



Pedestrian Safety at Intersections

Safety is important for all roadway users, and the Federal Highway Administration (FHWA) Office of Safety has established a goal of reducing pedestrian fatalities and injuries by 10 percent by the year 2011.¹ Although intersections represent a very small percentage of U.S. surface road mileage, more than one in five pedestrian deaths is the result of a collision with a vehicle at an intersection. Annually, an average of 4,852 pedestrians died in traffic crashes during the 10-year period between 1998 and 2007. During the most recent five-year period (2003-2007), an average of 85 fewer pedestrian fatalities (4,767) have resulted. During the same analysis periods for intersections, an average of 1,134 and 1,140 pedestrians, respectively, have been killed. The percentage of pedestrian fatalities that occurs at intersections ranges from 22.0 percent to 24.8 percent between 1998 and 2007. The average over this 10-year period is 22.4 percent and, for the most recent five-year period, the average has increased to 23.0 percent (See Figure 1 and Table 1; all statistics based on Fatality Analysis Reporting System).

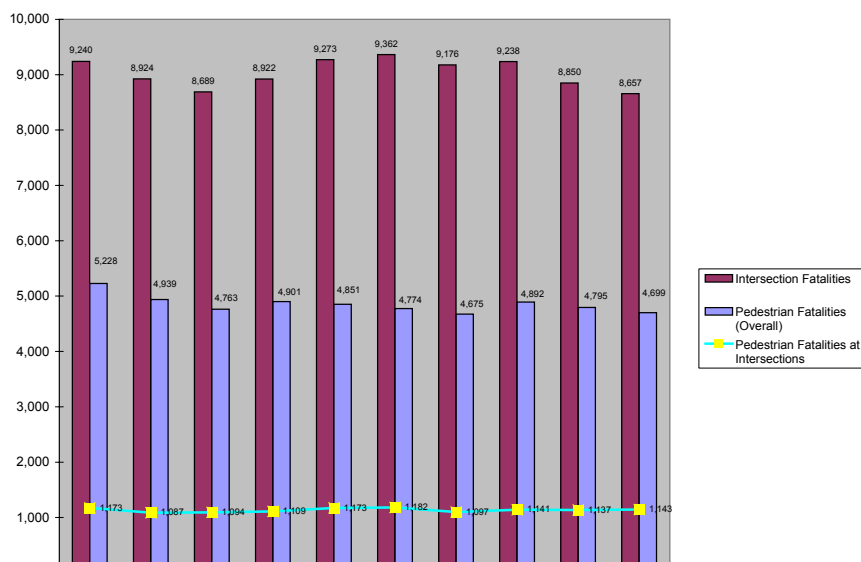


Figure 1: 1998–2007 Intersection and Pedestrian Fatalities and Pedestrian Fatalities at Intersections

Table 2 provides an overview of pedestrian fatalities at intersections as they relate to the age group of the pedestrian in the United States. As shown, the older population is overrepresented relative to intersection fatalities by a factor of more than 2 to 1. In fact, the age 75 to 84 age group is overrepresented by a factor of 3 to 1. All of the age groups under age 44 are underrepresented relative to pedestrian fatalities at intersections and have a ratio under 1.0 relative to their age group.

Pedestrian Safety Problems at Intersections

Pedestrian safety problems can occur at intersections for a variety of reasons, including the following:

- Complex signal phasing or lack of traffic control at high-volume, high-speed and multi-lane intersections.

1. FHWA Pedestrian Forum Newsletter, winter 2009.



U.S. Department of Transportation
Federal Highway Administration



Table 1: Intersection and Pedestrian Fatalities, 1998-2007

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Intersection Fatalities	9,240	8,924	8,689	8,922	9,273	9,362	9,176	9,238	8,850	8,657
Pedestrian Fatalities (Overall)	5,228	4,939	4,763	4,901	4,851	4,774	4,675	4,892	4,795	4,699
Pedestrian Fatalities at Intersections	1,173	1,087	1,094	1,109	1,173	1,182	1,097	1,141	1,137	1,143
% Pedestrian Fatalities at Intersections	22.4%	22.0%	23.0%	22.6%	24.2%	24.8%	23.5%	23.3%	23.7%	24.3%

Table 2: 2007 Pedestrian Fatalities at Intersections, by Age Group, in the United States

AGE	AGE GROUP PERCENTAGE OF US POPULATION	Number	Percentage	Over-representation Factor
<15	20.3%	67	5.9%	0.29
15-24	14.2%	109	9.5%	0.67
25-44	28.0%	244	21.3%	0.76
45-64	25.0%	356	31.3%	1.25
65-74	6.4%	156	13.6%	2.13
75-84	4.5%	155	13.6%	3.01
Age 85+	1.7%	50	4.4%	2.57
Unknown		6	0.52%	--
	TOTAL PEDESTRIAN FATALITIES AT INTERSECTIONS	1,143	100.0%	
	TOTAL PEDESTRIAN FATALITIES	4,699	24.3%	

- Limited or somewhat erratic compliance by motorists, even at simple STOP- or YIELD-controlled intersections. (See Figure 2)
- Pedestrian violation of traffic control devices, particularly in large urban centers.⁴ More than a quarter of fatal crashes involving pedestrians are the result of pedestrians disobeying intersection traffic control or making misjudgments while attempting to cross a street.²
- Low levels of enforcement for pedestrian and driver traffic control violations.
- Auto-oriented signal timing. Traffic signal timings may be too short to permit safe intersection crossing. Assumptions of walking speeds for signal timing may be too fast for many pedestrians to cross to the other side of the curb. At the same, additional lanes to increase roadway capacity can also have a negative effect on signal timing and pedestrian safety if not properly applied.
- Poor understanding of pedestrian signal displays by pedestrians.
- Conflicts with turning vehicles. Data consistently show that crashes with pedestrians occur far more often with turning vehicles than with through traffic. Left-turning vehicles are more often involved in pedestrian collisions than right-turning vehicles, partly because drivers are not clearly able to see pedestrians on the left.³
- Wide crossings. Research indicates that increasing the lanes on a roadway from four to six or more lanes increases the percentage of fatalities represented by pedestrian crashes by 64 percent.⁴



Figure 2: Example of erratic compliance

- Right-turns-on-red (RTOR) can potentially contribute to pedestrian crashes by creating conflicts between pedestrians and motorists. RTOR may also reduce pedestrian opportunities to cross intersections if motorists fail to yield the right-of-way to pedestrians.
- Pedestrian visibility to drivers is worse during hours of darkness, especially in areas with poor pedestrian-scale lighting. This is a common shortcoming of rural and suburban intersections. Pedestrians generally perceive that they are visible to drivers well before the drivers can actually see them.

Pedestrian Safety Countermeasures

To address pedestrian safety problems at intersections, the following section provides possible pedestrian safety countermeasures within the following categories:

- Crosswalk improvements;
- Intersection design/ physical improvements; and
- Intersection operations and signal hardware/technology.

While this section provides general countermeasures, specific countermeasures should be identified based upon detailed analysis of the pedestrian crash reports.

Crosswalk Improvements

Research reveals that just providing crosswalks at pedestrian crossings with uncontrolled approaches is not always adequate:

- On two-lane roads, the presence of marked crosswalks was not found to make a difference in pedestrian crash rates when compared to unmarked crosswalks.
- On multi-lane roads with volumes of more than 12,000 vehicles per day, having just a marked crosswalk was associated with higher pedestrian crash rates when compared with unmarked crosswalks. Additional measures are needed to make these types of crossings safer;
- Raised medians provide for significantly lower crash rates on multi-lane roads when compared with no raised medians.
- This does not mean crosswalks should not be provided. It suggests more than additional treatments beyond simply striping a crosswalk is required.⁵

Pedestrian Safety at Midblock Crosswalks/ Crossings of Uncontrolled Intersection Approaches

The following treatments can be used to improve pedestrian safety at midblock crosswalks or crossings of uncontrolled intersection approaches:

- Median cut-throughs angled to encourage pedestrians to look at oncoming traffic.
- Ladder or a cross-hatched pattern that is more visible to motorists.
- Advance yield markings (or stop lines as locally appropriate) the vehicle YIELD (or STOP) line farther back from crosswalk and add YIELD (or STOP) HERE FOR PEDESTRIANS sign.⁶
- Raised crosswalks.
- Curb extensions.

2. National Pedestrian Crash Report, NHTSA, 2008.

3. Insurance Institute for Highway Safety, Q&A: Pedestrians, December 2000.

4. Evaluation of Operational and Geometric Characteristics Affecting the Safety of Six-lane Roadways, Florida Department of Transportation, Tallahassee, FL, January, 2007.

5. Zegeer, Charles V. et. al. Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations. Executive Summary and Recommended Guidelines. FHWA RD-01-075, February 2002.

6. MUTCD Section 3B.16.

- Lane reductions/road diets to reduce roadway width.
- “PEDESTRIAN CROSSING” warning signs with pedestrian-actuated flashing beacons or rapid rectangular flashing beacons to alert on-coming traffic to pedestrians in the crosswalk.⁷
- In-pavement lights to alert motorists to the presence of a pedestrian crossing or when someone is preparing to cross the street. Transportation professionals should review the new Chapter 4L of the MUTCD that provides guidance on the use of in-pavement lights at crosswalks.
- STOP FOR PEDESTRIANS signs (R1-6) or YIELD TO PEDESTRIANS signs placed at crosswalks without signals in central business districts and other areas of high pedestrian activity to reinforce and remind drivers of the laws regarding yielding the right-of-way to pedestrians. See Figure 4.
- Pedestrian hybrid signals.⁸

Intersection Design/ Physical Improvements

- By considering pedestrians throughout the design process, pedestrians can be better accommodated at intersections.
- Use the appropriate design vehicle; use only the largest design vehicle that will use the intersection with considerable frequency.
- Where conflicting motor vehicle approaches are controlled and large truck movements are minimal, use the entire receiving width of the roadway to accommodate turning tractor trailer trucks.
- Install bulb-outs at intersections to reduce pedestrian crossing distance.

7. MUTCD Interim Approval for Optional Use of Rectangular Rapid Flashing Beacon (IA-11), FHWA, July 16, 2008.
 8. MUTCD (NPA) Chapter 4F. The NPA is a Notice of Proposed Amendment. While not yet part of the new MUTCD, it has been published to the Federal Register, comments have been received and, at the time of this Safety Brief’s authoring, are still being considered.



Figure 3: Unsignalized, midblock, ladder crosswalk. Usage of “State Law Stop for Pedestrian within Crosswalk” (R1-6) sign in median

- Provide wide refuge islands and raised medians.
- Provide for conflicts to occur at right angles.
- Reduce corner radii.
- Install midblock pedestrian crossing treatments.
- Construct pedestrian overpasses/underpasses.

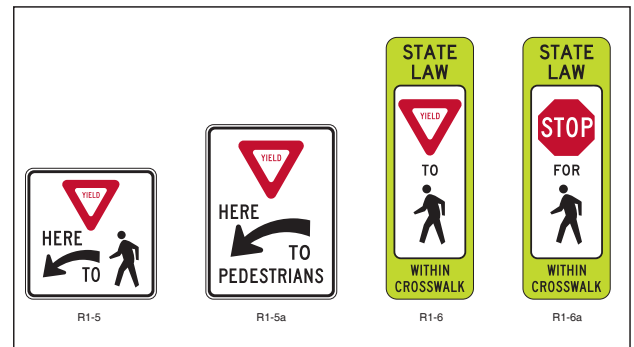


Figure 4: Unsignalized pedestrian crosswalk signs

Intersection Operations

- Provide pedestrian signals where appropriate.
- Include countdown pedestrian signals to provide additional information to pedestrians.⁹
- Time pedestrian signal timing to accommodate pedestrian walking speeds of 3.5 feet per second or include an extended push-button press to accommodate 3.5 foot per second speeds.¹⁰
- Consider protected-only left turn phasing.
- Consider leading pedestrian intervals.

9. MUTCD Section 4E.07.
 10. MUTCD (NPA) Section 4E.10.

- Consider restricting RTOR; the use of a blank-out sign can increase motorist compliance and reduce vehicular impacts to the intersection.
- Ensure the illumination is adequate to light not only the roadway approaches to the intersection but also the pedestrian approaches to the roadway as well.
- Use far-side bus stops.
- Consider exclusive pedestrian phasing.

If a location cannot be made safe for pedestrians, install barriers such as fences or shrubs to discourage pedestrians from crossing at unsafe locations; these must be designed so they do not create visual screens that could cause additional safety concerns.

Signal Hardware/ Technology

Pedestrian Countdown Displays

Provide pedestrian change interval countdown displays (use requirement anticipated in next MUTCD NPA Section MUTCD Section 4E.07 Countdown Pedestrian Signals). These displays count down the seconds of flashing DON'T WALK left before the pedestrian signal changes to solid DON'T WALK.

Accessible Pedestrian Signals (APS)

2003 MUTCD: Section 4E.06
Accessible Pedestrian Signals (APS)

The installation of APS at signalized locations should be based on an engineering study, which should consider the following factors: (1) potential demand for accessible pedestrian signals; (2) a request for accessible pedestrian signals; (3) traffic volumes during times when pedestrians might be present, including periods of low-traffic volumes or high turn-on-red volumes; (4) complexity of traffic signal phasing; and (5) complexity of intersection geometry. When using APS, the pedestrian signal must be visible and any push buttons must be accessible with audible locator tones for people with visual disabilities. See Figure 5.

Animated Eye Pedestrian Signal

Animated eyes are intended for use at pedestrian crosswalks as a supplement to conventional pedestrian signals. Animated eye displays may encourage pedestrians to look for turning vehicles traveling on an intersecting path by including a prompt as part of the pedestrian signal. The prompt is a pair of animated eyes that scan from side to side at the start of the WALK indication.¹¹



Figure 5: Example of APS

Pedestrian Intervals and Signal Phases

MUTCD NPA Section 4E.10

The pedestrian clearance time should be sufficient enough to allow a crossing pedestrian, who left the curb or shoulder during the WALKING PERSON signal indication, to travel at a walking speed of 3.5 feet per second and make it to at least the far side of the traveled way or to a median refuge. A walking speed of up to 4 feet per second may be used to evaluate the sufficiency of the pedestrian clearance time at locations where equipment such as an extended push button press or passive pedestrian detection has been installed to provide slower pedestrians an opportunity to request and receive a longer pedestrian clearance time.

The Three E-Approach: Engineering Alone is Not Sufficient

Improved pedestrian safety at intersections requires coordination among enforcement authorities, professional engineers, media, education experts, and vehicle designers to reduce both the number and severity of pedestrian collisions. Pedestrian safety cannot be improved by traffic engineering alone; it is a partnership between the driver, pedestrians, parents of young children, schools, police departments, and others.

From an enforcement perspective, motorist compliance with traffic control devices, posted speeds, and pedestrian safety laws needs to be ensured.

Pedestrians need to understand and obey intersection traffic control.

All partners need to develop a sustained and comprehensive intersection safety public awareness campaign that reaches both motorists and pedestrians. Pedestrians need to know how to make themselves more visible during evening and nighttime hours. One way to do this is to wear retro-reflective clothing and accessories. See Figure 6.

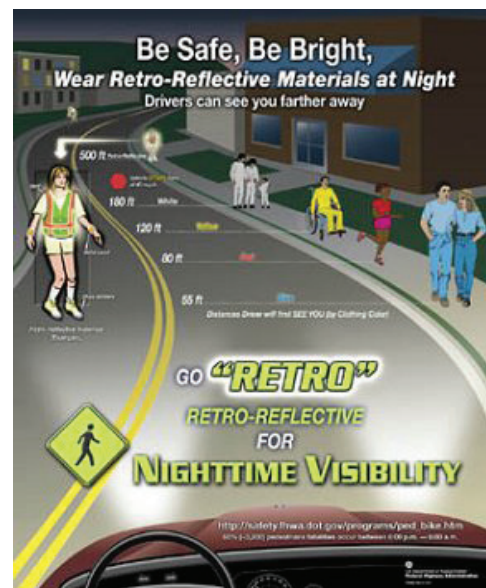


Figure 6: Poster distributed by FHWA

Sample Pedestrian Safety Programs/Tools

FHWA Pedestrian Road Safety Audit Guidelines

A road safety audit (RSA) is a formal safety examination of a future roadway plan or project or an in-service facility that is conducted by an independent, experienced multidisciplinary RSA team. All RSAs should include a review of pedestrian safety; however, some RSAs may be conducted to improve an identified pedestrian safety problem. The pedestrian road safety audit guidelines and prompt lists developed for the FHWA provide transportation agencies and teams conducting an RSA with a better understanding of the needs of pedestrians of all abilities.

<http://drusilla.hsrc.unc.edu/cms/downloads/PedRSA.reduced.pdf>.

11. MUTCD Section 4E.04.

Resources

Desktop Reference for Crash Reduction Factors

Publication No. FHWA-SA-07-015
A crash reduction factor is the percentage crash reduction that might be expected after implementing a given countermeasure at a specific site. FHWA has developed a set of resources to assist practitioners in identifying and deciding upon specific countermeasure treatments. These resources are developed around FHWA's Office of Safety focus areas of intersection safety, pedestrian safety and roadway departure safety.
http://safety.fhwa.dot.gov/tools/crf/desk_ref_sept2008/desk_ref_sept2008.pdf

FHWA's Pedestrian and Bicycle Intersection Safety Indices

The primary objective of this study was to develop safety indices to allow engineers, planners, and other practitioners to proactively prioritize intersection crosswalks and intersection approaches with respect to pedestrian and bicycle safety. The models in this study use easily collected, observable characteristics of an intersection to produce safety index values. Practitioners will be able to use these models on a small or large scale to determine where best to focus efforts to improve pedestrian and bicyclist safety.
<http://www.tfhrc.gov/safety/pedbike/pubs/06130/06130.pdf>

PEDSAFE: The Pedestrian Safety Guide and Countermeasure Selection System

PEDSAFE is intended to provide practitioners with the latest information available for improving the safety and mobility of pedestrians. The online tools provide the user with a list of possible engineering, education, or enforcement treatments to improve pedestrian safety and/or mobility based on user input about a specific location.
<http://www.walkinginfo.org/pedsafe/>

Toolbox of Countermeasures and Their Potential Effectiveness for Pedestrian Crashes

This tool identifies potential solutions for use by safety practitioners. This matrix is particularly helpful as a resource of potential engineering countermeasures, which may be implemented at a location to address a particular pedestrian crash type.
http://safety.fhwa.dot.gov/ped_bike/tools_solve/ped_tctpepc/ped_tctpepc.pdf

FHWA Pedestrian and Bicycle Crash Analysis Tool (PBCAT)

PBCAT is a crash-typing software intended to assist state and local pedestrian/bicycle coordinators, planners, and engineers with improving walking and bicycling safety through the development and analysis of a database containing details associated with crashes between motor vehicles and pedestrians or bicyclists.
<http://www.walkinginfo.org/facts/pbcat/download.cfm>

ITE/Partnership for a Walkable America Pedestrian Project Awards

ITE, in cooperation with the Partnership for a Walkable America and a grant from the Robert Wood Johnson Foundation, conducted a Pedestrian Project Award Program in 2003. More than 106 submittals were received in six categories: safety, facilities, education, policy, partnerships, and elderly and mobility impaired. Each submission, including the program description for both the winners and all nominees, has been digitized and is included on
<http://www.ite.org/activeliving/index.asp>

AASHTO Guide for the Planning, Design and Operation of Pedestrian Facilities, AASHTO, Washington, DC, 2004.

Florida Department of Transportation Pedestrian and Bicycle Research.
http://www.dot.state.fl.us/Safety/ped_bike/ped_bike_reports.shtm

Alternative Treatments for At-Grade Pedestrian Crossings. ITE, Washington, DC, 2001.

Design and Safety of Pedestrian Facilities: An ITE Recommended Practice. ITE, Washington, DC, 1998.

National Traffic Safety Administration Fact Sheets: Pedestrians. <http://www-nrd.nhtsa.dot.gov/Pubs/810994.pdf>

Pedestrian and Bicycle Information Center. <http://www.walkinginfo.org/>

Pedestrian Mobility and Safety Audit Guide. AARP/ITE, 2009. <http://www.ite.org/PedAudits/AuditGuide.pdf>

U.S. Access Board, Public Rights-of-Way Webpage. <http://www.access-board.gov/prowac/>