source listed above provides information related to pedestrian injuries, linking two or more datasets together can create a more complete picture of these crashes and the injury outcomes. For example, the Crash Outcomes Data Evaluation System (CODES), previously funded by NHTSA, linked traffic data sources to other datasets to better understand what occurred before, during and after a crash. Police crash reports linked to state-

level hospital inpatient discharge data and emergency department data would allow for the examination of crash-contributing factors with the medical and financial outcomes related to pedestrian injuries or other injuries occurring as a result of motor vehicle crashes. CODES, or similar data linkage projects, are useful tools for epidemiologists, researchers, and safety professionals.

Recommendations for Improving Pedestrian Injury Data



- **Collaborate to link data across multiple sources.** When possible, primary collectors of pedestrian injury data at state, regional, and local levels (e.g., health departments, transportation agencies, health care organizations, and law enforcement agencies) should work collaboratively to link data across multiple sources (e.g., behavioral surveys, traffic reports, emergency room data, and police reports) to generate a robust and comprehensive dataset of variables to inform pedestrian injury prevention research, programs, and policies.



Utilizing Pedestrian Exposure and Risk Data



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As defined in this report, pedestrian exposure relates to the possibility of suffering a pedestrian injury related to the act of being a pedestrian. While the common practice is to calculate pedestrian injury rates per population, this may not be the most accurate method, as it does not factor in pedestrian “activity” or “exposure” among the population. For example, a rate of 10 injuries per 100,000 population may appear impressive. However, this rate would be interpreted very differently if the area had a high level of pedestrian activity (which will be interpreted as a less severe injury rate) than if it had a low level of pedestrian activity (which will be interpreted as a more severe injury rate). The purpose of this section is to present options for measuring pedestrian exposure that will allow calculation of risk and to discuss the benefits and challenges of these options.

Measurements of pedestrian injury risk cannot be based solely on counts of pedestrian injuries. Stand-alone counts of pedestrian injuries may be insufficient to understand the risks faced by pedestrians as they move about their cities, towns, and neighborhoods. For example, suppose a city has made engineering improvements to several intersections deemed unsafe for pedestrians. These engineering solutions include: retrofitting several

intersections with curb extensions to slow motor vehicle traffic; improving signal timing to assist pedestrian crossings; and painting crosswalk markings to better delineate the pedestrian walkway. Suppose also that the city then detects a 20% increase in the count of pedestrian injuries at these intersections. In the absence of exposure measurement, the city will be unable to determine whether pedestrians face more or less risk at these locations. In this hypothetical scenario, counts of pedestrian volume (a potential exposure measure) could reveal a two-fold increase in pedestrian use (since the intersections may now be perceived by pedestrians as more safe, resulting in more pedestrian activity), which would indicate decreased risk per pedestrian despite increasing counts of injuries (where “per pedestrian” is the unit of exposure).

Walking is a behavior with numerous health and social benefits (U.S. DHHS, 2015), and decreasing pedestrian injuries through reduced walking would be counter-productive for public health. Instead, pedestrian conditions must be made safer and more inviting to allow for more walking with reduced pedestrian injury risk. Measuring exposure and calculating pedestrian risk is crucial for tracking this progress.

The Benefits of Exposure Measurement

Exposure assessment in pedestrian injury surveillance allows improved interpretation of trends or changes in pedestrian injury counts. This is an important benefit, but others should be noted as well. First, when consistent exposure measures are used, comparisons of pedestrian safety can be made across subgroups or locations. For example, suppose

a city measures differences in the number of injuries among race and ethnic groups. The only way to know whether individuals within each group face different risks than their peers in other groups is through estimating exposure. Exposure estimation might reveal that one race/ethnic groups walks more frequently than the others, and thus would

explain discrepant injury burdens. Similarly, differences in pedestrian fatalities in different parts of a city could be due in part to greater numbers of pedestrians in a given area.

Another benefit of an exposure assessment is the ability to compare pedestrian risk at different geographic scales. For example, a city or town may wish to compare their performance against a statewide estimate of pedestrian injury experience. If consistent exposure measures are used at the state and local levels, this is possible.

Challenges to Exposure Measurement

One challenge of pedestrian exposure measurement involves matching the injury outcome under study to the most appropriate exposure measure. For example, when analyzing only pedestrian injuries involving motor vehicles, the exposure measure should include only pedestrians along roadways who had the possibility of being struck by a vehicle. Conversely, a city interested in evaluating pedestrian risk along a trail corridor might only be interested in pedestrian traffic along the segment under consideration.

Similarly, an exposure that is appropriate for placing pedestrian injury in proper context may not be appropriate for comparing pedestrian injury experience with injuries experienced in other modes of transportation. For example, when expressed as injuries per mile traveled on foot versus in a car, the pedestrian exposure actually represents a much longer time period because the speeds of walking versus driving are quite discrepant. Such comparisons may need alternative exposure measures, including, for an example, the count of trips or time spent in transit per mode.

Finally, the data collected for exposure estimation are versatile. In addition to injury surveillance purposes, exposure data can be used to: measure amounts of walking and/or facility usage (such as trails, bridges, or sidewalks); evaluate facilities or interventions before and after implementation; prioritize projects; and conduct research into factors that may contribute to walking and injury prevalence. Such initiatives may also foster collaborations across the public health and transportation sectors.

Finally, comparisons of injuries at different geographic scales may be complicated by the choice of exposure measurement. For example, planners may be interested in the pedestrian risk experience at one particular intersection, where appropriate exposures might include the average daily count of pedestrians. It would be difficult to compare the risk experience at this intersection with average risk at the city, county, or state level, where exposure measures may include population-based estimates such as injuries per unit population or injuries per pedestrian commuter.

One overarching challenge to effective pedestrian exposure measurement is data availability. The transportation sector has traditionally placed greater emphasis on measuring vehicle volumes rather than pedestrian volumes, but recent efforts by the U.S. Department of Transportation and others suggest this is changing (U.S. DOT, 2015a, 2015c).

Primary Types and Sources of Pedestrian Exposure Data

Primary types and sources of pedestrian exposure data include:

- Population data
- Trip count data
- Travel time/distance data
- Commute mode share data
- Count data

A summary table in Appendix A.2 provide detailed descriptions of the pedestrian exposure data types and sources. The table also includes highlights of their strengths, weaknesses, and numerators for which they can be useful.

Population Data

Population-based exposure measures are usually drawn from census data and express pedestrian injuries per person or other population metric (e.g., per housing unit). The primary advantage of population data is ubiquity: in the United States, the U.S. Census Bureau publishes decennially detailed population figures and supplements these with annual estimates. These measures may be considered a proxy of pedestrian exposure, as areas with larger populations or population densities arguably have more pedestrians than comparable geographic units with smaller populations or population densities. This is also the challenge associated with these data: as proxy measures, they likely do not accurately reflect the true pedestrian activity of the place in question. For example, according to the U.S. Census Bureau, Chicago, IL and Houston, TX had similar populations in

2010 (2.7 and 2.1 million, respectively), but the 2010 the U.S. Census Bureau's American Community Survey (ACS) estimated that Chicago had approximately 79,200 pedestrian commuters (6.6% of 1.2 million workers), while Houston had 21,000 (2.1% of 1 million workers). If population were used as a basis of comparison between Chicago and Houston, faulty conclusions could be drawn.

Trip Count Data

Count of trips completed on foot are typically collected from travel surveys. One such survey is the National Household Travel Survey (NHTS). Administered by the U.S. Department of Transportation, Federal Highway Administration (FHWA), the NHTS can be used to monitor aggregate pedestrian trends related to demographics or land use patterns. However, since the NHTS does not provide localized data, it cannot be used for the analysis of walking trips. Regional or local travel surveys, conducted as an NHTS "add-on" or as an independent effort, provide spatially-referenced data and can therefore also be used for the analysis of walking trips. Expressing injuries on a per-trip basis has some advantages. First, comparisons between modes may be more appropriate when using trip-based versus distance-based exposure measurement. People tend to walk when the distance is a mile or less, and if possible, most will seek alternative modes for longer trips. This may attenuate the time difference when comparing walking miles to other modes. Second, trip data are available for all states from the NHTS. Unfortunately, the NHTS is repeated on an irregular interval of roughly eight years, limiting the timeliness of the data therein. Additionally, trip data collected

by local and regional agencies might not be publicly available, which limits utility.

Travel Time/Distance Data

Much like trip data, travel time and distance data are typically collected from surveys such as NHTS and MPO planning studies. In the NHTS, the trip-level data includes an estimate of distance and time spent en route. Some MPO or research data may also include global positioning system (GPS) monitoring that allows more precise quantification of route, distance, and time/speed. As noted earlier and in several source documents (Jonah & Engel, 1983; Mindell, Leslie, & Wardlaw, 2012, SafeTREC, 2010), trip distance and time may hinder comparisons of risk across modes due to the slow speed of pedestrian travel. On the other hand, transportation initiatives that encourage motorists to switch to non-motorized modes (including built environment interventions), could lead travelers to choose more proximal destinations, which would reduce the total miles traveled. Comparing injury risk per mile traveled might therefore be important to quantify changes in traveler safety.

Commute Mode Share Data

Information about commute mode share may also serve as a pedestrian exposure measure. Two data sources provide this information at the national level: ACS and the NHTS. Both ask employed respondents aged 16 years and older about their primary mode of transportation to work in the past week. This type of data has been used in the *Dangerous by Design* series of reports by Smart Growth America when calculating their “pedestrian danger index,” which is pedestrian deaths per 100,000 population divided by the percentage that report walking to work (Smart Growth Amer-

ica, 2017). A comparable alternative would be to express injuries or fatalities per pedestrian work-commuter. A notable strength of these data is that ACS provides information at geographies down to the block group level (when multiple years of data are combined) from American Fact Finder (<http://www.factfinder.census.gov>). Unfortunately, information on commute mode share does not provide an estimate of overall pedestrian activity, as the question captures only those people who report walking to work on most days of the week. Those that walk to other types of destinations or walk for pleasure are not captured.

Count Data

An intuitive way to measure pedestrian exposure is to count the number of pedestrians at a specific location. This is the pedestrian equivalent of the common practice of counting vehicles that pass a specific point in a roadway or intersection. Several resources to support pedestrian count data are available. An extensive review of pedestrian counting methods, including devices, techniques, and analytic/inflation strategies for modeling count data, is provided based on a comprehensive pedestrian exposure measurement program (SafeTREC, 2010). Another useful resource is the Transportation Research Board’s Guidebook on Pedestrian and Bicycle Volume Data Collection (NCHRP, 2014).

The FHWA provides technical and methodological support for monitoring non-motorized transportation. For example, FHWA recently published a user-friendly guidebook to support the development of data that can be communicated in the Traffic Monitoring Guide (TMG) format and eventually contributed to the national database of bicycle and pedestrian counts that is currently being developed

through the Traffic Monitoring Analysis System. The guidebook includes diagrams, illustrations, and numerous examples of how to interpret the TMG format and how to assemble correct and consistent information about bicycle and pedestrian count locations and counts. FHWA manages the Bicycle-Pedestrian Count Technology Pilot Project. The goal of the project is to increase the organizational and technical capacity of MPOs to establish and operate effective bicycle and pedestrian count programs, as well as provide lessons learned for peer agencies across the United States. The Pilot Project funded the purchase of a limited number of portable automatic counters to collect counts at various locations within MPO planning areas. FHWA publications can be found at: http://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/. The *FHWA Bicycle-Pedestrian Count Technology Pilot Project: Summary Report* can be found at https://www.fhwa.dot.gov/environment/bicycle_pedestrian/countpilot/summary_report/index.cfm.

Count data are perhaps most useful when monitoring pedestrian volume at a single site or corridor. Some municipalities may use repeated counts in the same location to estimate trends in walking behavior. While analytic techniques exist to scale-up counts to larger geographies and time periods, their utility at county, regional, or state levels may be limited by their geographic specificity.

At the most fundamental level, pedestrian exposure data can be collected manually for short durations at a subset of sites under the jurisdiction of the transportation agency. However, these counts suffer from temporal and spatial limitations. On the temporal side, the short-term nature of counts does

not provide data about hourly, daily, and annual pedestrian traffic, and generally does not provide sufficient information to assess the overall safety performance of a facility. To alleviate the temporal limitations, some agencies use automated continuous pedestrian volumes for longer durations (i.e., 24-hour or week-long counts). This is done at a few locations and can be used to extrapolate their short-term counts to 24-hour counts, using appropriate adjustment factors for time of day, day of week, and month of the year.

On the spatial side, it is cost-restrictive to conduct short-term pedestrian counts or install automated counters at every intersection or along every segment of road; as a result, these counts only cover a very small part of a jurisdiction's road network. A commonly used method to account for the spatial limitations of count data is to develop a statistical exposure model. National Cooperative Highway Research Program Report 770 (20) provides a summary of pedestrian exposure modeling research, highlighting three general categories of models that can provide facility-level volume estimates at roadway intersections and pedestrian network segments (NCHRP, 2011). The first group is labeled the "trip generation and flow" models. This approach estimates the number of pedestrian trips between small areas, such as block faces or pedestrian analysis zones. These models follow a traditional traveling modeling approach, since they estimate trip generation, trip distribution, and network assignment. The second group is labeled "network simulation" models. This category of models, including space syntax, develops volume estimates for each part of a pedestrian network based on network characteristics such as connectivity and sight lines. The third group is labeled

“direct demand” models. These models estimate pedestrian volumes along roadway segments and intersections using site and surrounding area characteristics.

Developing “direct demand” models involves two steps: First, a statistical model must be developed to identify significant relationships between extrapolated short-term volumes at each study location and explanatory variables describing the characteristics of the study location. Such explanatory variables can include land use characteristics, transportation system features, street network attributes, demographic factors, and any other

variables thought to be relevant to pedestrian volumes. Second, data must be collected on the explanatory variables that are found to be significant across the study area. These variables can then be applied to the model to predict pedestrian exposure across the entire study area. The relevant infrastructure inventory and land use data for such a study will depend on the specific study area.



Other Types and Sources of Pedestrian Exposure Data

Pedestrian Injuries as a Proportion of Total Traffic Injuries

An additional method of placing pedestrian injuries into a broader context involves expressing pedestrian injuries as a proportion of all traffic injuries. This is commonly done when referring to fatalities, as NHTSA's Fatality Analysis Reporting System (FARS) enables these analyses at the national, state, and county levels. This type of presentation is not a true measure of exposure, as it does not allow quantification of the risk a pedestrian faces during a walking trip, but it does permit interested parties to determine the contribution of pedestrian injuries to the overall burden of traffic injuries. These data can be compared to estimates of pedestrian mode share to determine if pedestrians contribute a greater burden of injuries than their contribution to total travel would suggest.

Emerging Data

The emergence of crowd-sourced participation tracking has the potential to revolutionize pedestrian exposure measurement. These techniques make use of wearable and portable technology such as fitness trackers (e.g., FitBit, Inc.), personal GPS monitors (e.g., Garmin, Inc.), and smartphones that often contain accelerometers and GPS components. These devices are often voluntarily used for tracking physical activity participation for health purposes. Users upload data to proprietary data repositories for automated analysis and reporting. The companies thereby amass vast quantities of data on walking and bicycling, including route choices when GPS is enabled. At least one such company, Strava, Inc., has begun selling de-identified data to cities to assist in planning efforts (Albergotti, 2014). Additional information on crowdsourcing pedestrian data can be found from the Pedestrian and Bicycle Information Center (Smith, 2015).

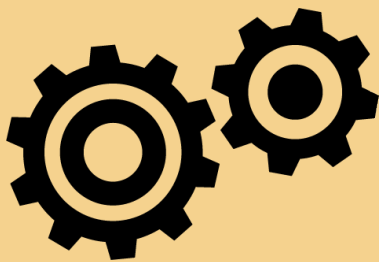
Data Sources for Pedestrian Exposure Assessments

Data sources that can be used for pedestrian exposure assessments (as the denominator) include:

1. National Household Travel Survey;
2. American Community Survey;
3. Local pedestrian counts; and
4. U.S. Census.

Summary tables in Appendix A.3 provides detailed descriptions of these data sources and include information to help potential users make an initial determination about the usefulness of the sources to their pedestrian injury surveillance needs.

Recommendations for Utilizing Pedestrian Exposure and Risk Data



- **Establish working contacts with partner organizations that manage injury and exposure data.** Agencies responsible for conducting pedestrian injury surveillance should establish working contacts with partner organizations responsible for managing injury and exposure data, including (but not limited to): state and federal departments of transportation, law enforcement agencies, metropolitan planning organizations, and public health entities.
- **Include estimates of pedestrian injury exposure so that risk can be calculated.** To support the comparison of pedestrian injury trends across groups and geographies, injury prevention and traffic safety professionals should include estimates of pedestrian injury exposure so that risk can be calculated. If definitive exposure measures are unavailable, consider using existing, publicly available proxy measures of pedestrian exposure to estimate risk and acknowledge the limitations thereof.
- **Make pedestrian-specific data collection a routine part of transportation data collection.** To increase availability of exposure measures, agencies conducting pedestrian injury surveillance should make pedestrian-specific data collection a routine part of transportation data collection by obtaining funding and/or collaborating with partner agencies that are collecting these data. Examples of data collection tools include: National Household Travel Survey (NHTS) add-ons; travel studies/surveys conducted by Metropolitan Planning Organizations or other regional agencies; count programs (automated and/or manual); and emerging data sources (e.g., app/crowd-sourced data).



Analyzing Pedestrian Injury Data



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To prevent pedestrian injuries and fatalities, data must be analyzed properly in order to:

1. Measure the magnitude of the problem;
2. Assess the factors that contribute to injuries and deaths over time; and
3. Implement and evaluate the effectiveness of prevention strategies.

In this section, we suggest an approach to culling and analyzing available pedestrian injury data and provide real-world examples of how analysts have used these data to support evidence-based injury prevention efforts. We provide a basic overview of variables, methods, and resources to inform both straightforward and more complex analyses. This overview of analytical methods

assumes the level of analysis undertaken will vary by end-user depending on available data and other resources, as well as the level of the analyst's expertise.

We define data as a collection of variables. A variable is an attribute that describes a person, place, thing, or idea, and can be classified as quantitative (numeric) or qualitative (categorical, non-numeric). An example of a quantitative variable is "victim age" (in years), which is a measurable quantity. An example of a qualitative variable is the primary factor a police officer determines contributed to a collision resulting in a pedestrian injury (e.g., speeding, stop sign running, failure to yield, etc.). Qualitative data can be created from narrative reports by individual record reviews to create categorical variables or through more complex data mining techniques using computer programming.

Key Variables for Pedestrian Injury Analysis

When a pedestrian is injured, data are collected on the event, as well as factors preceding and following the event, through a variety of mechanisms as described in the "Pedestrian Injury Data" section of this report. The following sections include an overview of key questions that can be used to inform variable selection for pedestrian injury data analysis.

Who?

"Who?" refers to the pedestrian, as well as all other parties involved in the event. Examples of variables include individuals who were involved in the crash and persons who were injured in the crash. Demographic information about the pedestrian, as well as operators of

other transportation modes involved (e.g., buses, cars, trains, bicycles, etc.) is also useful.

When?

"When?" refers to the timing of events, such as when the crash occurred (e.g., time of day, day of the week, month of the year, etc.). Data on when engineering or law enforcement interventions occurred relative to the site of the incident could also be informative for understanding patterns over time.

Where?

"Where?" refers to the crash location. The most precise information regarding the injury location should be collected when possible, as this information could be converted to latitude/longitude values (GPS coordinates).

If an analyst has access to mapping software, such as a Geographic Information System (GIS) platform, he or she can map the crash locations to look for spatial patterns. Analysts can also map street elements, such as traffic speeds (actual or posted), the presence of crosswalks, and other environmental elements, such as bus stops or businesses that generate pedestrian activity. In the absence of GIS software or expertise, analysts can be creative: looking into Google Maps applications, using open source software, or simply printing a map of the area and working “on paper” to understand injury clusters or other spatial patterns may lead to some helpful findings.



There are different categories or geographic “levels of analysis” that can be used when working with pedestrian injury data that have spatial information, such as:

- Area level: e.g., counties, towns, zip codes, census tracts, and census blocks.
- Corridor level: e.g., continuous road segments that might include many intersections.
- Intersection level: i.e., at the level of an individual intersection. This could be considered a “full zoom,” which is a traditional way of analyzing spatial data.

Even if analysts do not have access to mapping software, area, corridor, and intersection-level location data and analysis can be informative for describing spatial patterns by city or zip code.

To What Extent/How Severe?

“To What Extent/How Severe” refers to the severity of the injury, or injury outcome. Was the pedestrian injured in the field, treated by first responders, and then released to go home? Did the pedestrian go to the emergency room? Was the pedestrian admitted to a hospital? Did the pedestrian die? Ultimately, the severity of the injury impacts the data sources where the injury is captured and the potential variables available for analysis.



The Haddon Matrix

A commonly used paradigm in the field of injury prevention is the Haddon Matrix (Haddon, 1980; Christoffel and Gallagher, 2005). A medical professional and the first director of NHTSA, Dr. William Haddon created the matrix in the 1960s to better understand the circumstances before, during, and after a motor vehicle crash. The Haddon Matrix is a useful framework that combines the epidemiology triangle (host, agent, environment) with the levels of prevention (pre-event, event, post-event). With regard to pedestrian injury, the Haddon Matrix can help describe and categorize pre-event, event, and post-event variables at the level of individual behaviors (e.g., pedestrian and driver) and environmental factors (e.g., vehicle, physical, and social/policy environment). Combining these elements allows for the identification of potential variables for injury surveillance and epidemiologic analyses. These analyses are ultimately used to inform targeted injury prevention strategies at behavioral and environmental levels.

Table 5 depicts an example of how a Haddon Matrix can be used to better understand the factors that influence a pedestrian injury as a result of a collision with a motor vehicle. Each behavior and element in the matrix can be collected and analyzed as a variable. It is common not to have these data available from a single source. Some states and cities collect more data than others, and even when the data are available, they may not be publicly or transparently accessible. Potential data sources for these variables include records from: police, hospitals (emergency department, inpatient records), Medical Examiner's offices, vital statistics, emergency medical responder organizations, public works departments, and transportation agencies. Refer to the "Pedestrian Injury Data" section for more information and details regarding potential data sources. Because of limitations with respect to the availability of different variables, analysts are encouraged to explore and use non-traditional data sources for their analyses.

Table 5. Haddon Matrix Example: Pedestrian Injury Resulting from a Collision with a Motor Vehicle

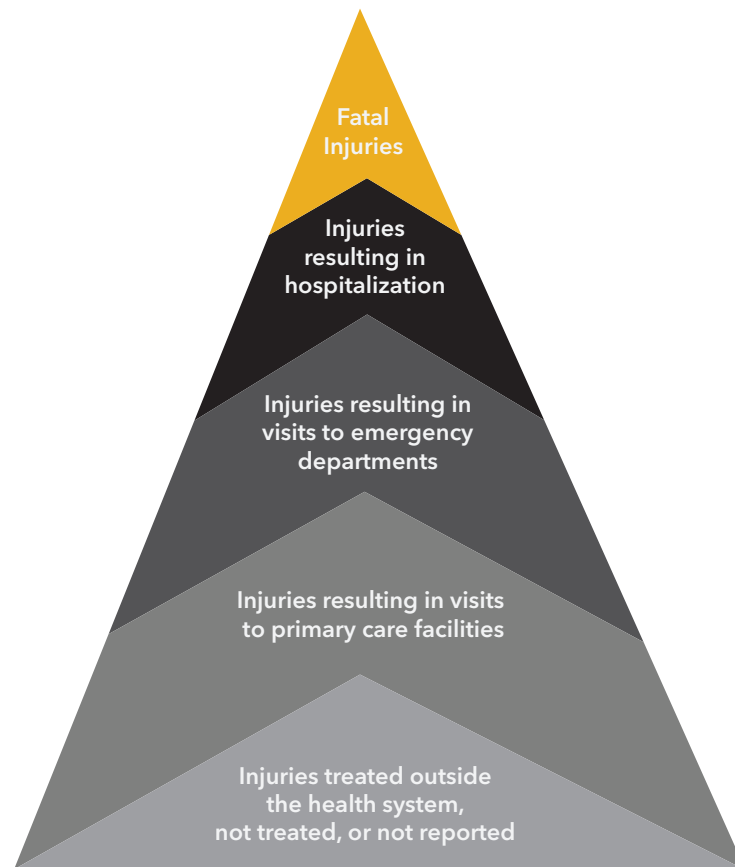
	Pedestrian Behavior	Driver Behavior	Vehicle Environment	Physical Environment	Social/Policy Environment
Pre-Event <i>Prevent event from occurring</i>	<ul style="list-style-type: none"> • Age • Alcohol/drug impairment • Disability/assistive device • Distraction Use of pedestrian facilities 	<ul style="list-style-type: none"> • Age • Alcohol/drug impairment • Distraction • Travel speed • Experience/skill in operating vehicle 	<ul style="list-style-type: none"> • Vehicle age/quality, maintenance • Vehicle safety features 	<ul style="list-style-type: none"> • Presence of pedestrian facilities • Roadway lighting • Roadway design features, posted speed 	<ul style="list-style-type: none"> • Enforcement/adjudications of speeding, impaired driving, other traffic laws • Jurisdictional goal/target for injury reduction (e.g., Vision Zero Goal) • Pedestrian surveillance systems in place • Pedestrian education and skill training programs
Event <i>Prevent injury during event</i>	<ul style="list-style-type: none"> • Reaction time/ability to perform evasive maneuver 	<ul style="list-style-type: none"> • Reaction time/ability to perform evasive maneuver 	<ul style="list-style-type: none"> • Vehicle type/size • Proper deployment of external air bags 	<ul style="list-style-type: none"> • Buffer zone • Presence of fixed objects near roadway 	<ul style="list-style-type: none"> • Roadway and environmental design policies and standards • Roadway maintenance
Post-Event <i>Sustain life when event occurs</i>	<ul style="list-style-type: none"> • Age and general health of victim 	<ul style="list-style-type: none"> • Age and general health of victim 	<ul style="list-style-type: none"> • Crash notification system • Fire prevention technology 	<ul style="list-style-type: none"> • EMS services/staff and systems • Distance to trauma care 	<ul style="list-style-type: none"> • Policies/funding/training to support EMS systems, police first responders, legal and social resources

Source: Williams, 1999

The Injury Pyramid (Figure 6), developed by the World Health Organization, shows the different categories of injury by severity; the pyramid shape illustrates the proportion of outcomes for those injured by level of contact with the healthcare system. Across most injury topics, more people sustain injuries and fewer people die. However, death/fatality data are generally easier to access because these data are considered a “vital statistic” that usually comes from one source (i.e., the Medical Examiner’s office). On the other

hand, injury data are hard to piece together because they come from different sources (e.g., hospitals, outpatient healthcare settings, police reports, EMS reports, etc.). To obtain a comprehensive picture of the magnitude and burden of pedestrian injury, analysts should try to access as much data as possible across each level of injury severity reflected in the pyramid. However, this will require accessing multiple data systems with a range of different variables available for analysis.

Figure 6. Injury Pyramid



Source: WHO, 2017

Statistical and Analytical Methods

Providing detailed statistical and analytical methodologies for pedestrian injury analysis is beyond the scope of this document. We anticipate that the extent of analyses will be shaped by factors, such as, the quality and robustness of the available data, as well as available time, resources, and capacity.

The field of pedestrian injury surveillance and data analysis is particularly ripe for interdisciplinary collaboration with respect to data methods and interpretation. All professionals working in this area – including transportation engineers, geospatial analysts, hospital staff, trauma responders, computer scientists, and law enforcement analysts – bring different methodological approaches that can help identify meaningful patterns in the data, as illustrated in the case study examples provided in this report.

Finally, it should also be noted that training in epidemiology and statistics is not standardized across the United States. For this reason, it is recommended that those new to epidemiology and statistical analysis refer to a free online copy of Basic Epidemiology (Second Edition), a textbook published by the World Health Organization (Bonita, Beaglehole, & Kjellstrohm, 2011). Chapters 2 and 9 provide potentially useful examples for analyzing data and presenting findings. These chapters explain how to calculate incidence, prevalence, case-fatality rates, age-adjusted rates, and other statistics. The book also includes a specific section on “Injury Epidemiology,” with “Traffic Crash Injuries” as a subsection.



Recommendations for Analyzing Pedestrian Injury Data



- **Collect or access data on variables that describe key characteristics of the injury.** Analysts or teams working on pedestrian injury surveillance projects should collect or access data on variables that describe key characteristics of the injury, including: factors that occur before, during, and after the event; variables that describe pedestrian and driver behavior; and the social and physical environment.
- **Map and conduct spatial analyses of pedestrian injuries.** To focus prevention efforts, users of pedestrian injury data should map and conduct spatial analyses of pedestrian injuries by city, zip code, corridor, intersection, or other geographic units to determine spatial patterns and clusters of pedestrian injuries.
- **Collaborate regularly across disciplines to analyze, interpret, disseminate, and utilize pedestrian injury data.** State, regional, and local professionals across the many disciplines responsible for pedestrian injury prevention and safety – e.g., public health, transportation, engineering, planning, law enforcement, education, health care, and public policy – should collaborate regularly to: analyze and interpret pedestrian injury data; disseminate data widely to key audiences; and utilize data to inform and advance prevention efforts.
- **Publish and disseminate useful approaches to data analysis to inform injury prevention initiatives.** Analysts or teams working on pedestrian injury surveillance projects should publish and disseminate useful approaches to data analysis to inform injury prevention initiatives, such as case studies, to help advance the practical application of surveillance data.

Case Studies



SAFE STATES

The following case studies are illustrative examples of how pedestrian injury data can be analyzed, using a range of methodological approaches and key variables to inform injury prevention efforts. The case studies presented below include the development

of a citywide pedestrian safety engineering capital plan in San Francisco, the development of a Complete Streets policy in West Virginia, and the evaluation of a Safe Routes to School program in New York City.

Prioritizing Pedestrian Safety Improvements in San Francisco, California

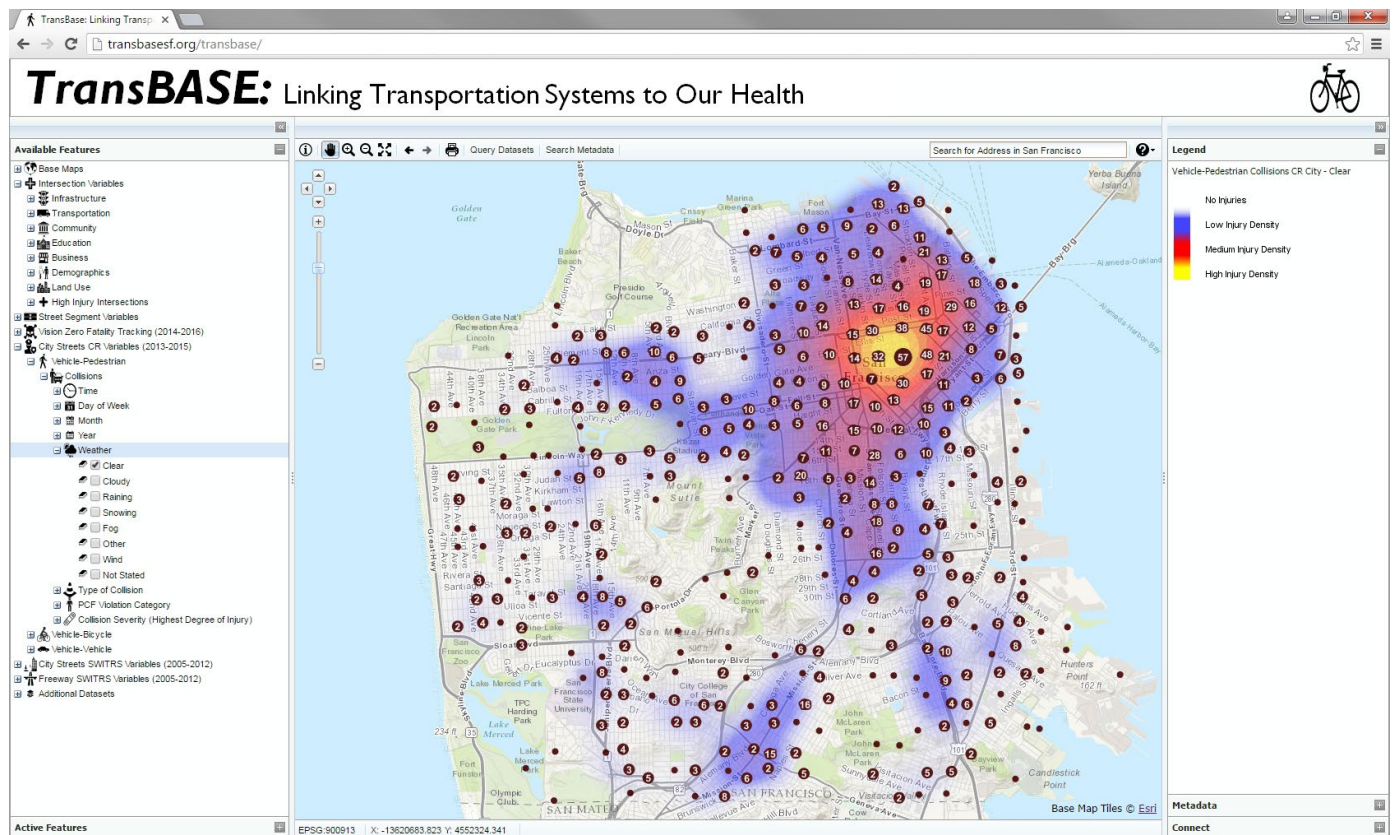
WalkFirst (2014) is an initiative to improve pedestrian safety in San Francisco, California that uses a data-driven, evidence-based capital planning process in support of San Francisco's "Vision Zero" goal of zero traffic deaths by 2024 (City of San Francisco, 2015). The effort was a collaboration between the San Francisco Municipal Transportation Agency, Department of Public Health, Planning Department, Department of Public Works, and the Controller's Office. WalkFirst utilized intersection-level data on collisions resulting in injuries or fatalities to pedestrians from California's Statewide Integrated Traffic Records System (SWITRS), currently California's best publicly available data source of police-reported pedestrian injuries that occur on public roadways. WalkFirst also utilized data on variables describing transportation, land use, sociodemographics, and other factors. These data provided additional information regarding factors associated with injury patterns on San Francisco streets.

Injury data were collected and linked in TransBASESF.org – an innovative, publicly accessible spatial database developed by the San Francisco Department of Public Health (SFPDH) – which links over 200 variables to intersection and street segment-level injury data to inform solutions to transportation safety issues (Morris, 2016). TransBASESF.org

and spatial analysis tools (depicted in Figure 7) were also utilized to identify San Francisco's "high pedestrian injury corridors": 6% of San Francisco streets where over 60% of severe and fatal injuries were concentrated (SFPDH, 2013). Data from TransBASESF.org were used to analyze collision patterns and identify crash profiles on high injury corridors (e.g., right turns at signalized intersections, injuries on streets with high traffic volumes and speeds, etc.). These analyses informed targeted recommendations for proven engineering countermeasures to address pedestrian safety issues, which included an analysis of costs paired with a targeted public engagement component. This approach resulted in a strategic roadmap of priority pedestrian safety projects at over 170 intersections and a toolbox of measures that are now being implemented by the San Francisco Municipal Transportation Agency to reduce serious pedestrian injuries and fatalities.

TransBASESF.org is now being replicated in collaboration between the Los Angeles Department of Transportation and Los Angeles County Department of Public Health.

Figure 7. San Francisco Pedestrian Injury Mapping and Spatial Analysis Using TransBASESF.org



Guiding Complete Streets Legislation in West Virginia

Policy solutions, specifically Complete Streets policies, offer an opportunity to impact population level physical activity through improved safety and infrastructure (Smart Growth America, 2015). This case study highlights how pedestrian and cyclist crash and injury data were used to successfully enact Complete Streets legislation in West Virginia in 2013. Statewide pedestrian- and cyclist-motor vehicle crash (PCMVC) data for 2000-2006 were provided by the West Virginia Department of Transportation Division of Highways (WVDOH) to a research team at West Virginia University. These data were used to create the following state- and county-level information:

- Annual number and rate of PCMVCs per 100,000 population;
- Annual number and rate of injuries and fatalities resulting from PCMVCs;
- Estimated cost per capita resulting from PCMVCs; and
- State- and county-specific reports for a knowledge broker (AARP of WV) to use when educating legislators about Complete Streets policies.

The WVDOH supplied de-identified data for each motor vehicle crash involving a pedestrian or cyclist in the state from 2000

to 2006 as collected from police reports. The functional injury level of the pedestrian or cyclist (as assessed by the police officer at the scene using KABCO⁵ codes) was used to calculate the associated costs using estimates utilized by the Federal Highway Administration (FHWA, 2005). The amount and detail of the data provided by the WVDOH allowed for cost estimations using Level 1 estimates. To arrive at a conservative cost estimate, the researchers assumed crash geometry 1 (single-vehicle struck human, at intersection) at a speed equal to or less than 45 miles per hour. (For details, see Table 2 of FHWA, 2005.)

West Virginia Senate Bill 158 ("Creating Complete Streets Act") was introduced on February 15, 2013, co-sponsored by the

chairs of the Transportation and Infrastructure Committee and the Health and Human Resources Committee in the Senate. During the legislative session, the AARP of West Virginia met with the Commissioner of the West Virginia Department of Transportation to discuss specific bill language and conducted meetings with members of the leadership team in the Senate and all the members of the Transportation and Infrastructure Committee. During these meetings, a one-page summary of state and county-specific data were presented to each legislative official. The bill was passed by the Senate and House, approved by the governor on April 10, 2013, and made effective 90 days from passage (July 9, 2013).

Assessing the Impact of a Safe Routes to School (SRTS) Program on Pediatric Pedestrian Injury in New York City

Safe Routes to School (SRTS) is a nationwide, federally-funded, locally-administered transportation initiative of safety improvements to the built environment surrounding schools or other improvements intended to encourage active travel to and from school (FHWA, 2016). Departments of Transportation in all 50 states and the District of Columbia introduced safety improvements at 10,400 of the nation's 98,706 elementary and secondary schools for a total cost of \$1.12 billion (Cradock, 2012).

As part of a CDC-funded research project, investigators at Columbia University in New York City, evaluated SRTS interventions to determine whether they were associated with changes in pediatric pedestrian injuries and fatalities. The investigators also measured the direct costs of capital improvements incurred

as part of the SRTS program and estimated the pediatric pedestrian injury reduction attributable to the program. This was a comprehensive, opportunistic, detailed study of the public health impact of interventions to the physical and social environments during the pre-injury phase for what may be the largest single investment in a pediatric injury prevention program in United States history.

The investigators used geocoded motor-vehicle crash data for 168,806 pedestrian injuries in New York City between 2001 and 2010. They calculated annual pedestrian injury rates per 10,000 population for different age groups and for census tracts with and without SRTS interventions during school-travel hours. The results showed the safety benefit the SRTS program in New

⁵ The KABCO severity scale (National Safety Council, 1990) is used by the investigating police officer on the scene to classify injury severity for pedestrians, cyclists, and motor vehicle occupants with five categories: K, killed; A, disabling injury; B, evident injury; C, possible injury; O, no apparent injury.

York City by demonstrating a nearly 44% pre-post SRTS implementation decline in school-age, school-travel pedestrian injuries at SRTS schools compared to essentially no change in non-SRTS areas (DiMaggio, 2013). Researchers used these results to conduct cost effectiveness analyses to show a net societal benefit of \$230 million and 2,055 quality-adjusted life years gained in New York City as a result of the SRTS program (Muennig, 2014). This initial, basic epidemiology also set the stage for more spatiotemporal modeling of all-age pedestrian injury data to help support New York City's Vision Zero initiative (DiMaggio, 2015).

This epidemiologic study contributes to the wider dissemination of the best available

evidence on cost-effective changes to the built environment to prevent pedestrian injury. They are particularly helpful when they are combined with studies that demonstrate programmatic success (Chriqui et al., 2012; Levin Martin, Moeti, & Pullen-Seufert, 2009; Stewart, Moudon, & Claybrooke, 2014). These studies can help build relationships between injury researchers, state and local public health officials, policy makers, and non-governmental organizations. In this case, the methods, data, and approaches used in the SRTS analysis were shared with and used by Transportation Alternatives, a New York City advocacy organization, which contributed to their efforts to have a citywide, 25 mile-per-hour speed limit enacted.

Additional Case Studies

PEDSAFE: Pedestrian Safety Guide and Countermeasure Selection System

Available at <http://www.pedbikesafe.org/pedsafe/>

Smart Growth America, Dangerous by Design Reports

Available at <https://smartgrowthamerica.org/resources/dangerous-by-design-2016/>



Conclusion

Pedestrian injuries and fatalities are not the result of random, inevitable, or unavoidable events. Despite their ubiquity and the complexity of circumstances that contribute to these events, pedestrian injuries and deaths can be prevented. However, effective prevention strategies require accurate, reliable, and credible data. Cross-agency efforts at state, regional, and local levels are needed to: standardize how pedestrian injuries are defined and measured; and systematically improve how pedestrian injury and risk data are routinely collected, linked, analyzed, and reported. By having improved access to data that are more complete and are of higher quality, pedestrian safety professionals can implement interventions that are more comprehensive, robust, contextually sound, and efficacious.

To this end, the recommendations provided in this report are intended to provide public health and transportation practitioners with a common point of reference from which they can collaboratively enhance their pedestrian injury surveillance efforts. By resolutely implementing the recommendations put forth by this document, professionals across these fields can collectively improve the practice of pedestrian injury surveillance and ultimately advance their shared goal: to make travel for pedestrians safer, more accessible, and more equitable in states and communities throughout the nation.



ISW8 Consensus Recommendations for Improving Pedestrian Injury Surveillance



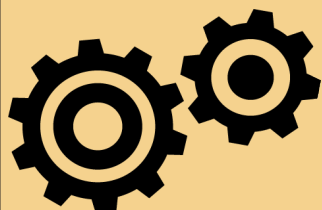
Recommendations for Enhancing Definitions of "Pedestrian" and "Pedestrian Injury"

1. **Use the definitions for "pedestrian" and "pedestrian injury" established by this report.** All state, regional, and local agencies that collect and analyze pedestrian injury surveillance data should use the consensus definitions of "pedestrian" and "pedestrian injury" established by this report.
2. **Train all primary collectors of pedestrian injury data.** To ensure that the definitions of "pedestrian" and "pedestrian injury" established by this report are used consistently, training should be provided to all to primary collectors of pedestrian injury data, including (but not limited to): state and local health departments; state and local transportation agencies; state and local law enforcement agencies; hospitals, emergency departments, and other medical facilities; and federal agencies (e.g., NHTSA and CDC).



Recommendations for Improving Pedestrian Injury Data

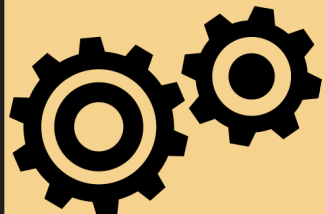
3. **Collaborate to link data across multiple sources.** When possible, primary collectors of pedestrian injury data at state, regional, and local levels (e.g., health departments, transportation agencies, health care organizations, and law enforcement agencies) should work collaboratively to link data across multiple sources (e.g., behavioral surveys, traffic reports, emergency room data, and police reports) to generate a robust and comprehensive dataset of variables to inform pedestrian injury prevention research, programs, and policies.



Recommendations for Utilizing Pedestrian Exposure and Risk Data

4. **Establish working contacts with partner organizations that manage injury and exposure data.** Agencies responsible for conducting pedestrian injury surveillance should establish working contacts with partner organizations responsible for managing injury and exposure data, including (but not limited to): state and federal departments of transportation, law enforcement agencies, metropolitan planning organizations, and public health entities.
5. **Include estimates of pedestrian injury exposure so that risk can be calculated.** To support the comparison of pedestrian injury trends across groups and geographies, injury prevention and traffic safety professionals should include estimates of pedestrian injury exposure so that risk can be calculated. If definitive exposure measures are unavailable, consider using existing, publicly available proxy measures of pedestrian exposure to estimate risk and acknowledge the limitations thereof.

ISW8 Consensus Recommendations for Improving Pedestrian Injury Surveillance



Recommendations for Utilizing Pedestrian Exposure and Risk Data

6. **Make pedestrian-specific data collection a routine part of transportation data collection.** To increase availability of exposure measures, agencies conducting pedestrian injury surveillance should make pedestrian-specific data collection a routine part of transportation data collection by obtaining funding and/or collaborating with partner agencies that are collecting these data. Examples of data collection tools include: National Household Travel Survey (NHTS) add-ons; travel studies/surveys conducted by Metropolitan Planning Organizations or other regional agencies; count programs (automated and/or manual); and emerging data sources (e.g., app/crowd-sourced data).



Recommendations for Analyzing Pedestrian Injury Data

7. **Collect or access data on variables that describe key characteristics of the injury.** Analysts or teams working on pedestrian injury surveillance projects should collect or access data on variables that describe key characteristics of the injury, including: factors that occur before, during, and after the event; variables that describe pedestrian and driver behavior; and the social and physical environment.
8. **Map and conduct spatial analyses of pedestrian injuries.** To focus prevention efforts, users of pedestrian injury data should map and conduct spatial analyses of pedestrian injuries by city, zip code, corridor, intersection, or other geographic units to determine spatial patterns and clusters of pedestrian injuries.
9. **Collaborate regularly across disciplines to analyze, interpret, disseminate, and utilize pedestrian injury data.** State, regional, and local professionals across the many disciplines responsible for pedestrian injury prevention and safety – e.g., public health, transportation, engineering, planning, law enforcement, education, health care, and public policy – should collaborate regularly to: analyze and interpret pedestrian injury data; disseminate data widely to key audiences; and utilize data to inform and advance prevention efforts.
10. **Publish and disseminate useful approaches to data analysis to inform injury prevention initiatives.** Analysts or teams working on pedestrian injury surveillance projects should publish and disseminate useful approaches to data analysis to inform injury prevention initiatives, such as case studies, to help advance the practical application of surveillance data.

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Appendix A: Data Sources

A.1 Numerator Data Sources

State Vital Statistics: Death Certificates	
Contact info/sponsor	This summary is a generic description of State Vital Statistics: Death Certificates data sets, and may not be accurate for any specific state. For specific information for a given state, contact the state Public Health Department or Health Statistics/Vital Statistics Office.
Data type and purpose	Census of all death certificates filed in the State or the District of Columbia. Non-resident deaths occurring in the U.S. are included in the national data file. Official tabulations are typically limited to U.S. residents.
Geographic scope	State
Availability Online query system Public use data set	Varies by state. Some states have online query systems: e.g., Utah, California, Colorado.
Data collection methodology	Administrative records (death certificates) completed by physicians, coroners, medical examiners, and funeral directors are filed with the State Vital Statistics offices.
Content	Based on the Standard U.S. death certificate. For a complete listing of uniform data elements for the nation, see the description of the National Vital Statistics System (NVSS). Additional elements may be available in some states.
Demographic Information	Name, social security number, date of birth, date of death, age, race, Hispanic origin, residence. States may limit access to identifying information.
Years of data	Varies by state with 1-3 year delay for complete annual data sets.

State Vital Statistics: Death Certificates

Variables and codes to identify cases	<p>Up to 20 causes of death are reported. Underlying and multiple causes of death are coded using ICD-10 (1999 to present) or ICD-9 (1979-1998). The ICD-10 underlying cause codes used to identify deaths involving pedestrians and pedal cyclists are grouped by traffic vs. non-traffic events. <i>Pedestrian, traffic:</i> [V02-V04](.1,.9), V09.2</p> <p><i>Pedestrian, non-traffic:</i> V01, [V02-V04](.0), V05, V06, V09(.0-.1,.3,.9)</p> <p><i>Pedal cyclist, traffic:</i> [V12-V14](.3-.9), V19(.4-.6)</p> <p><i>Pedal cyclist, non-traffic:</i> V10-V11, [V12-V14](.0-.2), V15-V18, V19(.0-.3,.8,.9)</p>
Strengths for use in pedestrian injury surveillance	<ul style="list-style-type: none"> • State Vital Statistics are complete, population-based data sets (i.e., not samples) of all resident and in-state fatalities. State Vital Statistic datasets contain useful demographic variables for analysis and for linkage with other data sets. • Cause of death information is consistently recorded using ICD-10 codes. ICD-10 codes provide information on the vehicles involved in the crash event (in broad categories). • Because vital records have been collected for decades, death certificate data can be used to determine long historical trends.
Challenges for use in pedestrian injury surveillance	<ul style="list-style-type: none"> • Information on the location of the crash event is often limited or incomplete. • Information on the circumstances of the death can be limited. • States may differ in the quality and completeness of the data collected.
Other relevant information	<p>State Vital Statistics data provide case level information which can be useful for in-depth analysis. However, there may be strict protocols that limit the ability of researchers to access the data.</p>

State Level Hospital Inpatient Discharge Data

Contact info/sponsor	This summary is a generic description of state level hospital patient discharge data sets, but it may not be accurate for any specific state. For example, states may differ on the quality and completeness of the data collected. Contact the state Hospital Association, Public Health Department or Health Statistics Office.
Data type and purpose	Data systems designed primarily to capture billing and licensing information, but often used for health planning and surveillance purposes.
Geographic scope	<ul style="list-style-type: none"> Primarily a state level data system. Inpatient data collected from all licensed hospitals in each state. Licensed hospitals include general acute care, acute psychiatric, chemical dependency recovery, and psychiatric health facilities, but excludes federal and tribal hospitals. State level data can be disaggregated by region, county and zip code levels. There are some national level aggregations of state level data (e.g., CDC/NCIPC Injury Indicators Project).
Availability Online query system Public use data set	Depends on the state; many have both query systems and public data sets. Contact the state Hospital Association, or Public Health Department, or Health Statistics Department for details.
Data collection methodology	Hospital level reporting requirements are based on state and national laws and regulations. Data quality and completeness may vary (e.g., E-coding compliance). Each state's system is consistent with American Hospital Association (AHA) and National Center for Health Statistics (NCHS) agreements (www.ahacentraloffice.com).
Content	Dataset consists of a record for each inpatient discharged from a licensed hospital. Available data include patient demographics, source of admission, area of residence, principal and secondary diagnoses (ICD-9-CM diagnosis codes), procedures, type of discharge, cause of injury (ICD-9-CM E codes), source of payment, length of stay, charges, hospital type of ownership, capacity, financing, staffing ratios, and location.

State Level Hospital Inpatient Discharge Data	
Demographic Information	Demographic information include: Age, sex, ethnicity, race, county, zip code of residence and hospital, date of birth, date of admission, date of discharge, and source of payment. Variables will vary across states.
Years of data	Depends on the state, but generally this data source has been in place for decades (e.g. since the early 1990s)
Variables and codes to identify cases	ICD-9-CM codes consistent with CDC and NCHS: http://www.cdc.gov/nchs/icd/icd9cm_addenda_guidelines.htm For SAS program: http://www.cdc.gov/nchs/data/ice/icd9cm_morbiditysascode.txt .
Strengths for use in pedestrian injury surveillance	Dataset captures pedestrian incidents severe enough to be hospitalized. Uses ICD-9-CM coding scheme. Most states have well established systems for collecting, monitoring and reporting these data. Includes some information on type of collision. Includes information on level of severity.
Challenges for use in pedestrian injury surveillance	Potential duplicate counts of individuals; variability among states in the completeness and quality of external cause coding. Hospitalizations generally represent the most severe pedestrian cases; there are substantially fewer cases than are seen in emergency departments, and their characteristics may not be representative of all pedestrians. Lack of detail on circumstances surrounding crash.
Other relevant information	Difficult to determine the incidence of injury given potential duplicate counts of same injury event (e.g., need to count a person-injury event only once and to include only the first or initial visit for the injury). Currently, there are no standard guidelines or recommendations on how to de-duplicate injury surveillance data.

State Level Emergency Department Data

Contact info/sponsor	This summary is a generic description of State Level Emergency Department (ED) data sets, and may not be accurate for any specific state. For example, states may differ on the availability, quality and completeness of the data collected. Contact the State Hospital Association, Public Health Department or Health Statistics Office.
Data type and purpose	Administrative data systems designed primarily to capture billing and licensing information, but often used for health planning and surveillance purposes.
Geographic scope	<ul style="list-style-type: none"> • Primarily a state level data system. • ED data are collected from all licensed EDs in each state, and excludes federal and tribal EDs. • State level data can be disaggregated to region, county and zip code levels. There are several national level aggregations of state level data (e.g., HCUP).
Availability Online query system Public use data set	Depends on the state; many have both query systems and public datasets. Contact the state Emergency Medicine Department, Public Health Department, or Hospital Association for details.
Data collection methodology	Hospital level reporting requirements are based on state and national laws and regulations. Data quality and completeness may vary (e.g., E-coding compliance). But each state's system is consistent with American Hospital Association (AHA) and National Center for Health Statistics (NCHS) agreements.
Content	Patient information: Demographics, source of admission, area of residence; principal and secondary diagnoses (ICD-9-CM diagnosis codes), procedures, type of discharge, external cause of injury E codes), source of payment, length of stay, charges; hospital type of ownership, capacity, financing; staffing ratios and location.
Demographic Information	Age, sex, and for some states, race/ethnicity; county and zip code of residence and ED; date of birth, date of admission, date of discharge, source of payment.

State Level Emergency Department Data	
Years of data	Depends on the state; Generally this data source has not been in place as long as Hospital Inpatient Discharge Data.
Variables and codes to identify cases	ICD-9-CM codes consistent with CDC and NCHS. www.cdc.gov/nchs/icd/icd9cm_addenda_guidelines.htm
Strengths for use in pedestrian injury surveillance	Uses standard ICD-9-CM coding scheme. Type of collision and patient demographics may vary significantly than what can be found using hospitalization data alone. Most states have well established systems for collecting, monitoring & reporting these data.
Challenges for use in pedestrian injury surveillance	Lack of detail on circumstances surrounding crash. Potential duplicate counts of individuals; variability among states in the completeness and quality of external cause coding (E Codes). Not all states have state-level ED data systems.
Other relevant information	Difficult to determine the incidence of injury considering given potential duplicate counts of same injury event (e.g., need to count a person-injury event only once and to include only the first or initial visit for the injury). Currently, there are no standard guidelines or recommendations on how to de-duplicate injury surveillance data.

Police Crash Reports

Contact info/sponsor	This will vary by state, but the state Department of Transportation (or similarly named agency) generally houses the data that are reported by City, County, and State police. In some instances regional or metropolitan-area data may be accessible by the responsible Metropolitan Planning Organization.
Data type and purpose	Vehicle crash data reports are developed from a standardized set of elements (Model Minimum Uniform Crash Criteria [MMUCC]) to report crash-, vehicle, and person-specific data about crashes involving vehicles.
Geographic scope	Nationally and in all 50 states, the District of Columbia, Puerto Rico, the U.S. Virgin Islands, and Guam.
Availability Online query system Public use data set	Will vary by state.
Data collection methodology	Each vehicle crash to which police respond will have an accompanying crash report. This can vary by state. Some states have reporting thresholds so not all vehicle crashes are required to be reported. Additionally, if police do not respond, motorist crash reports may be submitted and included in the crash database.
Content	Crash-, vehicle, and person-specific data about crashes involving vehicles.
Demographic Information	Crash location (including GPS coordinates in some states or Linear Referencing System identifier), gender, date of birth of driver and pedestrian. Full list of all potential variables in MMUCC at: http://www.mmucctraining.us/index.aspx .
Years of data	Will vary by state

Police Crash Reports

LIST OF POTENTIAL VARIABLES

Model Minimum Uniform Crash Criteria (MMUCC), 4th Edition

Crash Data Elements:

Variables and codes to identify cases

- | | | |
|---|--|---|
| <ul style="list-style-type: none"> • C1 Case Identifier • C2 Crash Classification • C3 Crash Date and Time • C4 Crash County • C5 Crash City/Place (political jurisdiction) • C6 Crash Location • C7 First Harmful Event | <ul style="list-style-type: none"> • C8 Location of First Harmful Event Relative to the Trafficway • C9 Manner of Crash / Collision Impact • C10 Source of Information • C11 Weather Conditions • C12 Light Condition • C13 Roadway Surface Condition • C14 Contributing Circumstances, Environment | <ul style="list-style-type: none"> • C15 Contributing Circumstances, Road • C16 Relation to Junction • C17 Type of Intersection • C18 School Bus-Related • C19 Work Zone - Related (Construction/ Maintenance/Utility) |
|---|--|---|

Police Crash Reports

Variables and codes to identify cases	Vehicle Data Elements:		
	<ul style="list-style-type: none"> • V1 Vehicle Identification Number (VIN) • V2 Motor Vehicle Unit Type and Number • V3 Motor Vehicle Registration State and Year • V4 Motor Vehicle License Plate Number • V5 Motor Vehicle Make • V6 Motor Vehicle Model Year • V7 Motor Vehicle Model • V8 Motor Vehicle Body Type Category • V9 Total Occupants in Motor Vehicle • V10 Special Function of Motor Vehicle in Transport 	<ul style="list-style-type: none"> • V11 Emergency Motor Vehicle Use • V12 Motor Vehicle Posted/Statutory Speed Limit • V13 Direction of Travel Before Crash • V14 Trafficway Description • V15 Total Lanes in Roadway • V16 Roadway Alignment and Grade • V17 Traffic Control Device Type • V18 Motor Vehicle Maneuver/Action • V19 Vehicle Damage • V20 Sequence of Events 	<ul style="list-style-type: none"> • V21 Most Harmful Event for this Motor Vehicle • V22 Bus Use • V23 Hit and Run • V24 Towed Due to Disabling Damage • V25 Contributing Circumstances, Motor Vehicle • V26 Motor Carrier Identification** • V27 Gross Vehicle Weight Rating / Gross Combination Weight Rating** • V28 Vehicle Configuration** • V29 Cargo Body Type** • V30 Hazardous Materials (Cargo Only)**

Police Crash Reports

Variables and codes to identify cases	Person Data Elements:		
	<ul style="list-style-type: none"> • P1 Name of Person Involved • P2 Date of Birth • P3 Sex • P4 Person Type • P5 Injury Status • P6 Occupant's Motor Vehicle Unit Number • P7 Seating Position • P8 Restraint Systems / Motorcycle Helmet Use • P9 Air Bag Deployed 	<ul style="list-style-type: none"> • P10 Ejection • P11 Driver License Jurisdiction • P12 Driver License Number, Class, CDL and Endorsements** • P13 Speeding Related • P14 Driver Actions at Time of Crash • P15 Violation Codes • P16 Driver Distracted By • P17 Condition at Time of Crash • P18 Law Enforcement Suspects Alcohol Use • P19 Alcohol Test 	<ul style="list-style-type: none"> • P20 Law Enforcement Suspects Drug Use • P21 Drug Test • P22 Non-Motorist Number • P23 Non-Motorist Action/ Circumstance Prior to Crash • P24 Non-Motorist Actions/Circumstances at Time of Crash • P25 Non-Motorist Location at Time of Crash • P26 Non-Motorist Safety Equipment • P27 Unit Number of Motor Vehicle Striking Non-Motorist • P28 Transported to First Medical Facility By

Police Crash Reports

Variables and codes to identify cases	Derived and Linked Data Elements:		
	<i>Crash Data Elements Derived From Collected Data</i>	<i>Person Data Elements Derived From Collected Data</i> <i>Person Data Elements Obtained After Linkage to Other Data</i>	<i>Roadway Data Elements Obtained After Linkage to Other Data</i>
	<ul style="list-style-type: none"> • CD1. Crash Severity • CD2. Number of Motor Vehicles Involved • CD3. Number of Motorists • CD4. Number of Non-Motorists • CD5. Number of Non-Fatally Injured Persons • CD6. Number of Fatalities • CD7. Alcohol Involvement • CD8. Drug Involvement • CD9. Day of Week 	<ul style="list-style-type: none"> • PD1. Age <ul style="list-style-type: none"> • Level 3: All Drivers • PL1. Driver License Restrictions • PL2. Driver License Status • PL3. Drug Test Result • Level 6: All Injured Persons • PL4. Injury Area • PL5. Injury Diagnosis • PL6. Injury Severity 	<ul style="list-style-type: none"> • RL1. Bridge/Structure Identification Number • RL2. Roadway Curvature • RL3. Grade • RL4. Part of National Highway System • RL5. Roadway Functional Class • RL6. Annual Average Daily Traffic • RL7. Widths of Lane(s) and Shoulder(s) • RL8. Width of Median



Police Crash Reports	
Strengths for use in pedestrian injury surveillance	<ul style="list-style-type: none">• Comprehensive accounting of all police reported pedestrian crashes• Detailed set of variables preceding a crash• Assessment of potential level of pedestrian injury using KABCO coding system
Challenges for use in pedestrian injury surveillance	<ul style="list-style-type: none">• Number of variables required by each state will vary• Accessibility of data and quality of data will vary from state to state• Injury severity is an estimate made by police officer responding to the incident• Accuracy of data may vary based on the reporting officer
Other relevant information	Each report also contains a narrative which may prove useful in filling in missing data elements and/or verifying accuracy of reporting. However, the narrative may not be included in the electronic file and only found in the hard copy.

National Vital Statistics System (NVSS) - Mortality (ICD-9 and ICD-10)

Contact info/sponsor	Centers for Disease Control and Prevention (CDC) National Center for Health Statistics (NCHS) Division of Vital Statistics 3311 Toledo Rd. Hyattsville, MD, 20782 Website: http://www.cdc.gov/nchs/nvss.htm
Data type and purpose	Census of all death certificates filed in the 50 States and the District of Columbia. Non-resident deaths occurring in the US are included in the national data file. Official tabulations, however, are typically limited to US residents.
Geographic scope	NVSS mortality files include data for the 50 States and the District of Columbia. Data for the territories of Puerto Rico, Virgin Islands, Guam, American Samoa, and the Commonwealth of the Northern Marianas are included in a separate file.
Availability Online query system Public use data set	<ul style="list-style-type: none"> • Mortality data generally lag 1-2 years from the current year. Timeliness is improving as states move toward comprehensive electronic death registration. • Public-use multiple cause of death (MCD) files are available online at: http://www.cdc.gov/nchs/data_access/Vitalstatsonline.htm#Mortality_Multiple • From 2005 forward the public-use MCD files do not contain state or county identifiers. Researchers can request these data by submitting a proposal to NCHS (http://www.cdc.gov/nchs/nvss/dvs_data_release.htm). Other items such as birth dates and death dates can be accessed via NCHS' Research Data Center. • MCD data are available on the CDC interactive data system WONDER in the MCD application http://wonder.cdc.gov/mcd.html • Data on leading causes of injury death, and counts and rates by mechanism and intent of injury are also available from WISQARS http://www.cdc.gov/injury/wisqars/index.html

National Vital Statistics System (NVSS) - Mortality (ICD-9 and ICD-10)

Data collection methodology	Administrative records (death certificates) completed by physicians, coroners, medical examiners, and funeral directors are filed with State Vital Statistics offices; selected statistical information is forwarded to NCHS to be combined into a national statistical file. The most recent revisions to the US standard death certificate were in 1978, 1989 and 2003. Demographic information on the death certificate is provided by the funeral director and is based on information supplied by an informant (typically, a family member or friend). Medical certification of cause of death is provided by the physician, medical examiner, or coroner.
Content	Public-use: Year of death, day of week, month of death, underlying and multiple causes of death, injury at work (beginning in 1993), place of death, educational attainment (beginning in 1989) for selected states, whether an autopsy was performed (not available from 1995-2002). Restricted access: State and county of decedent's residence, State and county where the death occurred.
Demographic Information	Sex, race, Hispanic origin (beginning in 1984), age at death, place of decedent's residence, educational attainment (beginning in 1989) for selected states, marital status (beginning in 1979). Restricted access: Place of birth (state), date of birth (after 1989)
Years of data	The data system began in 1900 but not all states participated before 1933. Coverage of deaths has been complete since 1933. Electronic data files available since 1968.
Variables and codes to identify cases	Up to 20 causes of death are reported. Underlying and multiple causes of death are coded using ICD-10 (1999 to present) or ICD-9 (1979-1998). The ICD-10 underlying cause codes used to identify deaths involving pedestrians and pedal cyclists are grouped by traffic vs. non-traffic events. <i>Pedestrian, traffic: [V02-V04](.1,.9), V09.2</i> <i>Pedestrian, non-traffic: V01, [V02-V04](.0), V05, V06, V09(.0-.1,.3,.9)</i> <i>Pedal cyclist, traffic: [V12-V14](.3-.9), V19(.4-.6)</i> <i>Pedal cyclist, non-traffic: V10-V11, [V12-V14](.0-.2), V15-V18, V19(.0-.3,.8,.9)</i>

National Vital Statistics System (NVSS) - Mortality (ICD-9 and ICD-10)

Strengths for use in pedestrian injury surveillance

- Complete count of deaths.
- Use of standard ICD coding system
- National in scope, but also includes state and county FIPS codes.
- Ability to place pedestrian deaths within the larger context of deaths from all causes.

Challenges for use in pedestrian injury surveillance

- Information on the location of the crash event is often limited or incomplete.
- Information on the circumstances of the death can be limited.
- States may differ in the quality and completeness of the data collected.

National Emergency Medical Services Information System (NEMSIS)

Contact info/sponsor	National Highway Traffic Safety Administration (NHTSA), Office of Medical Services Phone: (801) 585-9161 Email: nhtsa.ems@dot.gov Website: NEMSIS Technical Assistance Center http://www.nemsis.org/
Data type and purpose	Ongoing collection of emergency medical services (EMS) event data from states and territories. Contains information on prehospital care provided by EMS.
Geographic scope	National, state, and local Emergency Medical Services (EMS) data.
Availability Online query system Public use data set	National information queries are available at http://www.nemsis.org/reportingTools/reports/nationalReports/index.html State specific reports are also available but must be accessed by the state EMS agency.
Data collection methodology	Data are collected electronically by states from EMS agencies. Participating state agencies routinely send standardized data electronically to the NEMSIS Technical Assistance Center, where data are compiled to create the national database.
Content	Prehospital EMS event data without identifiers. Identifier information is only available in compliance with HIPAA requirements.
Demographic Information	Patient age, sex, race, ethnicity, home address, insurance, occupation, industry are collected locally. Not all demographic variables are available in the national database. Scene characteristics include date/time, GPS location, incident address and location type, destination address and GPS.

National Emergency Medical Services Information System (NEMSIS)

Years of data	National estimates available from 2012 forward.
Variables and codes to identify cases	There are cause of injury (variable name E10_01) codes for pedestrian traffic accidents (9610). In 2013, reports were submitted on 34,246 pedestrian traffic accidents (based on NEMSIS cause of injury code 9610).
Strengths for use in pedestrian injury surveillance	Pedestrian injuries treated by prehospital EMS agencies.
Challenges for use in pedestrian injury surveillance	Database is a convenience sample and might not be nationally representative. No details on the crash event itself, also GPS coordinates might be useful for linking to other (e.g., law enforcement) datasets.
Other relevant information	This database is particularly useful for identifying the number of pedestrian injuries treated by EMS including patient physical exam findings and procedures performed at the scene.

Nationwide Emergency Department Sample (NEDS)	
Contact info/sponsor	Healthcare Cost and Utilization Project (HCUP) Agency for Healthcare Research and Quality (AHRQ) Email: hcup@ahrq.gov Phone (toll free): 1-866-290-HCUP Website: http://www.hcup-us.ahrq.gov/nedsoverview.jsp
Data type and purpose	The NEDS was developed as part of HCUP to enable analyses of emergency department (ED) utilization patterns and to support public health professionals, administrators, policymakers, and clinicians in their decision-making regarding the delivery of emergency department care.
Geographic scope	The NEDS provides national and regional estimates of ED visits. The NEDS is built using a 20% stratified sample of hospitals based on region, teaching status, urban/rural location, and trauma center designation. All visits within the sample of selected EDs are included. The NEDS does not contain state identifiers.
Availability Online query system Public use data set	Estimates from the NEDS can be queried on-line using HCUPNet at http://hcupnet.ahrq.gov/ Public data sets are available for purchase at http://www.hcup-us.ahrq.gov/tech_assist/centdist.jsp .
Data collection methodology	States collect the ED data for administrative purposes. State-based organizations submit abstracts of the Inpatient/ED visits to AHRQ HCUP, which then aggregates the data into a uniform dataset in a standardized format. The NEDS is constructed from the State Emergency Department Database (SEDD) and the State Inpatient Database (SID). Thirty-two states participate in the SEDD (non-admitted ED visits) and 47 states participate in the SID (ED visits resulting in admission). The NEDS includes ED visits that resulted in an admission as well as ED visits that did not result in admission (e.g., treated and released, transferred to another hospital, transferred to another type of health facility, left against medical advice, or died in the ED).

Nationwide Emergency Department Sample (NEDS)

Content	In the dataset standardization process, AHRQ develops a core set of variables that are reasonably consistent across all states. The dataset includes primary and secondary ICD-9-CM diagnosis and external cause codes; CPT-4 procedure codes; identification of injury-related ED visits including mechanism, intent, and severity of injury; discharge status from the ED; patient demographics (e.g., sex, age, median income for ZIP code); expected payment source; total ED charges (for ED visits) and total hospital charges (for inpatient stays for those visits that result in admission); and hospital characteristics (e.g., region, trauma center indicator, urban/rural location, teaching status).
Demographic Information	Age, sex, income and for some states, race/ethnicity
Years of data	As of June 2015, data are available for 2006 through 2012. Purchase of the NEDS is open to all users who sign a Data Use Agreement.
Variables and codes to identify cases	ICD-9-CM external cause codes can be used to identify pedestrian injuries. In 2011, 94.0% of injury-related ED discharges had external cause codes.
Strengths for use in pedestrian injury surveillance	Weighted data from participating states can be used to create national and regional estimates for ED visits for pedestrian injuries.
Challenges for use in pedestrian injury surveillance	The dataset does not include information on use of protective devices or where the injury occurred.
Other relevant information	NEDS is available for a fee. Latest year available as of June 2015 is 2012. Many states have ED data available at the state level.

Nationwide Inpatient Sample (NIS)	
Contact info/sponsor	Healthcare Cost and Utilization Project (HCUP) Agency for Healthcare Research and Quality (AHRQ) Email: hcup@ahrq.gov Phone (toll free): 1-866-290-HCUP Website: http://www.hcup-us.ahrq.gov/nisoverview.jsp
Data type and purpose	Encounter or case count data for hospital discharges.
Geographic scope	National estimates of hospitalization discharges.
Availability Online query system Public use data set	Estimates from the NIS can be queried on-line using HCUPNet at http://hcupnet.ahrq.gov/ Public data sets are available for purchase at http://www.hcup-us.ahrq.gov/tech_assist/centdist.jsp .
Data collection methodology	States collect hospital discharge data for administrative purposes. State-based organizations submit abstracts of the data to AHRQ HCUP, which then aggregates the data into a uniform dataset in a standardized format. Beginning with the 2012 data year, HCUP's NIS is a 20% sample of discharges from all community hospitals participating in HCUP, excluding rehabilitation and long-term acute care hospitals. The NIS covers all patients, including individuals covered by Medicare, Medicaid, or private insurance, as well as those who are uninsured. The NIS is sampled from the State Inpatient Databases (SID), all inpatient data that are currently contributed to HCUP.
Content	The NIS contains clinical and resource-use information that is included in a typical discharge abstract. It contains clinical and nonclinical data elements for each hospital stay, including ICD-9-CM codes for primary and secondary diagnoses and external cause; patient demographic characteristics (e.g., sex, age, race, median household income for ZIP Code); hospital characteristics (e.g., ownership); expected payment source; total charges; discharge status; length of stay; severity and comorbidity measures.

Nationwide Inpatient Sample (NIS)

Demographic Information	Sex, age, race, median household income for ZIP Code
Years of data	As of June 2015, NIS data are available from 1988 through 2011.
Variables and codes to identify cases	ICD-9-CM external cause codes can be used to identify pedestrian injuries. Approximately 85.7% of the injury records in the NHIS have an external cause code.
Strengths for use in pedestrian injury surveillance	Weighted data from participating states can be used to create national estimates for hospital discharges for pedestrian injuries.
Challenges for use in pedestrian injury surveillance	The dataset does not include information on use of protective devices or where the injury occurred.
Other relevant information	<p>NIS is available for a fee.</p> <p>Latest year available as of June 2015 is 2011.</p> <p>Many states have hospital discharge data available at the state level.</p> <p>HCUP periodically (every 3 years) produces a similar dataset limited to patients aged 21 years and under. This dataset is the Kid's Inpatient Database (KID). It is based on the same data sources as the NIS but with a different sampling scheme.</p>

A.2 Measures of Exposure: Data Types, Sources, Strengths, & Limitations

Type	Source(s)	URL(s)	Strengths	Limitations	Numerators for which this is useful
Population Data	<ul style="list-style-type: none"> US Census 	http://factfinder.census.gov	Data available for all of USA at multiple geographic scales including census block groups	Does not quantify how common walking is; this measure just shows how many people reside in an area	Aggregated population data at multiple geographic scales
Trip Counts	<ul style="list-style-type: none"> National Household Travel Survey (NHTS) Some state surveys Metropolitan Planning Organizations 	http://nhts.ornl.gov http://surveyarchive.org	Can provide population-representative estimates of the number or proportion of trips taken by pedestrians	<p>Data may not be available for all geographic areas.</p> <p>NHTS data available for USA, states, and some metropolitan areas, but pedestrian data may be limited in sub-national samples</p>	Aggregated population data at national, state, municipal, and, in where availability permits, smaller areas such as zip codes
Time/ Distance Traveled	<ul style="list-style-type: none"> National Household Travel Survey (NHTS) Some state surveys Metropolitan Planning Organizations 	http://nhts.ornl.gov http://surveyarchive.org	<p>Can provide estimate of the amount of time pedestrians spend are vulnerable to transportation-related injury.</p> <p>Provides basis for calculating injuries per unit distance traveled.</p>	<p>Data may not be available for all geographic areas.</p> <p>NHTS data available for USA, states, and some metropolitan areas, but pedestrian data may be limited in sub-national samples.</p> <p>Discrepant speeds may hinder comparisons across modes.</p>	Aggregated population data at national, state, municipal, and, in where availability permits, smaller areas such as zip codes.

Type	Source(s)	URL(s)	Strengths	Limitations	Numerators for which this is useful
Commute Mode Share	<ul style="list-style-type: none"> US Census NHTS 	http://factfinder.census.gov http://nhts.ornl.gov	<p>Provides population-representative information on the prevalence of walking to work.</p> <p>Data available down to block groups (ACS, 5-year estimates).</p>	<p>Does not capture those who walk infrequently or for non-work travel.</p> <p>Does not provide estimate of time or distance traveled.</p>	Aggregated population data available at smaller geographical scales, Census block group.
Count Data	<ul style="list-style-type: none"> Local jurisdictions Future: Federal Traffic Monitoring Analysis System (TMAS) 	http://bikepeddocumentation.org/	<p>Provides location-specific data on pedestrian volume.</p> <p>Allows calculation of risk per pedestrian.</p> <p>Data from a few observation periods can be scaled up for daily, weekly, monthly, or annual estimates.</p>	<p>Limited utility for aggregated pedestrian injury data at geographic scales larger than specific locations (i.e., roadway intersections).</p>	Location- or corridor-specific pedestrian injury data.

A.3 Denominator Data Sources

United States Census	
Sponsor	U.S. Census Bureau, U.S. Department of Commerce
Primary purpose	Population and housing census
Geographic scope	National
Frequency	Decennial (three most recent: 2010, 2000, 1990)
Content	Statistical about demographic, social, economic, and housing characteristics aggregated across geographical units and groups
Data collection methodology	Census questionnaires mailed to all U.S. households
Availability	Data can be obtained through the U.S. Census website American Fact Finder: http://factfinder.census.gov
Strengths for use in pedestrian injury surveillance	Available consistently across the U.S., and can be considered a rough proxy of changes in pedestrian exposure over time.
Challenges for use in pedestrian injury surveillance	Data that grows less accurate as years pass. Population, or population density, does not accurately reflect the true pedestrian exposure.
Other relevant information	Various attributes from the Census can be used as potential inputs for pedestrian exposure models

American Community Survey

Sponsor	U.S. Census Bureau, U.S. Department of Commerce
Primary purpose	Data on how people commute to work, including the percentage of people who walk to work
Geographic scope	National
Frequency	Annual
Content	Statistical about demographic, social, economic, and housing characteristics aggregated across geographical units and groups
Data collection methodology	The Census Bureau selects a random sample of addresses to be included in the ACS (approximately 295,000 addresses a month). The sample is designed to ensure good geographic coverage and does not target individuals.
Availability	ACS data can be obtained through the U.S. Census website: http://www.census.gov/acs/ . Or American Fact Finder
Strengths for use in pedestrian injury surveillance	Since it is updated annually it can be used to track trends at a much better resolution than the decennial Census.
Challenges for use in pedestrian injury surveillance	Since it is only a sample the annual data is considered reliable at the state level or above. It can be considered reliable for large cities with a population $\geq 65,000$ when used in 3-year increments.
Other relevant information	<p>ACS measures only the mode someone "usually" used to commute to work in the week prior to the survey. If the respondent uses more than one mode to get to work, the survey specifically instructs the respondent to list only the mode used for longest distance. Thus, the survey is likely to underestimate pedestrian travel that is done in conjunction with other modes like transit, and may not represent even the main mode someone usually uses if they for some reason traveled differently in the week prior to taking the survey.</p> <p>Estimate of pedestrian travel to work as obtained from the ACS necessarily leaves out a large portion of other potential pedestrian trips and cannot be reliably extrapolated to estimate the percentage of those trips made on foot.</p>

National Household Travel Survey (NHTS)	
Sponsor	Federal Highway Administration, U.S. Department of Transportation
Primary purpose	Inventory of daily travel
Geographic scope	National
Frequency	Every 7-8 years. Most recent surveys: 2016 (expected in April 2017), 2009, 2001
Content	Includes: (i) purpose of the trip (work, shopping, social, etc.); (ii) means of transportation (car, walk, bus, subway, etc.); (iii) travel time of trip; (iv) time of day/day of week; and more for all modes, purposes, trip lengths, and all areas of the country, urban and rural.
Data collection methodology	Data for a sample of households, data is collected on daily trips taken by household members and individuals, over a single 24-hour period
Availability	Available to download from http://nhts.ornl.gov/index.shtml
Strengths for use in pedestrian injury surveillance	When NHTS data is current, it does provide detailed pedestrian trip information such as mode-share, travel-time, and trip-length
Challenges for use in pedestrian injury surveillance	Data that grows less accurate as years pass. The sampling plan includes a relatively small sample of households for each state, so extrapolating data from these surveys to the state level may produce a relatively inaccurate estimate of total pedestrian trips.
Other relevant information	<p><u>State and Regional Travel Surveys</u></p> <p>Some State and Regional agencies conduct their region their own household travel survey which would include a larger sample size. Some examples include:</p> <ul style="list-style-type: none"> • Atlanta Regional Commission (ARC), in conjunction with the Georgia Department of Transportation (GDOT) • Southeastern Wisconsin Regional Planning Commission (SEWRPC) • California Department of Transportation (CA DOT) <p>Some agencies also participate in the Add-on program that allows them to obtain additional samples and data elements, along with random national samples.</p>

Site Specific Pedestrian Counts (Manual, Sensor, Video)

Sponsor	Local agencies, MPO's, State agencies
Primary purpose	Traffic studies of pedestrian count programs
Geographic scope	Specific locations
Frequency	Varies depending on the sponsoring agency
Content	Number of pedestrian crossing per unit time for a specific spot
Data collection methodology	Short-term screen (2-8 hours), and long term screen counts (>8 hours). Counts can be collected manually, by in-pavement sensors, or videos.
Availability	<p>Varies depending on the sponsoring agency.</p> <p>Some agencies make the data available:</p> <ul style="list-style-type: none"> National archive for bicycle and pedestrian count data. Bike-Ped Portal: http://bp.its.pdx.edu/ WASDOT Permanent Bicycle & Pedestrian Count Program: http://www.wsdot.wa.gov/mapsdata/travel/bikepedcount.htm San Diego Regional Bike and Pedestrian Counters: http://www.eco-public.com/ParcPublic/?id=681
Strengths for use in pedestrian injury surveillance	Most useful when monitoring pedestrian volume at a single site or corridor.
Challenges for use in pedestrian injury surveillance	While analytic techniques exist to scale-up counts to larger geographies and time periods, their utility at the county, state, or higher levels may be limited by their geographic specificity.
Other relevant information	Commonly used as the dependent variables for pedestrian exposure models.



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