Selecting Improvements for Pedestrians ∞ Chapter 3

PHOTO BY MICHAEL RONKIN

Identification of High-Crash Locations

Pedestrian Crash Typing

Definitions of Pedestrian Crash Types

Crash-Related Countermeasures

Performance Objectives

Program of Improvements

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Pedestrians are quite often in conflict with left-turning vehicles when permissive signal phasing is used.

Deciding on the set of treatments that will provide the greatest benefits in terms of providing safety and mobility requires transportation and land-use planners, engineers, law enforcement officials, and community leaders to engage in problem-solving. In most cases, a two-prong approach is required. The first prong involves an examination of the pedestrian crash problem through a review of historical crash data. Two specific types of crash analyses include the identification of high-crash locations and the detailed examination of pre-crash maneuvers that lead to pedestrian-motor vehicle incidents. Both are described in more detail in this chapter.

However, many of the problems faced by pedestrians either do not involve crashes or the crashes are not reported. Thus, the second prong addresses these types of problems by focusing on performance objectives that will lead to changes in behavior, which in turn, will result in a safer and more accessible environment for pedestrians. The types of objectives most often pursued by local agencies are discussed in this chapter.

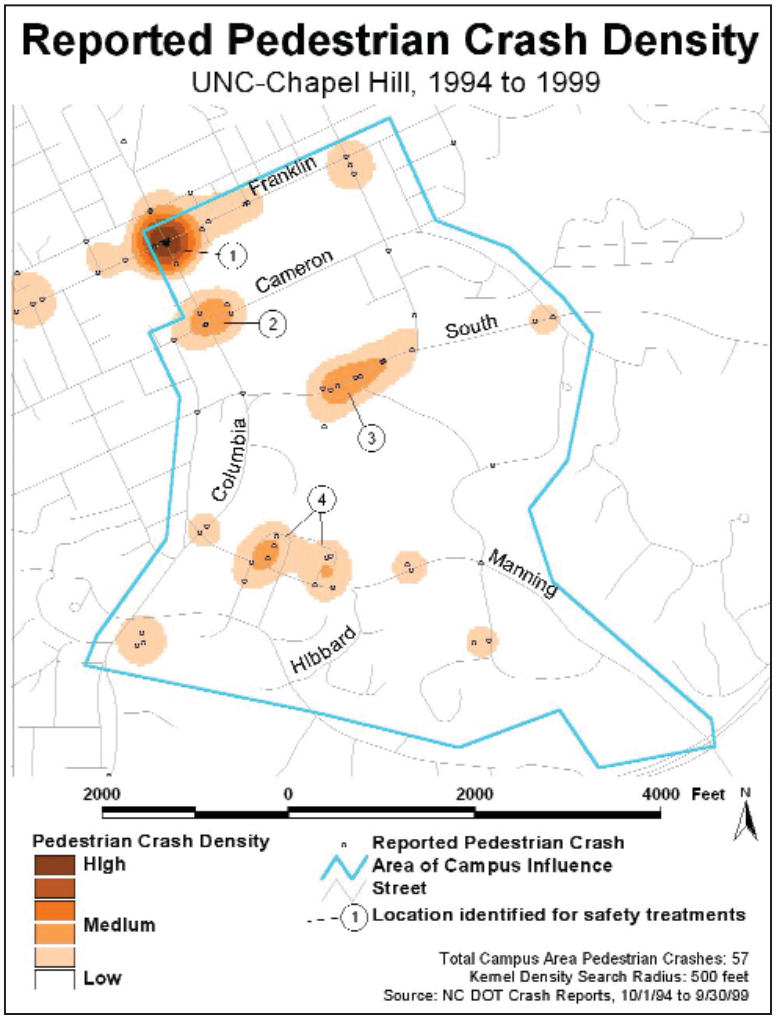
IDENTIFICATION OF HIGH-CRASH LOCATIONS

A first step in the problem-solving process of improving pedestrian safety and mobility is to identify locations or areas where pedestrian crash problems exist and where engineering, education, and enforcement measures will be most beneficial. Mapping the locations of reported pedestrian crashes in a neighborhood, campus, or city is a simple method of identifying sites for improving walking safety. One method of analyzing crash locations includes using computerized Geographic Information Systems (GIS) software, as shown by the density map of reported pedestrian crashes on a college campus pictured below.

This type of map can help transportation engineers and planners focus safety improvements on intersections, street sections, or neighborhoods where pedestrian crashes have occurred.

Several issues should be considered when creating GIS maps of reported crash locations. First, the total number of pedestrians and vehicles that use each location will affect reported crash density.

Second, pedestrian crashes may not be reported frequently enough to establish a pattern of unsafe walking locations. In either case, performing a conflict analysis, noting pedestrian and driver behavior or examining roadway and walkway characteristics at specific sites, or mapping locations known to have a high potential for pedestrian crashes in an area may improve the identification of unsafe locations for walking. Other methods for identifying locations with possible pedestrian problems include using walkability checklists and calculating a pedestrian level of service.



PEDESTRIAN CRASH TYPING

The development of effective roadway design and operation, education, and enforcement measures to accommodate pedestrians and prevent crashes is hindered by insufficient detail in computerized State and local crash files. Analysis of these databases can provide information on where pedestrian crashes occur (city, street, intersection, two-lane road, etc.), when they occur (time of day, day of week, etc.), and characteristics of the victims involved (age, gender, injury severity, etc.). Current crash files cannot provide a sufficient level of detail regarding the sequence of events leading to the crash.

In the 1970s, methods for typing pedestrian and bicycle crashes were developed by the National Highway Traffic Safety Administration (NHTSA) to better define the sequence of events and precipitating actions leading to pedestrian/motor vehicle crashes.[1,2,3,4] These methodologies were applied by Hunter in a 1996 study to more than 8,000 pedestrian and bicycle crashes from 6 States.[1,2,3,4] The results provided a representative summary of the distribution of crash types experienced by pedestrians and bicyclists. Some of the most frequently occurring types, include dart-out first half (i.e., the pedestrian is struck in the first half of the street being crossed) (24 percent), intersection dash (13 percent), dart-out second half (10 percent), midblock dart (8 percent), and turning-vehicle crashes (5 percent).[1,2,3,4]

The crash-typing methodology described above has evolved over time and has been refined as part of a software package known as the Pedestrian and Bicycle Crash Analysis Tool (PBCAT).[5] The development of PBCAT was sponsored by the Federal Highway Administration (FHWA) and NHTSA through the University of North Carolina Highway Safety Research Center. Those interested may register for the PBCAT software and user's manual from the Pedestrian and Bicycle Information Center website at: www.walkinginfo.org/pbcat.

PBCAT is a software product intended to assist State and local pedestrian and bicycle coordinators, planners, and engineers with the problem of lack of data regarding the sequence of events leading to a crash. PBCAT accomplishes this goal through the development and analysis of a database containing details associated with crashes between motor vehicles and pedestrians or bicyclists. One of these details is the crash type, which describes the pre-crash actions of the parties involved. The more than 60 specific pedestrian crash types used in PBCAT can be collapsed into 12 crash typing groups for purposes of selecting treatments.

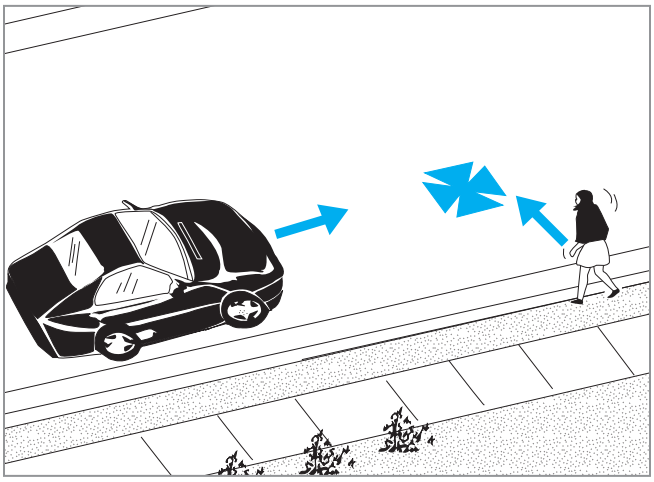
DEFINITIONS OF PEDESTRIAN CRASH TYPES

Provided below are the definitions of the 12 crash types included in the PEDSAFE application. These definitions are from the PBCAT software.[5] For any crash type, there are multiple problems or possible causes that may have led to the crash. The following section also provides examples of a few possible causes/problems for each crash type and some of the countermeasures within PEDSAFE that may be applicable. At the end of each potential solution is the countermeasure number in parentheses, which can be used to quickly locate the countermeasure description in Chapter 5. Neither the list of problems and possible causes nor the suggested countermeasures are to be considered comprehensive. Practitioners will still be required to supplement the analysis and recommendations with their own investigations and knowledge of local policies and practices.

1. DART/DASH

The pedestrian walked or ran into the roadway at an intersection or midblock location and was struck by a vehicle. The motorist's view of the pedestrian may have been blocked until an instant before the impact.

Possible Cause/Problem #1
Child runs into neighborhood/collector street.



General Countermeasures

a. Provide adequate nighttime lighting (5).
b. Add on-street bike lanes (8).
c. Narrow travel lanes (9).
d. Provide curb extensions (19).
e. Install spot street narrowing at high midblock-crossing locations (20).

f. Implement traffic-calming measures such as chicanes, speed humps, or speed tables (22, 24, 25).

g. Provide a raised pedestrian crossing (27).

h. Design gateway to alert motorists that they are entering neighborhood with high level of pedestrian activity (28).

i. Convert street to driveway link/serpentine, woonerf, or a pedestrian street (31, 32, 36).

j. Install street diverters or full/partial street closures at selected intersection(s) (33, 34, 35).

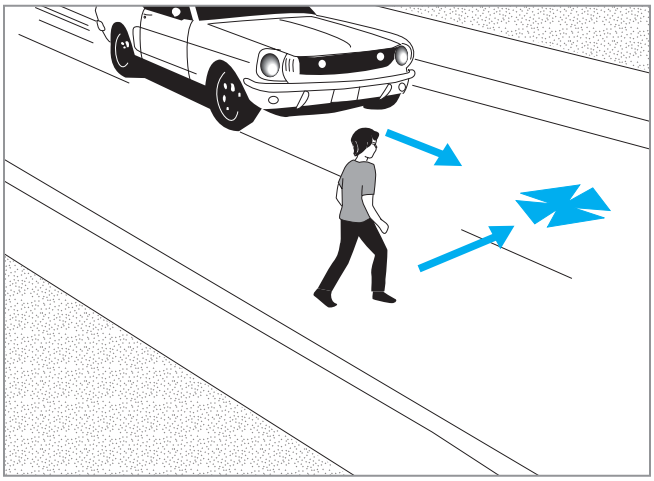
k. Provide adult crossing guard (in school zone) (44).

l. Remove or restrict on-street parking (47).

m. Educate children about safe crossing behavior and adults about speeding (48).

Possible Cause/Problem #2

Pedestrian is struck while crossing a high-speed and/or high-volume arterial street.



General Countermeasures

a. Relocate bus stop (4).

b. Improve/add nighttime lighting (5).

c. Install overpass or underpass (6).

d. Install medians or pedestrian crossing islands (18, 21).

e. Provide curb extensions at intersections or midblock to improve direct line of sight between vehicle and pedestrian (19).

f. Add traffic-calming measures (19-32).

g. Provide staggered crosswalk through the median (forcing pedestrians to walk and look to the right for oncoming traffic in the second half of street) (21).

h. Install midblock traffic signal with pedestrian signals, if warranted (37, 38).

i. Install standard warning sign (see Manual on Uniform Traffic Control Devices (MUTCD)) or yellow or fluorescent yellow/green signs to alert drivers to pedestrian crossing area (40, 43).

j. Bus young children across busy streets (44).

k. Adjust school district boundaries (44).

l. Use speed-monitoring trailer (46).

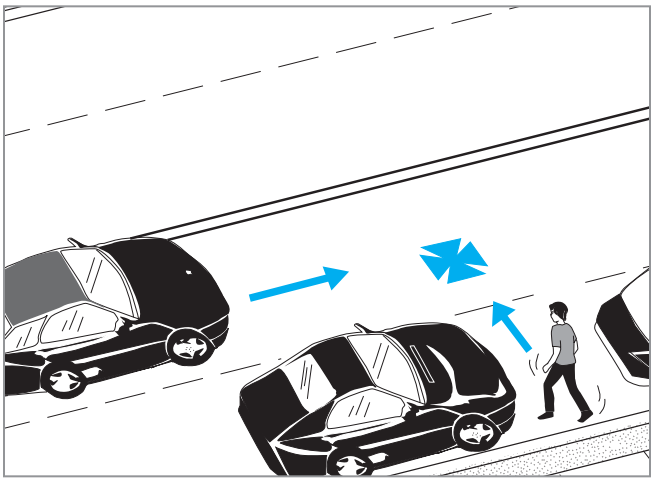
m. Enforce speed limits, pedestrian ordinances (49).

2. MULTIPLE THREAT/TRAPPED

The pedestrian entered the roadway in front of stopped or slowed traffic and was struck by a multiple-threat vehicle in an adjacent lane after becoming trapped in the middle of the roadway.

Possible Cause/Problem #1 (multiple threat)

The pedestrian entered the traffic lane in front of stopped traffic and was struck by a vehicle traveling in the same direction as the stopped vehicle. The stopped vehicle may have blocked the visibility between the pedestrian and the striking vehicle, and/or the motorist may have been speeding.



General Countermeasures

a. Relocate bus stop to far side of crossing area (4).

b. Improve roadway lighting (5).

c. Provide midblock or intersection curb extensions (19).

d. Install traffic-calming devices such as speed tables or raised pedestrian crossings on local or other neigh-

borhood streets (25, 27).

e. Provide raised crosswalks to improve pedestrian visibility (27).

f. Install traffic signals if warranted, including pedestrian signals (37, 38).

g. Install flashers or advance warning signs (37, 43).

h. Recess stop lines 9.1 m (30 ft) in advance of crosswalk (42).

i. Install barriers or signs to prohibit crossings and direct pedestrians to safer crossing locations nearby (43).

j. Enforce crosswalk laws (49).

Possible Cause/Problem #2

Pedestrian is struck while crossing a high-speed and/or high-volume arterial street.

General Countermeasures

a. Reduce roadway width. For example, add sidewalks and bike lanes to a roadway by narrowing four-lane undivided roadways to two through lanes plus a center two-way left-turn lane or wide raised median (1, 8, 9, 10).

b. Improve roadway lighting (5).

c. Construct overpass or underpass (6).

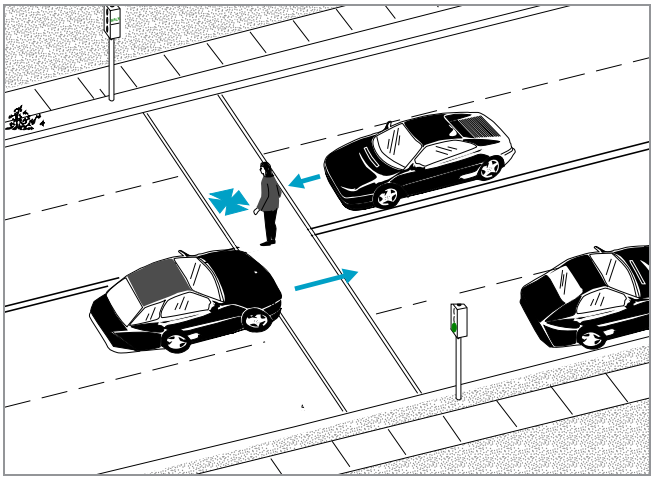
d. Narrow travel lanes (e.g., add bike lanes) to slow vehicle speeds and reduce crossing distance (9).

e. Install raised median or pedestrian crossing island (12, 21).

f. Increase police enforcement of speed limit (49).

Possible Cause/Problem #3 (trapped)

Pedestrian began crossing on green signal and became trapped in the roadway when the signal changed.



General Countermeasures

a. Reduce roadway width (9).

b. Provide midblock or intersection curb extensions (19).

c. Install raised pedestrian crossing island (21).

d. Provide raised crosswalk to improve pedestrian visibility (27).

e. Install pedestrian signals (38).

f. Adjust pedestrian signal timing (39).

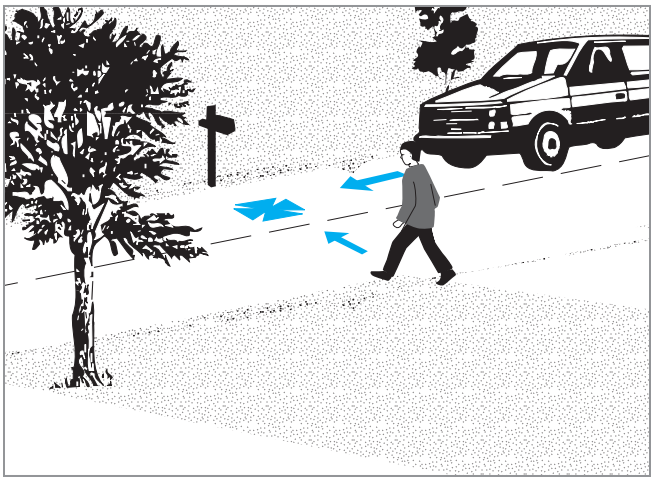
g. Enforce crosswalk laws (49).

3. UNIQUE MIDBLOCK (MAILBOX, ICE-CREAM VENDOR, PARKED VEHICLE)

The pedestrian was struck while crossing the road to/from a mailbox, newspaper box, or ice-cream truck, or while getting into or out of a stopped vehicle.

Possible Cause/Problem #1

Pedestrian struck while going to/from a private residence mailbox/newspaper box.



General Countermeasures

a. Improve lighting (5).

b. Add bike lanes and reduce total roadway and lane width (8, 9, 10).

c. Provide raised median on multi-lane arterial street (12).

d. Provide traffic-calming measures (e.g., chicanes or raised devices on residential streets) (22, 26, 27).

e. Construct gateway or provide signs that identify neighborhood as an area with high levels of pedestrian activity (28, 45).

f. Install pedestrian warning signs (see MUTCD) (43).

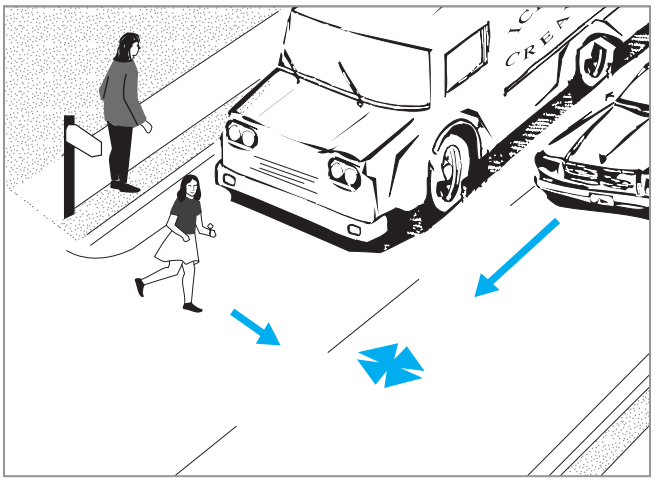
g. Implement driver education program (48).

h. Implement pedestrian education program (48).

i. Relocate mailboxes to safer crossing area or provide safer crossings at existing location.

Possible Cause/Problem #2

Pedestrian struck while going to/from an ice-cream vendor or similar destination.



General Countermeasures

a. Reduce roadway width or remove a lane (9, 10).

b. Provide traffic-calming measures on local streets (19-32).

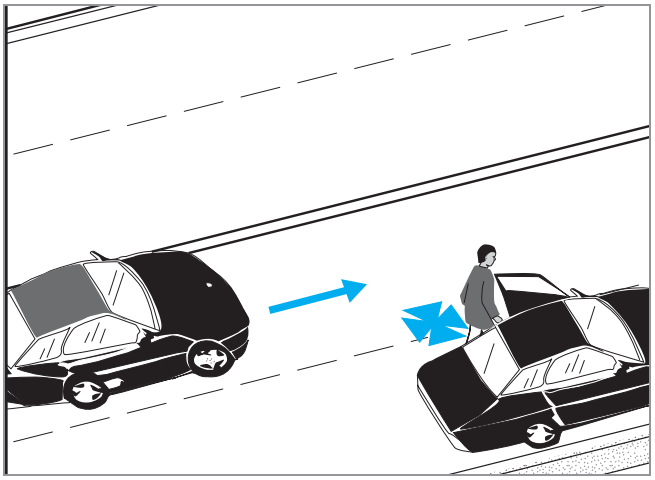
c. Add pedestrian crossing islands to roadway (21).

d. Create Public Service Announcements (PSAs) to educate parents, children, and drivers (48).

e. Adopt an Ice-Cream Truck Ordinance. This ordinance would prohibit motorists from passing a stopped ice-cream truck. Trucks would be equipped with flashing lights and a "stop" arm that would extend when the truck stopped to serve children (49).

Possible Cause/Problem #3

Pedestrian struck while getting into/out of parked vehicle.



General Countermeasures

a. Improve roadway lighting (5).

b. Implement traffic-calming measures on local/collector streets (19-32).

c. Implement speed-reduction measures such as chicanes or speed tables (22, 26).

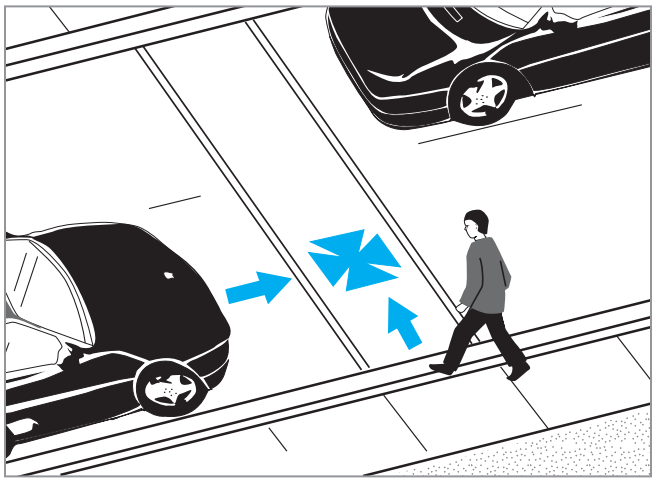
d. Restrict on-street parking (47).

4. THROUGH VEHICLE AT UNSIGNALIZED LOCATION

The pedestrian was struck at an unsignalized intersection or midblock location. Either the motorist or the pedestrian may have failed to yield.

Possible Cause/Problem #1

Motorist fails to yield to pedestrian at two-lane, low-speed road crosswalk (or unmarked crossing).



General Countermeasures

a. Improve crosswalk marking visibility (3).

b. Improve roadway lighting (5).

c. Reduce curb radius to slow vehicle speeds (14).

d. Install curb extensions or choker (19, 20).

e. Use special paving treatments along street to slow traffic, add chicanes, or use serpentine design (20, 22, 31).

f. Construct raised pedestrian crossing island (21).

g. Install speed humps, speed tables, raised intersections, or raised crosswalks (24, 25, 26, 27).

h. Use landscaping that slows vehicle speeds without impeding sightlines (29).

i. Install traffic signal with pedestrian signals, if warranted (37, 38).

j. Install overhead CROSSWALK, school zone, or other warning signs (43).

Possible Cause/Problem #2

Pedestrian has difficulty crossing multilane road (which may also have high travel speeds and/or high traffic volumes).

General Countermeasures

a. Ensure that curb ramps are provided to make crossing easier for all pedestrians (2).

b. Place bus stop at far side of intersection (4).

c. Install nighttime lighting (5).

d. Construct overpass or underpass (6).

e. Install bike lanes and/or narrow or reduce the number of roadway lanes (8, 9, 10).

f. Add bike lanes or modify four-lane, undivided street to two lanes plus a two-way, left-turn lane (TWLTL) or wide median with turning pockets (8, 10).

g. Install raised medians or pedestrian crossing islands (12, 21).

h. Install traffic signal with pedestrian signals, if warranted (37, 38).

i. Use police speed enforcement (49).

Possible Cause/Problem #3

Motorist unwilling to yield due to high motorist speeds or high traffic volumes.

General Countermeasures

a. Install bike lanes and/or narrow or reduce the number of roadway lanes (8, 9, 10).

b. Construct pedestrian crossing island or medians (12, 21).

c. Implement traffic-calming measures (19-32).

d. Provide gateway, create a pedestrian street, or identify neighborhood with signs (28, 36, 45).

e. Install traffic signal with pedestrian signals, if necessary (37, 38).

f. Install signs or sidewalk barriers to guide pedestrians to safer crossing locations (43).

g. Use speed-monitoring trailer (46).

h. Increase police enforcement of speed limit (49).

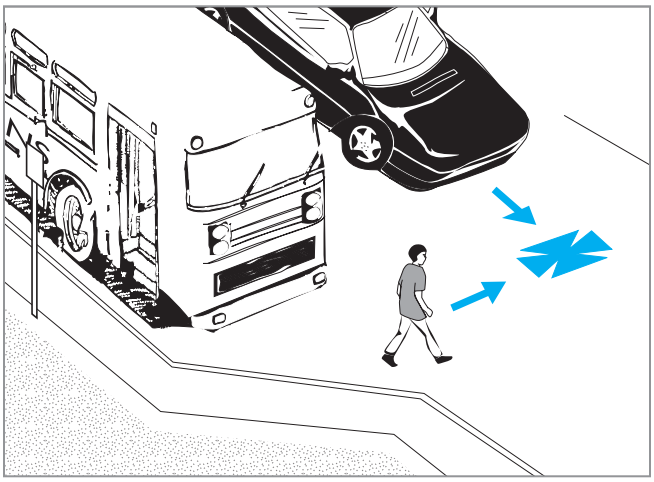
i. Install special overhead pedestrian-actuated flashers with warning signs.

5. BUS-RELATED

The pedestrian was struck by a vehicle while: (1) crossing in front of a commercial bus stopped at a bus stop; (2) going to or from a school bus stop; or (3) going to or from, or waiting near a commercial bus stop.

Possible Cause/Problem #1

Motorist fails to yield to pedestrian or pedestrian crosses during inadequate gap in traffic due to limited sight distance at intersection.



General Countermeasures

a. Install crosswalk markings to encourage pedestrians to cross in the crosswalk behind the bus (3).

b. Move bus stop to far side of intersection or crosswalk (4).

c. Consider an alternative bus stop location (4).

d. Mark bus stop area with pedestrian warning signs (4).

e. Install or improve roadway lighting (5).

f. Install pedestrian crossing medians or raised crosswalk (12, 21, 27).

g. Install curb extension (19).

h. Remove parking in areas that obstruct the vision of motorists and pedestrians (47).

Possible Cause/Problem #2

Pedestrian has difficulty walking along roadway and crossing at midblock location with high vehicle speeds and/or high volumes.

General Countermeasures

a. Provide an accessible sidewalk and curb ramps (1, 2).

b. Install sidewalk and/or sidewalk barriers to direct pedestrians to a nearby crossing location (2).

c. Provide bus pull-off area (4).

d. Consider an alternative bus stop location (4).

e. Install or improve roadway lighting (5).

f. Add bike lanes or painted shoulder (8).

g. Reduce number of roadway lanes (10).

h. Install midblock curb extensions (19).

i. Install traffic and pedestrian signals, if warranted (37, 38).

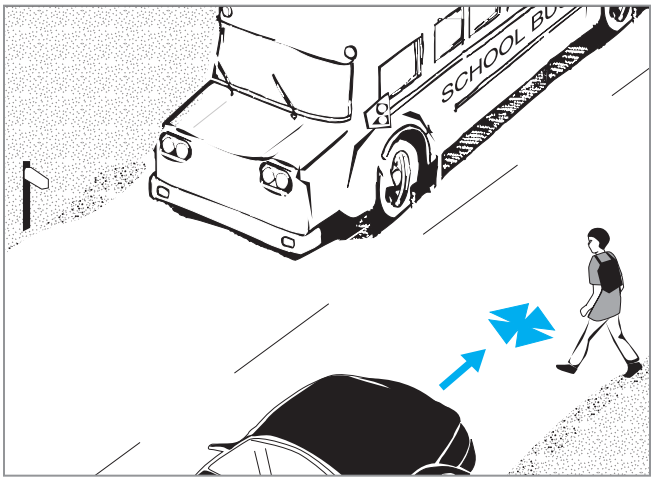
j. Add recessed stop lines (42).

k. Provide pedestrian education/training (48).

l. Increase police speed enforcement (49).

Possible Cause/Problem #3

Pedestrian has difficult time crossing, waiting, or walking in the vicinity of school bus stop.



General Countermeasures

a. Provide sidewalks (1).

b. Install or improve roadway lighting (5).

c. Provide street furniture or other amenities at bus stop (7).

d. Select safer location for school bus stop (44).

e. Implement pedestrian/driver education programs (48).

f. Educate pedestrians to cross behind the bus at far side of bus stops (48).

g. Involve school, neighborhood groups, and PTA in promoting education and enforcement (48, 49).

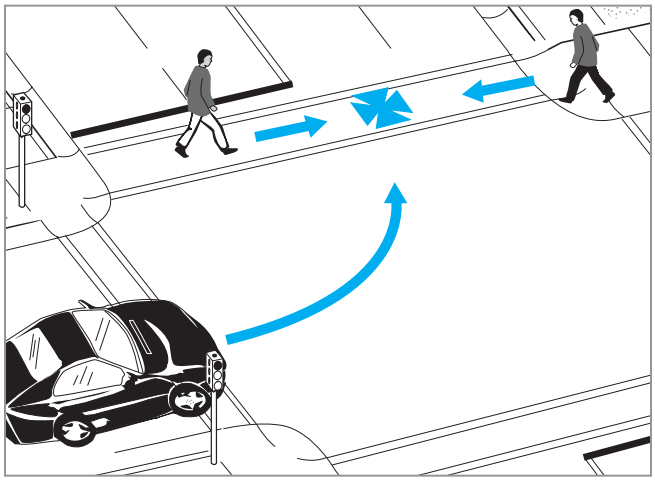
h. Enforce regulations against passing stopped school bus (49).

6. TURNING VEHICLE

The pedestrian was attempting to cross at an intersection, driveway, or alley and was struck by a vehicle that was turning right or left.

Possible Cause/Problem #1

Conflict between pedestrian and left-turning vehicle.



General Countermeasures

a. Add curb ramps or curb extensions (2, 19).

b. Install raised median and pedestrian crossing island (12, 21).

c. Convert to one-way street network (if justified by surrounding areawide pedestrian and traffic volume study) (13).

d. Consider using modified T-intersections, intersection median barriers, diverters, or street closures (17, 18, 33, 34).

e. Use traffic-calming devices, such as a raised intersection or raised pedestrian crossing, to reduce vehicle speeds (26, 27).

f. Provide separate left-turn and WALK/DON'T WALK signals (38).

g. Add special pedestrian signal phasing (e.g., exclusive protected pedestrian signal or leading pedestrian interval) (38).

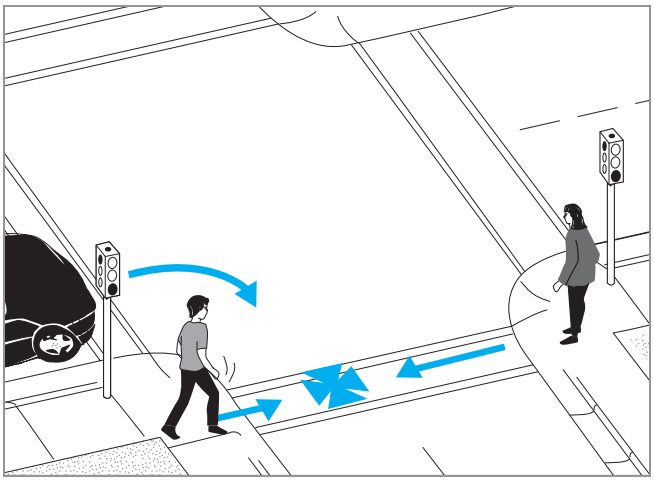
h. Prohibit left turns (43).

i. Install warning signs for pedestrians and/or motorists (see MUTCD) (43).

j. Develop/provide Public Safety Announcement (PSA) safety messages (48).

Possible Cause/Problem #2

Conflict between pedestrian and right-turning vehicle.



General Countermeasures

a. Provide marked crosswalks and advanced stop lines (3, 42).

b. Improve intersection lighting to improve visibility (5).

c. Remove intersection snow/clutter at the corner to improve visibility and give pedestrian space to stand outside of roadway (7).

d. Install raised median and pedestrian crossing island (12, 21).

e. Reduce right-turn radii (14).

f. Add curb extensions (19).

g. Use a traffic-calming device, such as a raised intersection or raised pedestrian crossing, to reduce vehicle speeds (26, 27).

h. Consider street closure (35).

i. Provide leading pedestrian interval (39).

j. Prohibit Right Turn on Red (RTOR) (41).

k. Install warning signs for pedestrians and/or motorists (43).

l. Remove on-street parking from the approaches to crosswalks (47).

Possible Cause/Problem #3

Substantial number of school children crossing and large turning vehicle movement.

General Countermeasures

a. Install crosswalk markings (3).

b. Improve intersection lighting (5).

c. Consider using modified T-intersections, intersection median barriers, diverters, or street closures (17, 18, 33, 34).

d. Install curb extensions (19).

e. Install pedestrian crossing islands for wide two-way streets (21).

f. Add exclusive pedestrian phase or leading pedestrian interval (39).

g. Restrict Right Turn on Red (41).

h. Prohibit left turns (43).

i. Provide adult crossing guards during school crossing periods, or two guards for wide streets (44).

j. Educate motorists (48).

k. Educate children about safe crossing behavior (48).

l. Provide police enforcement at the intersection (49).

Possible Cause/Problem #4

Inadequate sight distance and/or intersection geometrics.

General Countermeasures

a. Add marking treatments that improve visibility of pedestrian crossing areas (3).

b. Improve intersection lighting (5).

c. Reduce turn radii (14).

d. Install pedestrian safety islands (21).

e. Remove sight obstructions and/or roadside obstacles (e.g., trees/shrubs, mailboxes, poles, newsstands, trash cans) (29).

f. Install motorist regulatory signs and/or pedestrian warning signs (see MUTCD) (37, 38).

g. Provide special pedestrian signal phasing (e.g., exclusive protected pedestrian signal interval) (39).

h. Prohibit Right Turn on Red (RTOR) (41).

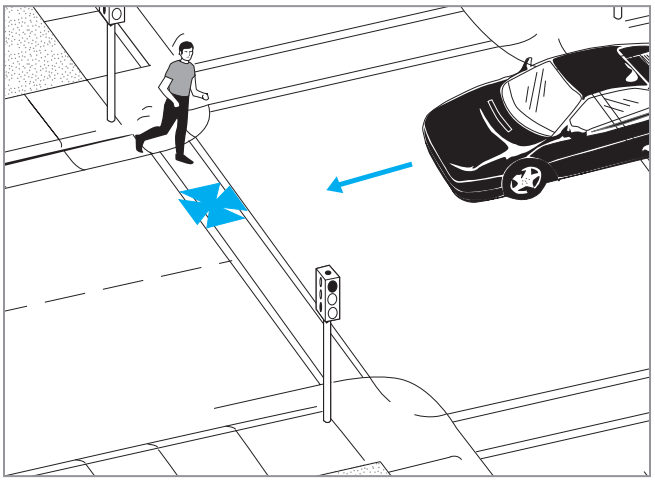
i. Prohibit left turns (43).

7. THROUGH VEHICLE AT SIGNALIZED LOCATION

The pedestrian was struck at a signalized intersection or midblock location by a vehicle that was traveling straight ahead.

Possible Cause/Problem #1

Pedestrian could not see traffic signal.



General Countermeasures

a. Install new or larger pedestrian WALK/DON'T WALK and/or audible pedestrian signals (38).

Possible Cause/Problem #2

Children crossing in school zones.

General Countermeasures

a. Provide pavement markings and school zone signs (3, 44).

b. Convert to one-way street network (if justified by surrounding areawide pedestrian and traffic volume study) (13).

c. Consider using intersection median barriers, diverters, or street closures (18, 33, 34).

d. Provide curb extensions to reduce crossing distance (19).

e. Use traffic-calming devices such as mini-circle or raised intersection to reduce vehicle speeds (23, 26).

f. Provide a raised pedestrian crossing (27).

g. Provide advanced stop lines (42).

h. Install pedestrian signals (43).

i. Provide adult crossing guards, or two guards for wide streets (44).

j. Install school regulatory flashers (e.g., SPEED LIMIT 25 MPH WHEN FLASHING) (44).

k. Provide pedestrian education to students and

motorists (48).

l. Increase police enforcement (49).

Possible Cause/Problem #3

Excessive delay to pedestrians prior to getting the WALK interval.

General Countermeasures

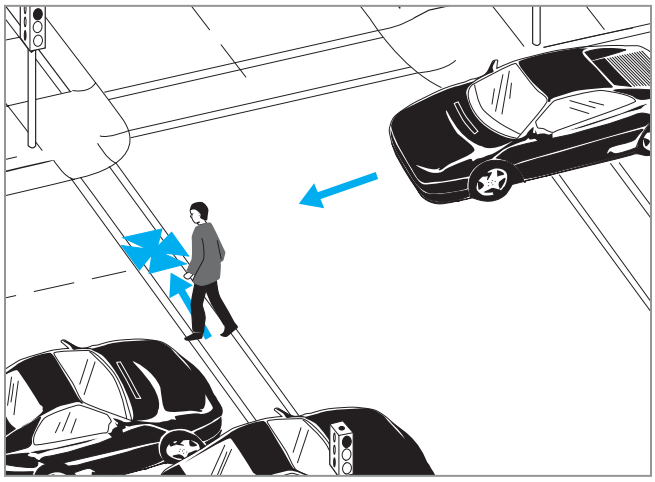
a. Provide pedestrian crossing islands (21).

b. Re-time signal to be more responsive to pedestrian needs (e.g., shorter cycle lengths or convert to fixed-time operation) (39).

c. Provide quick-response pedestrian push-buttons or automatic (e.g., microwave or infrared) detectors (40).

Possible Cause/Problem #4

Lack of pedestrian compliance with WALK phase due to other causes.



General Countermeasures

a. Re-time signal to be more responsive to pedestrian needs (e.g., shorter cycle length) (39).

b. Provide adequate WALK and clearance intervals (39).

c. Provide leading pedestrian interval (39).

d. Provide adult crossing guard at school crossings (44).

e. Provide pedestrian and motorist education (48).

Possible Cause/Problem #5

Motorist did not see pedestrian in time to stop.

General Countermeasures

a. Add marking treatments that improve visibility of pedestrian crossing areas (3, 30).

b. Move bus stop to far side of intersection (4).

c. Improve nighttime lighting (5).

d. Add curb extensions (19).

e. Add pedestrian crossing islands or raised crosswalk (21, 27).

f. Use traffic-calming devices, such as speed tables or a speed-monitoring trailer, on streets approaching the intersection if speed is an issue (25, 46).

g. Construct raised intersection (26).

h. Remove sight obstructions such as mailboxes or parked vehicles (29, 47).

i. Remove on-street parking near intersection (e.g., up to 30.5 m [100 ft]) (47).

Possible Cause/Problem #6

Motorist ran red light at signalized intersection.

General Countermeasures

a. Improve lighting (5).

b. Add short all-red interval at signal (39).

c. Increase police enforcement (49).

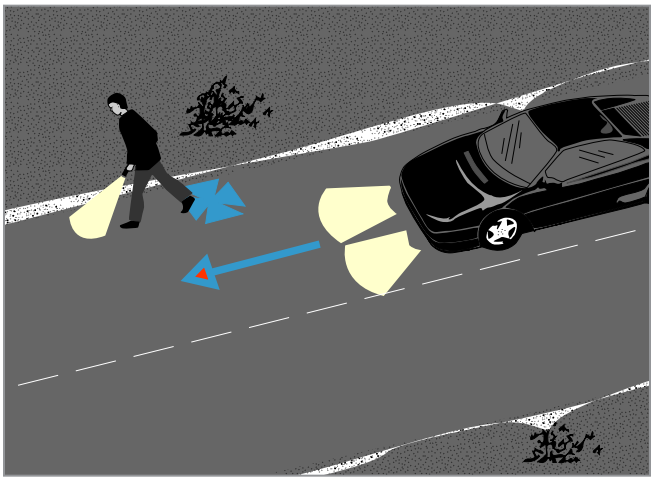
d. Install camera enforcement (49).

8. WALKING ALONG ROADWAY

The pedestrian was walking or running along the roadway and was struck from the front or from behind by a vehicle.

Possible Cause/Problem #1

Inadequate walking area.



General Countermeasures

a. Provide a sidewalk on both sides of road (1).

b. Provide an asphalt path or paved shoulder (1).

c. Construct and maintain sidewalks and curb ramps to be usable by people with disabilities (1, 2).

d. Add sidewalk, install bicycle lanes or painted shoulders, reduce number of lanes (e.g., four lanes to three lanes), and add planting strips (1, 8, 10, 29).

Possible Cause/Problem #2

High vehicle speeds and/or volume.

General Countermeasures

a. Add sidewalk or walkway (1).

b. Construct and maintain sidewalks and curb ramps to be usable by people with disabilities (1, 2).

c. Increase lateral separation between pedestrians and motor vehicles (e.g., bike lanes or landscape buffers) (1, 8, 29).

d. Provide lighting (5).

e. Construct gateway or install signs to identify neighborhood as area with high pedestrian activity (28, 45).

f. Install "Walk on Left Facing Traffic" signs (43).

g. Use speed-monitoring trailers (46).

h. Increase police enforcement of speed limit (49).

Possible Cause/Problem #3

Inadequate route to school.

General Countermeasures

a. Provide sidewalks on both sides of road (1).

b. Construct and maintain sidewalks and curb ramps to be usable by people with disabilities (1, 2).

c. Implement traffic-calming methods at selected sites (19-32).

d. Provide adult crossing guards (44).

e. Involve school groups and PTA in evaluating safe routes to school and promoting education and enforcement (48, 49).

Possible Cause/Problem #4

Sidewalks are not accessible to all pedestrians.

General Countermeasures

a. Repair and maintain sidewalks (1).

b. Remove obstacles in sidewalk (1).

c. Build missing sidewalk segments (1).

d. Construct curb ramps (2).

e. Relocate poles and street furniture to provide continuous passage in sidewalk area (7).

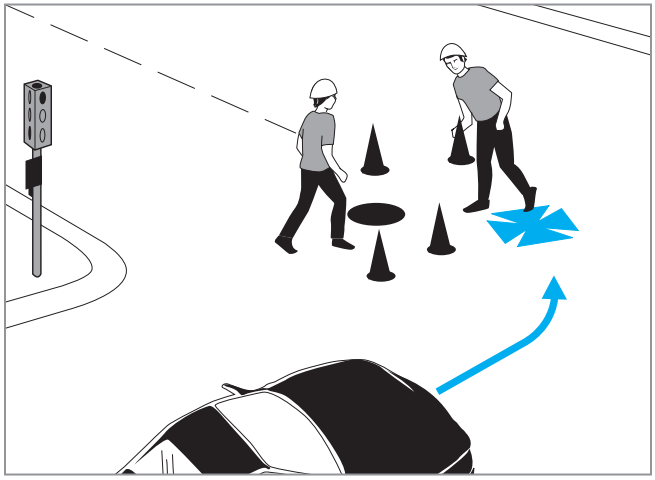
f. Enforce parking laws to prevent cars from blocking sidewalks and curb ramps (49).

9. WORKING/PLAYING IN ROAD

A vehicle struck a pedestrian who was: (1) standing or walking near a disabled vehicle, (2) riding a play vehicle that was not a bicycle (e.g., wagon, sled, tricycle, skates), (3) playing in the road, or (4) working in the road.

Possible Cause/Problem #1

Worker, policeman, etc. struck in roadway (arterial street).



General Countermeasures

a. Improve lighting and retroreflective materials on workers (5).

b. Improve traffic control measures (e.g., signs, markings, cones, barricades, and flashers) warning motorists of workers' presence (43).

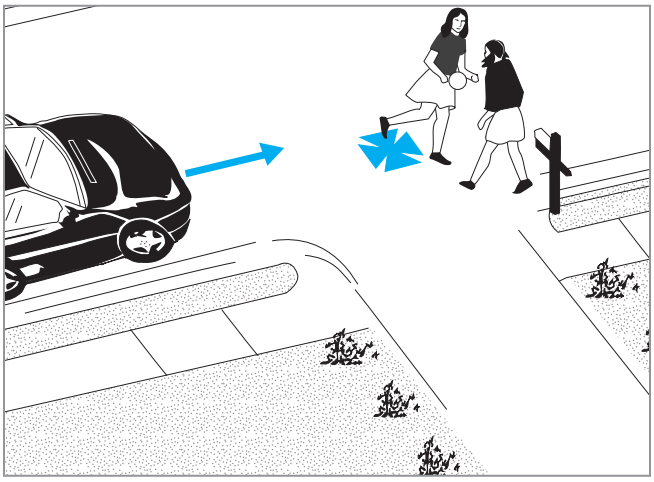
c. Increase worker safety training (48).

d. Increase police enforcement of speed limits in work zones (49).

e. Provide better physical separation/protection from motor vehicles.

Possible Cause/Problem #2

Pedestrian was struck playing on foot or on play vehicle (e.g., skateboard, wagon, sled, in-line skates) on local/collector street.



General Countermeasures

a. Provide accessible sidewalks or walkways on both sides of street (1, 2).

b. Improve lighting (5).

c. Introduce traffic-calming measures (e.g., street narrowing, speed humps) (9, 24).

d. Convert streets to a woonerf or use signs to identify neighborhood as area with high levels of pedestrian activity (32, 45).

e. Consider street closures (full or partial) or using diverters (34, 35).

f. Implement pedestrian and motorist education programs (48).

g. Provide community park/playground.

Possible Cause/Problem #3

Vehicle speeds are excessive on local street.

General Countermeasures

a. Narrow streets and/or travel lanes (9).

b. Convert to driveway link/serpentine street (11, 31).

c. Install traffic-calming devices such as chicanes, mini-circles, speed humps, and/or speed tables (22, 23, 24, 25).

d. Use speed-monitoring trailers in conjunction with police enforcement (46, 49).

Possible Cause/Problem #4

Walking to/from disabled vehicle.

General Countermeasures

a. Provide sidewalks, walkways, or paved shoulders (1).

b. Provide adequate nighttime lighting (5).

c. Educate drivers about what to do if a vehicle becomes disabled (48).

d. Provide motorist assistance program.

Possible Cause/Problem #5

Working on or standing by a disabled vehicle.

General Countermeasures

a. Provide paved shoulders (1).

b. Provide adequate nighttime lighting (5).

c. Educate drivers about what to do if a vehicle becomes disabled (48).

d. Provide a motorist assistance program.

10. NON-ROADWAY (SIDEWALK, DRIVEWAY, PARKING LOT, OR OTHER)

The pedestrian was standing or walking near the roadway edge, on the sidewalk, in a driveway or alley, or in a parking lot, when struck by a vehicle.

Possible Cause/Problem #1

Pedestrian was struck while waiting to cross roadway, standing at or near curb.

General Countermeasures

a. Provide accessible sidewalks/walkways and crosswalks (1, 3).

b. Provide sidewalk buffer (bike lane or landscape strip) (1, 8, 29).

c. Improve nighttime lighting (5).

d. Reduce curb radii to slow turning cars (14).

e. Install sidewalk barriers (29).

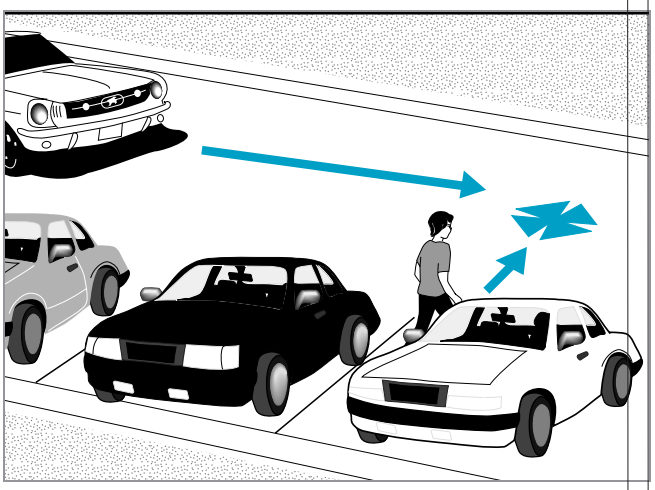
f. Use adult crossing guard (44).

g. Implement driver education program (48).

h. Increase speed enforcement (49).

Possible Cause/Problem #2

Pedestrian was struck in parking lot, driveway, private road, gas station, alley, etc.



General Countermeasures

a. Maintain level sidewalk across driveway area (1).

b. Move sidewalk farther back so that driver will have more time to stop for a pedestrian crossing a driveway (1).

c. Improve nighttime lighting (5).

d. Remove landscaping or other visual obstructions near driveways (29).

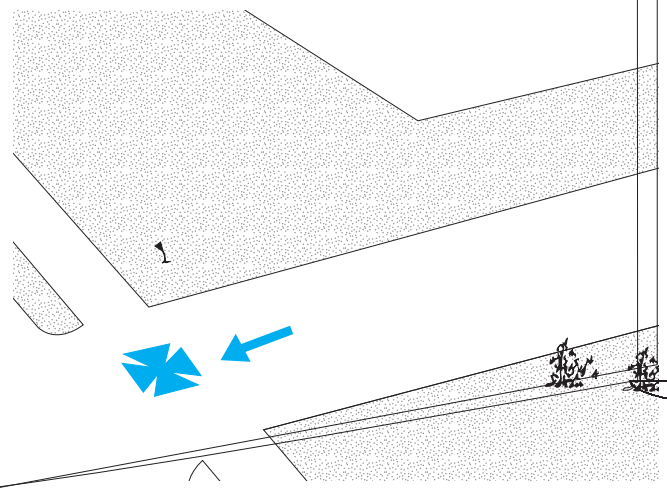
e. Implement pedestrian and motorist education programs (48)

f. Redesign or re-stripe parking lot to provide clear pedestrian path across parking lot.

g. Build/improve local parks for child activities.

Possible Cause/Problem #3

Vehicle entered or exited a driveway or alley and struck pedestrian.



General Countermeasures

a. Provide sidewalk or walkway (1).

b. Maintain level sidewalks across driveways or alleys (11).

c. Provide clear walking path across driveway (11).

d. Remove unneeded driveways and alleys (11).

e. Remove sight obstructions (e.g., trim hedges or lower fencing) (11, 29).

f. Narrow driveways and reduce turning radii (14).

g. Add adequate planting strip or sidewalk separation (29).

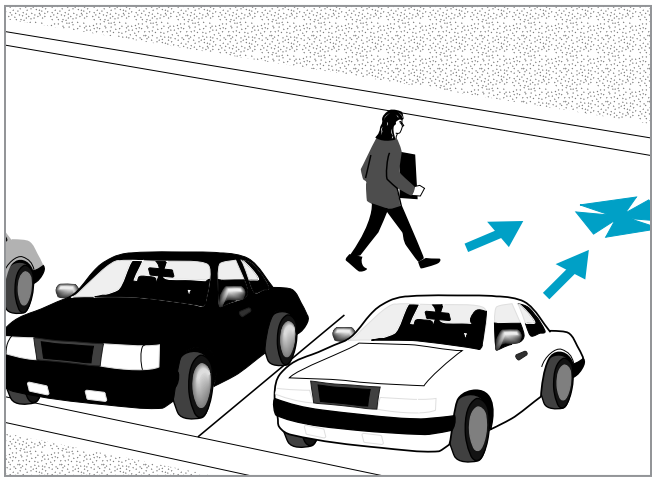
h. Provide advance warning signs for drivers (43).

11. BACKING VEHICLE

The pedestrian was struck by a backing vehicle on a street, in a driveway, on a sidewalk, in a parking lot, or at another location.

Possible Cause/Problem #1

Pedestrian struck by backing vehicle.



General Countermeasures

a. Provide clearly delineated walkways for pedestrians in parking lots (1).

b. Relocate pedestrian walkways (1).

c. Improve nighttime lighting (5).

d. Remove unneeded driveways and alleys (11).

e. Remove landscaping or other sight obstruction near driveways (11, 29).

f. Provide curb extensions or raised pedestrian crossings to improve the visibility of pedestrians to backing motorists (19, 27).

g. Eliminate, modify, or relocate parking if feasible (47).

h. Enhance pedestrian education (48).

i. Enhance motorist education (48).

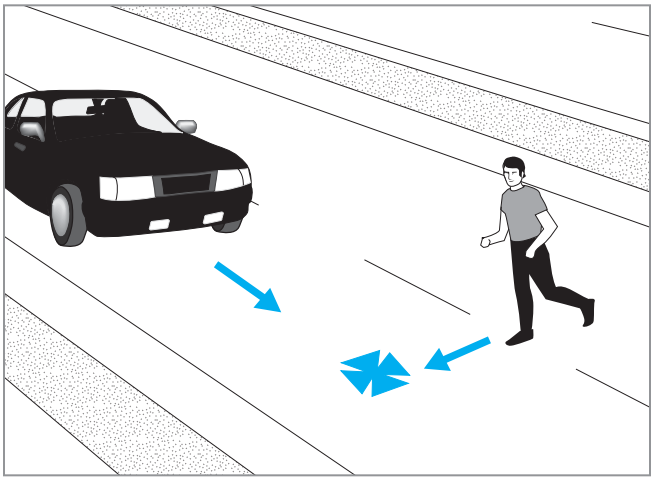
j. Provide auditory backing alert on vehicle.

12. CROSSING EXPRESSWAY

The pedestrian was struck while crossing a limited-access expressway or expressway ramp.

Possible Cause/Problem #1

Disabled vehicle (pedestrian crosses expressway to seek help).



General Countermeasures

a. Install/upgrade roadway lighting (5).

b. Educate drivers on what to do if a vehicle is disabled (48).

c. Increase police surveillance (49).

d. Provide motorist assistance program.

Possible Cause/Problem #2

Pedestrians routinely cross section of expressway.

General Countermeasures

a. Install/upgrade nighttime lighting (5).

b. Provide pedestrian overpass/underpass (6).

c. Install large, visible pedestrian warning signs (43).

d. Increase police surveillance (49).

e. Install pedestrian fencing or barriers along roadway right-of-way.

MISCELLANEOUS

Finally, there are a number of other pedestrian crash types, such as:

- intentional crashes
- driverless vehicle incidents
- pedestrian struck after a vehicle/vehicle collision
- pedestrian struck by falling cargo
- emergency vehicle striking a pedestrian
- pedestrian standing or lying in the road

Possible Cause/Problem #1

Pedestrian lying in road.

General Countermeasures

a. Install or upgrade nighttime lighting (5).

b. Increase police enforcement and surveillance (49).

c. Provide taxi rides home from bars.

Possible Cause/Problem #2

Emergency vehicle-related.

General Countermeasures

a. Install/upgrade lighting (5).

b. Provide public education (48).

c. Increase police surveillance (49).

Possible Cause/Problem #3

Pedestrian falls from vehicle.

General Countermeasures

a. Pass/enforce laws and provide education programs against riding in back of pickup trucks (48, 49).

b. Increase police enforcement of teens "vehicle surfing" (49).

CRASH-RELATED COUNTERMEASURES

A total of 49 different pedestrian countermeasures are presented in Chapter 5 of this guide. To assist engineers and planners who may want further guidance on which measures are appropriate to address certain types of pedestrian crashes, a matrix is provided on pages 28-31. The applicable treatments within the seven categories of countermeasures are shown for each of the 12 crash type groups.

To illustrate how to use the table, consider the second crash type group in the table ("Multiple Threat/ Trapped"). This is a crash involving an unsignalized crossing on a multilane road, where one vehicle stops to let a pedestrian cross the street. The pedestrian steps into the street in front of the stopped vehicle and then continues into the adjacent lane in front of an oncoming vehicle and is struck. The driver of the second vehicle may not see the pedestrian, since the sight distance is typically blocked by the first (stopped) vehicle.

The chart shows that there are 20 potential countermeasures that may reduce the probability of this type of crash, depending on the site conditions. These countermeasures include curb extensions (which improve sight distance between pedestrians and motorists), pedestrian crossing islands (which provide places of refuge in the middle of the street), crosswalk enhancements, and other possible countermeasures.

In Chapter 5, details are provided on each of the countermeasures listed. The quick reference index at the start of Chapter 5 can be used to easily locate the page containing the detailed description. The Web/CD application allows the list of countermeasures to be refined on the basis of site characteristics (see Chapter 4).

These charts are intended to give general information on candidate solutions that should be considered when trying to reduce a pattern of pedestrian crashes at a location or roadway section. Many pedestrian crashes are the direct result of careless or illegal driver behavior and/or unsafe pedestrian behavior. Many of these crashes cannot necessarily be prevented by roadway improvements alone. In such cases, pedestrian and/or motorist education and enforcement activities may be helpful.

PERFORMANCE OBJECTIVES

Pedestrians face a variety of challenges when they walk along and across streets with motor vehicles. Communities are asking for help to "slow traffic down," "make it safer to cross the street," and "make the street more inviting to pedestrians."

The following is a list of requests (objectives) that transportation professionals are likely to face when working to provide pedestrian safety and mobility:

- Reduce speed of motor vehicles.
- Improve sight distance and visibility for motor vehicles and pedestrians.
- Reduce volume of motor vehicles.
- Reduce exposure time for pedestrians.
- Improve access and mobility for all pedestrians, especially those with disabilities.
- Encourage walking by improving aesthetics, safety, and security.
- Improve compliance with traffic laws (motorists and pedestrians).
- Eliminate behaviors that lead to crashes (motorists and pedestrians).

Each of these objectives can be accomplished through a variety of the individual treatments presented in this chapter. Yet, most treatments will work best when used at multiple locations and in combination with other treatments.

In addition, many of the treatments will accomplish two or more objectives. The key is to make sure that the right treatments are chosen to accomplish the desired effect.

The matrix located on pages 32-33 shows which countermeasures are appropriate to consider for the eight performance objectives. In using the chart, it is important to remember that it is simply a guide. In all cases, good engineering judgment should be applied when making decisions about what treatment will be best for a specific location.

PROGRAM OF IMPROVEMENTS

Some pedestrian crashes are associated with deficient roadway designs. Pedestrians and motorists often contribute to pedestrian crashes through a disregard or lack of understanding of laws and safe driving or walking behavior.[6] Because most crashes are a result of human error, crashes will not be completely eliminated as long as pedestrians and vehicles share the same space. Yet, the consequences of these crashes are exacerbated by speeding, failing to yield, or failing to check both directions for traffic, so new education, enforcement, and engineering tools are needed to manage the conflict between pedestrians and drivers.

A complete program of pedestrian safety improvements includes:[6,7]

- Provision of pedestrian facilities, such as sidewalks and crosswalks.
- Roadway and engineering measures, such as traffic control devices, lighting, and roadway design strategies implemented on streets and highways for both pedestrian and vehicular movements.
- Programs to enforce existing traffic laws and ordinances for motorists (e.g., obeying speed limits, yielding to pedestrians when turning, traffic signal compliance, obeying drunk-driving laws) and pedestrians (e.g., crossing the street at legal crossings, obeying traffic and pedestrian signals).
- Wearing of reflective clothing and materials by pedestrians, and/or using a flashlight when walking at night.
- Education programs provided to motorists and pedestrians.

Roadway improvements can often reduce the likelihood of a pedestrian crash. Physical improvements are most effective when tailored to an individual location and traffic problem. Factors to consider when choosing an improvement include: location characteristics, pedestrian and vehicle volume and types, vehicle speed, design of a given location, city laws and ordinances, and financial constraints.[6,8] Many of these factors are included for consideration in the PEDSAFE Selection Tool (see Chapter 4).

It is important to remember that overuse or unjustified use of any traffic control measure is not recommended, since this may breed disrespect for such devices.[9] Although facilities for pedestrians can, in many cases, reduce the risk of pedestrian collisions, crash reduction is not the only reason for providing such facilities. Other benefits of pedestrian facilities include improved access to destinations by walking, better air quality due to less dependence on driving, and improved personal health. Traffic and transportation engineers have the responsibility for providing facilities for all modes of travel, including walking.[6]

COUNTERMEASURES ASSOCIATED WITH

CRASH TYPE GROUP	A. Pedestrian Facility Design	B. Roadway Design	C. Intersection Design
1. Dart/Dash	• Crosswalk Enhancements • Transit Stop Treatments • Roadway Lighting • Overpass/Underpass • Steet Furniture	• Bike Lane/Shoulder • Road/Lane Narrowing • Raised Median	
2. Multiple Threat / Trapped	• Crosswalk Enhancements • Transit Stop Treatments • Roadway Lighting • Overpass/Underpass	• Bike Lane/Shoulder • Road/Lane Narrowing • Fewer Lanes • Raised Median	• Intersection Median Barrier
3. Unique Midblock (mailbox, ice cream vendor, parked vehicles)	• Roadway Lighting	• Bike Lane/Shoulder • Road/Lane Narrowing • Raised Median	
4. Through Vehicle at Unsignalized Location	• Curb Ramp • Crosswalk Enhancements • Transit Stop Treatments • Roadway Lighting • Overpass/Underpass	• Bike Lane/Shoulder • Road/Lane Narrowing • Fewer Lanes • Raised Median • Smaller Curb Radius	• Intersection Median Barrier
5. Bus-Related	• Sidewalk/Walkway • Curb Ramps • Crosswalk Enhancements • Transit Stop Treatments • Roadway Lighting • Street Furniture	• Bike Lane/Shoulder • Fewer Lanes	
6. Turning Vehicle	• Curb Ramp • Crosswalk Enhancements • Transit Stop Treatments • Roadway Lighting • Overpass/Underpass	• Raised Median • One-way Street • Smaller Curb Radius • Right-Turn Slip Lane	• Modern Roundabout • Modified T-Intersection • Intersection Median Barrier

SPECIFIC CRASH TYPE GROUPS

D. Traffic Calming	E. Traffic Management	F. Signals and Signs	G. Other Measures
• Curb Extension • Choker • Pedestrian Crossing Island • Chicane • Speed Humps • Speed Table • Raised Pedestrian Crossing • Gateway • Driveway Link/Serpentine • Woonerf	• Diverter • Full Street Closure • Partial Street Closure • Pedestrian Street	• Traffic Signal • Pedestrian Signal • Signal Enhancement • Sign Improvement	• School Zone Improvement • Identify Neighborhood • Speed-Monitoring Trailer • Parking Enhancement • Ped./Driver Education • Police Enforcement
• Curb Extension • Pedestrian Crossing Island • Speed Table • Raised Pedestrian Crossing		• Traffic Signals • Pedestrian Signal • Advanced Stop Lines • Sign Improvement	• School Zone Improvement • Ped./Driver Education • Police Enforcement
• Chicane • Speed Humps • Speed Table • Gateway		• Sign Improvement	• Identify Neighborhood • Speed-Monitoring Trailer • Parking Enhancement • Ped./Driver Education • Police Enforcement
• Curb Extension • Choker • Pedestrian Crossing Island • Chicane • Speed Humps • Speed Table • Raised Intersection • Raised Pedestrian Crossing • Gateway • Landscape Options • Paving Treatments • Driveway Link/Serpentine	• Pedestrian Street	• Traffic Signals • Pedestrian Signal • Sign Improvement	• School Zone Improvement • Identify Neighborhood • Speed-Monitoring Trailer • Parking Enhancement • Ped./Driver Education • Police Enforcement
• Curb Extension • Pedestrian Crossing Island • Raised Pedestrian Crossing		• Traffic Signal • Pedestrian Signal • Advanced Stop Lines • Sign Improvement	• School Zone Improvement • Parking Enhancement • Ped./Driver Education • Police Enforcement
• Curb Extension • Pedestrian Crossing Island • Mini-Circle • Raised Intersection • Raised Pedestrian Crossing • Paving Treatments	• Diverter • Full Street Closure • Partial Street Closure	• Traffic Signals • Pedestrian Signal • Pedestrian Signal Timing • Signal Enhancement • RTOR Restriction • Advanced Stop Lines • Sign Improvement	• School Zone Improvement • Parking Enhancement • Ped./Driver Education • Police Enforcement

COUNTERMEASURES ASSOCIATED WITH

CRASH TYPE GROUP	A. Pedestrian Facility Design	B. Roadway Design	C. Intersection Design
7. Through Vehicle At Signalized Location	• Curb Ramp • Crosswalk Enhancements • Transit Stop Treatments • Roadway Lighting • Overpass/Underpass	• Raised Median • One-way Street	• Modern Roundabout • Intersection Median Barrier
8. Walking Along Roadway	• Sidewalk/Walkway • Curb Ramp • Roadway Lighting • Street Furniture	• Bike Lane/Shoulder • Road/Lane Narrowing • Fewer Lanes	
9. Working/Playing In Road	• Sidewalk/Walkway • Roadway Lighting	• Bike Lane/Shoulder • Road/Lane Narrowing	
10. Non-Roadway (sidewalk, driveway, parking lot, or other)	• Sidewalk/Walkway • Roadway Lighting	• Bike Lane/Shoulder • Driveway Improvement • Smaller Curb Radius	
11. Backing Vehicle	• Sidewalk/Walkway • Roadway Lighting	• Driveway Improvement	
12. Crossing Expressway	• Roadway Lighting • Overpass/Underpass		

SPECIFIC CRASH TYPE GROUPS

D. Traffic Calming	E. Traffic Management	F. Signals and Signs	G. Other Measures
• Curb Extension • Pedestrian Crossing Island • Mini-Circle • Raised Intersection • Raised Pedestrian Crossing • Paving Treatments	• Diverter • Full Street Closure • Partial Street Closure	• Traffic Signal • Pedestrian Signal • Pedestrian Signal Timing • Signal Enhancement • Advanced Stop Lines • Sign Improvement • Police Enforcement	• School Zone Improvement • Speed-Monitoring Trailer • Parking Enhancement • Ped./Driver Education
		• Sign Improvement	• School Zone Improvement • Identify Neighborhood • Speed-Monitoring Trailer • Ped./Driver Education • Police Enforcement
• Chicane • Mini-Circle • Speed Humps • Speed Table • Gateway • Driveway Link/Serpentine • Woonerf	• Diverter • Full Street Closure • Partial Street Closure • Pedestrian Street	• Sign Improvement	• Identify Neighborhood • Speed-Monitoring Trailer • Ped./Driver Education • Police Enforcement
• Curb Extension • Landscape Options		• Sign Improvement	• School Zone Improvement • Parking Enhancement • Ped./Driver Education • Police Enforcement
• Curb Extension • Raised Pedestrian Crossing • Landscape Options			• Parking Enhancement • Ped./Driver Education
		• Sign Improvement	• Ped./Driver Education • Police Enforcement

COUNTERMEASURES ASSOCIATED WITH

OBJECTIVE	A. Pedestrian Facility Design	B.Roadway Design	C.Intersection Design
1. Reduce Speed of Motor Vehicles *To be used in conjunction with other treatments	• Street Furniture*	• Add Bike Lane/Shoulder • Road Narrowing • Reduce Number of Lanes • Driveway Improvements • Curb Radius Reduction • Right-Turn Slip Lane	• Modern Roundabouts
2. Improve Sight Distance and Visibility for Motor Vehicles and Pedestrians	• Crosswalk Enhancements • Roadway Lighting • Move Poles/Newspaper Boxes at Street Corners	• Add Bike Lane/Shoulder	
3. Reduce Volume of Motor Vehicles		• Reduce Number of Lanes	
4. Reduce Exposure for Pedestrians	• Overpasses/Underpasses	• Road Narrowing • Reduce Number of Lanes • Raised Median • Pedestrian Crossing Island	
5. Improve Pedestrian Access and Mobility	• Sidewalk/Walkway • Curb Ramps • Crosswalk Enhancements • Transit Stop Treatments • Overpasses/Underpasses	• Raised Median	
6. Encourage Walking by Improving Aesthetics	• Street Furniture • Roadway Lighting • Landscaping Options	• Raised Median	
7. Improve Compliance With Traffic Laws			• Red-Light Cameras
8. Eliminate Behaviors That Lead to Crashes			• Red-Light Cameras

SPECIFIC PERFORMANCE OBJECTIVES

D. Traffic Calming	E. Traffic Management	F. Signals and Signs	G.Other Measures
• Curb Extension • Choker • Chicane • Mini-Circle • Speed Humps • Speed Table • Raised Pedestrian Crossing • Raised Intersection • Driveway Link/Serpentine • Woonerf • Landscaping Options* • Paving Treatments*		• Signal Enhancement (e.g., Adjust Signal Timing for Motor Vehicles) • Sign Improvement*	• Speed-Monitoring Trailer • School Zone Improvement
• Curb Extension • Speed Table • Raised Pedestrian Crossing • Raised Intersection • Paving Treatments		• Sign Improvement (e.g., Warning Sign) • Advanced Stop Lines	
• Woonerf	• Diverters • Full Street Closure • Partial Street Closure • Pedestrian Street		
• Curb Extension • Choker • Pedestrian Crossing Island		• Pedestrian Signal Timing • Accessible Pedestrian Signal	
• Choker • Pedestrian Crossing Island		• Traffic Signal • Signal Enhancement • Accessible Pedestrian Signal • Pedestrian Signal Timing	
• Gateway • Landscaping • Paving Treatments			• Identify Neighborhood
• Traffic Calming: Choker, Chicane, Mini-Circle, Speed Hump, Speed Table			• Speed-Monitoring Trailer • Pedestrian/Driver Education • Police Enforcement
• Traffic Calming: Choker, Chicane, Mini-Circle, Speed Hump, Speed Table		• Pedestrian Signal Timing	• Pedestrian/Driver Education • Police Enforcement