Accident Analysis and Prevention 106 (2017) 82–98

Contents lists available at ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

# Comparison of US metropolitan region pedestrian and bicyclist fatality rates

J. Schneider[a,*], Jason Vargo[b], Aida Sanatizadeh[a]

[a] University of Wisconsin-Milwaukee, Department of Urban Planning, School of Architecture and Urban Planning, 2131 E. Hartford Avenue, Milwaukee, WI 53211, United States

[b] University of Wisconsin-Madison, Global Health Institute, 1300 University Avenue, Madison, WI 53706, United States

ARTICLE INFO

*Keywords:*
Pedestrian
Bicycle
Metropolitan region
Fatality rates
Road safety
Active transportation

ABSTRACT

Annual US pedestrian and bicyclist fatalities involving motor vehicles have each increased by 30% in just six years, reaching their highest levels in two decades. To provide information to reverse this trend, we quantified pedestrian and bicyclist fatality rates in 46 of the largest US metropolitan statistical areas (MSAs) during two five-year time periods: 1999–2003 and 2007–2011. We divided the annual average number of pedestrian and bicyclist fatalities during 1999–2003 from the Fatality Analysis Reporting System by the annual estimates of pedestrian and bicycle trips, kilometers traveled, and minutes traveled from the 2001 National Household Travel Survey (NHTS) and the annual average number of fatalities from 2007 to 2011 by similar estimates from the 2009 NHTS. The five most dangerous regions for walking during 2007–2011 averaged 262 pedestrian fatalities per billion trips while the five safest averaged 49 pedestrian fatalities per billion trips. The five most dangerous regions for bicycling averaged 458 bicyclist fatalities per billion trips while the five safest averaged 75 bicyclist fatalities per billion trips. Random-effects meta-analysis identified eight metropolitan regions as outliers with low pedestrian fatality rates, six with high pedestrian fatality rates, one with a low bicyclist fatality rate, and five with high bicyclist fatality rates. MSAs with low pedestrian and bicycle fatality rates tended to have central cities recognized as Walk Friendly Communities and Bicycle Friendly Communities for investing in pedestrian and bicycle projects and programs. Random-effects meta-regression showed that certain socioeconomic characteristics and high pedestrian and bicyclist mode shares were associated with lower MSA fatality rates. Results suggest that pedestrian and bicycle infrastructure and safety programs should be complemented with strategies to increase walking and bicycling. In particular, safety initiatives should be honed to reduce pedestrian and bicyclist fatality risk in immigrant communities and to make pedestrian travel safer for the growing senior-age population.

## Introduction

Communities throughout the US are promoting walking and bicycling to enhance physical activity, reduce emissions, support local business, and create desirable places to live (Alliance for Biking and Walking 2016). Yet, many communities face the challenge of creating safer conditions for pedestrians and bicyclists within built environments that have been shaped by decades of automobile-oriented roadway design and land use development (Ewing et al., 2003; Dumbaugh and Rae 2009).

Globally, 1.25 million people are killed in traffic crashes each year, including more than 260,000 pedestrians and 48,000 bicyclists (World Health Organization, 2015). Recent US trends underscore the need for national and international efforts to improve pedestrian and bicycle safety. After experiencing a steady decline in pedestrian and bicyclist fatalities involving motor vehicles for approximately three decades, reaching 4100 pedestrian fatalities and 630 bicyclist fatalities in 2009 (NHTSA, 2016a,b), annual pedestrian and bicyclist fatalities have each increased by 30% in just six years, reaching nearly 5400 pedestrian and 820 bicyclist fatalities in 2015 (NHTSA, 2016c), the highest number of pedestrian and bicyclist fatalities since the mid-1990s. Had the US maintained 2009 fatality levels, approximately 3300 fewer pedestrians and 590 fewer bicyclists would have been killed between 2011 and 2015.

To address this challenge, the United Nations seeks to reduce traffic fatalities by 50% by 2020 (UN General Assembly, 2015), and Pillar 2 of the United Nations *Decade of Action for Road Safety, 2011–2020* emphasizes the need for the safety of vulnerable road users, including pedestrians and bicyclists (World Health Organization and United Nations Regional Commissions, 2010). Within the US, federal initiatives such as *Safer People, Safer Streets* (USDOT, 2014), *Pedestrian and Bicyclist Road Safety Assessments* (USDOT, 2015), and the *Surgeon General's Call*

* Corresponding author.
*E-mail addresses:* rjschnei@uwm.edu (J. Schneider), javargo@wisc.edu (J. Vargo), sanatiz4@uwm.edu (A. Sanatizadeh).

http://dx.doi.org/10.1016/j.aap.2017.04.018
Received 22 November 2016; Received in revised form 28 March 2017; Accepted 25 April 2017
0001-4575/ 

*to Action to Promote Walking and Walkable Communities* (USDHHS, 2015) show that pedestrian and bicyclist safety are high priorities.

This study as two primary aims: 1) quantify pedestrian and bicyclist fatality rates in 46 of the largest US metropolitan statistical areas (MSAs), and, if the rates are different among MSAs, 2) understand the underlying reasons behind these differences. If there are metropolitan-level differences, the characteristics of regions with low fatality rates can help inform safety strategies to prevent pedestrian and bicycle fatalities nationally and globally.

### 1.1. Pedestrian and bicycle exposure and risk

Traffic safety risk is typically represented using an incident rate, which is the number of incidents (e.g., crashes, injuries, fatalities) divided by a measure of exposure (e.g., street crossings, trips, distance traveled, time traveled). Comparisons of risk are important for understanding safety differences between time periods, between study sites, and between communities, but pedestrian and bicyclist risk comparisons often lack adequate exposure data. Consider, for example, alternative explanations for the 30% increase in pedestrian and bicyclist fatalities in the US since 2009. On one hand, more fatalities could simply be due to a 30% increase in pedestrian and bicyclist activity. On the other hand, if pedestrian and bicyclist travel remained constant since 2009, roadway conditions, road user behaviors, or some other factors made each unit of pedestrian and bicyclist travel more dangerous.

Pedestrian and bicyclist exposure have been represented by street crossings (Schneider et al., 2010; Molino et al., 2012), trips (Pucher and Dijkstra 2003; Beck et al., 2007), distance traveled (Pucher and Dijkstra 2003), and time traveled (Keall 1995; Rodgers 1995), respective of mode. Several studies compare and discuss the benefits of different measures of exposure (McAndrews et al., 2013; Guler and Grembek 2016). Trips can represent travel behavior (i.e., how often particular modes are used to travel from place to place). However, trips can be any length, representing a variety of distances, and durations. Travel distances and times may provide a more reasonable representation of potential interactions with automobile traffic. Guler and Grembek (2016) compared total injury (fatal and non-fatal) rates across travel modes and 10 California counties. They found that time-based mode share was more powerful than trip-based mode share for explaining variation in injuries per time traveled by bicycle, though the results were less clear for pedestrian risk. One challenge for using distance and time metrics is that travel survey respondents may not report them as accurately as trips (Scholssberg et al., 2007). Further complicating bicyclist exposure analysis, portions of a trip may be separated from automobiles on a multi-use trail or barrier-separated bike lane (less exposure), but other portions may be in mixed traffic (more exposure). This level of information has been collected but is resource-intensive (Dill 2009).

### 1.2. Pedestrian and bicyclist fatality rates from previous studies

A number of studies have estimated pedestrian and bicyclist fatality rates for specific geographic areas and compared these rates between socioeconomic groups (Table 1). Pucher and Dijkstra (2003) found US pedestrian fatality rates to be three times higher than Germany and six times higher than the Netherlands and US bicyclist fatality rates to be two times higher than Germany and three times higher than the Netherlands in 2000. Distance-based fatality rates suggest that the safety gap for bicyclists between the US and European countries was even wider in 2010 (Buehler and Pucher 2017). Beck et al. (2007) showed that pedestrians were 1.5 times and bicyclists were 2.3 times more likely than motor vehicle occupants to be fatally injured on a given trip in the US. In addition, pedestrian and bicyclist fatality rates both generally increased with age and were higher for males than females. Edwards and Mason (2014) estimated US bicyclist fatality rates per million kilometers bicycled. Bicyclist fatality rates were generally higher rates for older age groups (although teenage bicyclists had higher fatality rates than bicyclists in their 20 s and 30s). McAndrews et al. (2013) estimated trip-, distance-, and time-based fatality rates for different population subgroups in Wisconsin but did not compare these rates between communities.

Several studies have compared pedestrian fatality rates between areas using US Census walk-to-work mode share data to represent pedestrian exposure. Analyzing the 356 US counties with one or more pedestrian fatalities during the year 2000, Ewing et al. (2003) found that pedestrian fatality rates were higher in counties with more urban sprawl (characterized by lower population density and accessibility to destinations) and lower per capita incomes. Smart Growth America (2014) developed a Pedestrian Danger Index for the 51 largest US metropolitan regions to represent pedestrian fatality risk, concluding that pedestrians tend to be safer in regions with higher levels of walking, more compact development, and policies and design guidelines that emphasize pedestrian safety. One limitation of using journey-to-work mode share to calculate fatality rates is that it underestimates pedestrian and bicyclist activity—it does not include recreation, shopping, school, and social trips. This means that pedestrian and bicyclist risk is overestimated in regions with more walking and bicycling for non-work purposes.

A prominent finding in road safety studies is the concept of “safety in numbers,” first articulated in the general traffic safety literature by Smeed (1949) and for pedestrian and bicycle modes by Jacobsen (2003). Safety in numbers suggests that more pedestrian or bicyclist travel is associated with less crash risk for each individual pedestrian or bicyclist. This concept has been quantified through differences in crash rates between communities (Jacobsen 2003; Edwards and Mason 2014; Guler and Grembek 2016), roadway intersections (Geyer et al., 2006; Schneider et al., 2010), and time periods (Schneider et al., 2013). Safety in numbers has been criticized for its potential to inspire communities to encourage walking and bicycling without making other infrastructure and education and enforcement changes that may have a more direct relationship with improving safety (Geyer et al., 2006; Bhatia and Wier, 2011). More research is needed to understand causal mechanisms behind safety in numbers. For example, higher pedestrian and bicycle mode shares may be associated with reduced crash risk because motorists adapt their behavior to be more cautious around pedestrians and bicyclists or pedestrians and bicyclists adapt their behavior to become more predictable (Jacobsen 2003; Geyer et al., 2006). Behavioral adaptation may contribute to lower bicyclist risk, but agent-based simulations suggest that the density of bicyclists on a particular roadway may also lead to safety in numbers by reducing the physical surface area of each individual bicyclist exposed to nearby motor vehicles (Thompson et al., 2015; Thompson et al., 2016).

## Methods

We calculated pedestrian and bicyclist fatality rates during two five-year periods (1999–2003 and 2007–2011) for 46 Metropolitan Statistical Areas (MSAs) with populations greater than one million in 2000. These two periods are centered on the two most recent National Household Transportation Survey (NHTS) years (2001 and 2009) in order to match the fatality data with travel data. Boston, Hartford, and Providence were excluded from the analysis because their boundaries did not correspond with county boundaries, preventing an accurate comparison between travel data (provided at the MSA level) and fatality data (provided at the county level). We used MSA boundaries from 2000 for both analysis periods.

### 2.1. Fatality data

Fatal injuries from traffic crashes throughout the US are compiled in the Fatality Analysis Reporting System (FARS). FARS records include all