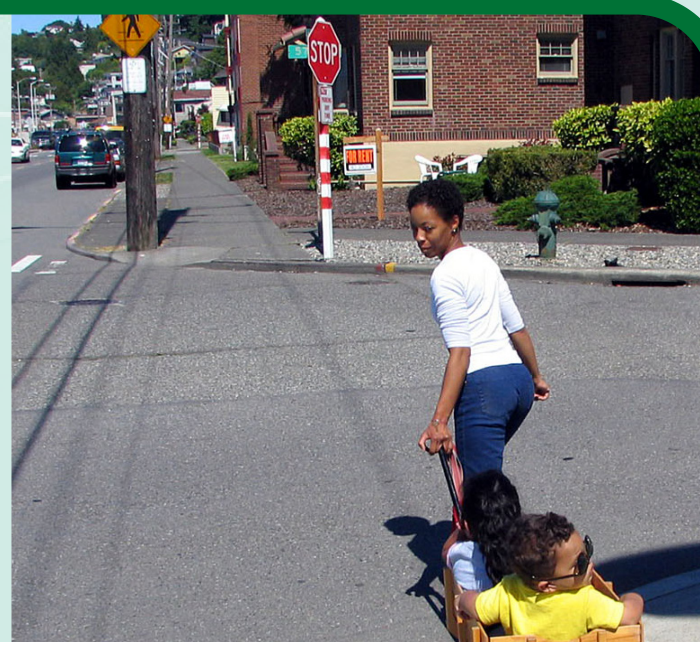
Low-Cost Pedestrian Safety Zones: Countermeasure Selection Resource



U.S. Department of Transportation
National Highway Traffic Safety Administration

NHTSA

Dunlap and Associates, Inc.

THE UNIVERSITY OF NORTH CAROLINA
HIGHWAY SAFETY RESEARCH CENTER

CERS
Center for Education and Research in safety

Suggested APA Format Citation:

Dunlap and Associates, Inc., UNC Highway Safety Research Center, & Center for Education and Research in Safety. (2023b, July). *Low-cost pedestrian safety zones: countermeasure selection resource* (Report No. DOT HS 813 479). National Highway Traffic Safety Administration.

This report is accompanied by another report:

Dunlap and Associates, Inc., UNC Highway Safety Research Center, & Center for Education and Research in Safety. (2023a, July). *Low-cost pedestrian safety zones: An eight-step handbook* (Report No. DOT HS 813 478). National Highway Traffic Safety Administration.

Technical Report Documentation Page

1. Report No. DOT HS 813 479	**2. Government Accession No.**	**3. Recipient's Catalog No.**
4. Title and Subtitle Low-Cost Pedestrian Safety Zones: Countermeasure Selection Resource		**5. Report Date** July 2023 **6. Performing Organization Code**
7. Author(s) Dunlap and Associates, Inc., UNC Highway Safety Research Center, & Center for Education and Research in Safety		**8. Performing Organization Report No.**
9. Performing Organization Name and Address Dunlap and Associates, Inc. 110 Lenox Ave # 1 Stamford, CT 06906 UNC Highway Safety Research Center 130 Mason Farm Rd. CB # 3430 Chapel Hill, NC 27514 Center for Education and Research in Safety 1021 Hol Hi Drive Kalamazoo, MI 49008		**10. Work Unit No. (TRAIS)** **11. Contract or Grant No.** Contract DTNH2216D00017/Task Order 693JJ919F000174
12. Sponsoring Agency Name and Address National Highway Traffic Safety Administration 1200 New Jersey Avenue SE Washington, DC 20590		**13. Type of Report and Period Covered** Final Report **14. Sponsoring Agency Code**
15. Supplementary Notes Ruth Esteban-Muir was the contracting officer's representative for this project.		
16. Abstract This report presents details about different low-cost countermeasure combinations that can be deployed within an identified area, or "zone," in support of the pedestrian zone approach. Countermeasure selection should be based on the crash and risk profiles identified through data analysis. The following assumptions guided the countermeasures included evidence, cost and planning and built times. The table at the end of this report demonstrates how engineering and behavioral countermeasures can be used in combination to create a comprehensive package of interventions within a particular zone.		
17. Key Words pedestrian safety zone, countermeasures		**18. Distribution Statement** This document is available to the public from the DOT, BTS, National Transportation Library, Repository & Open Science Access Portal, https://rosap.ntl.bts.gov.

19. Security Classif. (of this report)	**20. Security Classif. (of this page)**	**21. No. of Pages**	**22. Price**
Unclassified	Unclassified	35	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

Contents

Introduction

This report presents details about different low-cost countermeasure combinations that can be deployed within an identified area, or "zone," in support of the pedestrian zone approach. Countermeasure selection should be based on the crash and risk profiles identified through data analysis.

The following assumptions guided the countermeasures included in this report:

- **Evidence:** The level of evidence for the individual countermeasures in the various modalities and for the combinations shown varies from compelling operational or research studies to the best engineering judgment of the research team. No attempt has been made to characterize the extent of evidence for any of the countermeasures, but all have the support of all the disciplines on the study team.
- **Cost:** Most of the specific costs for the countermeasures listed in this resource come from the Pedestrian and Bicyclist Safety Countermeasure Selection Tools (PEDSAFE and BIKESAFE). Costs derived from other sources are cited where used. Many of the "low-cost" countermeasures listed here can quickly become "high-cost" based on several variables including the size of the application and site-specific implementation complications. Other countermeasures that could be considered "high-cost" from the outset (e.g., pedestrian hybrid beacon, new traffic signal, sidewalk) are included because their cost may not be considered "high" by some larger sites, and they may become less expensive as they become more widely used.
  - The general cost estimates presented are for a single installation of the engineering countermeasures rather than systemic installation (which could decrease the per-item cost while increasing total program cost).
  - Estimates include initial materials and installation and do not reflect life cycle costs (e.g., operations, maintenance, financing, depreciation, disposal). Additionally, costs assume that the project does not trigger a required upgrade to curb ramps per ADA, which would increase the cost of the overall project.
- **Planning and Build Times:** These were developed based on the project team's assessment of what is involved in getting the countermeasure into operation. Timeframes are grouped as short, medium, and long. Short is 1 month or less, medium is within 6 months, and long is 7 months or more.
  - Community-specific factors such as permitting, council approval requirements, necessary NEPA approvals, right of way acquisition can extend the amount of time required compared to the timeframes presented.

The table at the end of this report demonstrates how engineering and behavioral countermeasures can be used in combination to create a comprehensive package of interventions in a particular zone.

Engineering

1. High-Visibility Crosswalk Marking

Description

Adding a high-visibility crosswalk marking to an unmarked crosswalk or upgrading less visible crosswalk markings (e.g., parallel lines) to a high-visibility pattern can improve safety for pedestrians. Unlike the more traditional crosswalk marking that uses two parallel lines to outline the crossing location, high-visibility bars placed parallel to the travel lane are used to identify the crossing location. The result is a more visible crosswalk marking that can be more easily detected by both motorists and pedestrians. The high-visibility crosswalk can help reduce crashes involving crossing pedestrians at intersection or midblock locations and can be used at both controlled and uncontrolled locations.

Effectiveness

High-visibility crosswalks are more visible to drivers and have been shown to increase motorist yielding rates. They can also require less maintenance than parallel line crosswalks, as vehicle wheels track between ladder bars of marking. Research shows that high-visibility crosswalk markings can reduce the risk of pedestrian crashes by 37 percent to 48 percent. It should be noted that these studies were not highly rated in the Crash Modification Factors (CMF) Clearinghouse. Marked crosswalk effectiveness can be influenced by many factors, including the types of accompanying countermeasures installed alongside the crosswalk marking itself (Federal Highway Administration, 2018).

Source: North Carolina DOT

Implementation and Operational Considerations

- **Cost:** $600 to $5,700, average $2,540. Costs of painting are low, but curb extensions/ infrastructure changes add substantial cost. Costs increase to $6,000 to $11,000 if installed in thermoplastic (for permanent changes), based on a two- to four-lane road.
- **Planning Time:** Short - if installing as upgrade to existing crosswalks. Medium if installing crosswalks for the first time and need to develop engineering design for installment.
- **Build Time:** Short (less than 1 week).

Sources and More Information

Zegeer et al., 2013, Marked Crosswalks chapter

McGrane, A., & Mitman, 2013

FHWA, 2018b

Thomas, Thirsk, & Zegeer, 2016

2. Parking Restrictions/ Daylighting

Description

Motor vehicles that park at or near crosswalks can obscure the presence of crossing pedestrians from traffic approaching the crosswalk. Those same parked vehicles can prevent pedestrians from seeing, and reacting to, vehicles that may not yield at the crossing. Restricting parking within a certain distance of a crosswalk, or a certain distance away from an intersection, will open sight lines to allow pedestrians and drivers of motor vehicles to see one another and avoid collisions. Parking is typically restricted within 20 to 25 feet of an intersection or marked crossing. Restrictions can be coupled with physical barriers, such as planters or flexible delineators, placed in the area where parking is restricted.

In some cases, agencies will develop curb extensions to extend the curbs to the full extent of the restricted parking area, which increases the cost substantially.

Effectiveness

Parking restrictions at intersections have been shown to reduce pedestrian-involved crashes by 30 percent (FHWA, 2018b).

Implementation and Operational Considerations

- **Cost:** $3,440 to $4,800 based on removal of one to two parking spaces (20 ft recommended by NACTO) per road on all four legs of the intersection, and installation of temporary signage or other materials, such as planters or bollards. Price range reflects difference in material costs. Installing curb extensions may increase price. Add staff hours for eight people/day to install (four install, four manage traffic).
- **Planning Time:** Medium - Identify priority intersections through traffic data analysis. Parking restrictions may be unpopular, which can cause planning to be contentious.
- **Build Time:** Short (less than 1 week).

Sources and More Information

Zegeer et al., 2013, Parking Restrictions chapter

FHWA, 2018b

Thomas, Thirsk, & Zegeer, 2016

3. Adjust Stop Bar at Intersection

Description

Drivers of motor vehicles may approach intersections and encroach upon the pedestrian crosswalk while waiting. To encourage drivers to stop further back from the intersection and crosswalk, agencies can move or place the stop bar at either signal- or stop-controlled intersections in a location that allows buffer space between the stopped vehicle and the crosswalk. This change can also open sight lines so that pedestrians and drivers of motor vehicles can see one another and avoid collisions. Placement of the stop bar is important, as drivers may ignore it if it is placed too far in advance of the intersection. For uncontrolled crossings, see Advanced Stop/Yield Lines.

Effectiveness

While anecdotal evidence suggests this is a promising countermeasure, no research has quantified its effectiveness.

Implementation and Operational Considerations

- **Cost:** $1,020 to $2,000, based on materials costs to place stop bar eight feet from crosswalk (minimum recommended by NACTO). Price assumes two lanes on each leg. Removal of lane markings beyond advance stop bar can add to price, so taping over/not maintaining lane markings may be the best option. Add $150 for installation equipment plus cost of staff hours for eight people/day to install (four install, four manage traffic).
- **Planning Time:** Short.
- **Build Time:** Short.

Sources and More Information

Zegeer et al., 2013, Advanced Stop Lines chapter

NACTO, 2013, Conventional Crosswalks chapter

Source: pedbikeimages.org / Dan Burden

4. Speed Humps and Speed Tables

Description

Speed humps and speed tables are similar traffic calming devices that use vertical deflection to reduce vehicle speeds. They are typically used on lower-volume, lower-speed streets. While speed humps and speed tables are similar, they differ in terms of their size and intended design speeds. Speed tables could allow for crosswalks to be placed on them (raised crossings) and are generally just longer speed humps with a flat top. It is important to distinguish both speed humps and speed tables from speed bumps.

Effectiveness

As noted in NCHRP Synthesis 498 (Thomas et al., 2016), "the effects of raised crossings on motorist yielding and pedestrian crashes are not well-documented." In lower-speed settings, however, research conducted for the Highway Safety Manual suggests that they should reduce severe crashes. These studies estimated that speed tables reduced crashes by 30 percent and fatal injury crashes by 36 percent.

Implementation and Operational Considerations

- **Cost:** Speed humps: $2,000; Speed tables: $5,000 to $15,000.
- **Planning Time:** Medium - Identify sites based on public input and traffic data analysis, then plan and design the installation. The design time will vary depending upon the permanence of the installation. Permanent installations may approach long-term planning due to engineering requirements.
- **Build Time:** Short to medium.

Source: pedbikeimages.org / Dan Burden

Sources and More Information

Zegeer et al., 2013, Speed Humps chapter

Zegeer et al., 2013, Speed Tables chapter

FHWA, 2018b

Thomas, Thirsk, & Zegeer, 2016

5. Curb Extension

Description

A curb extension (also called a bulb-out) builds off the principles behind parking restrictions and daylighting at crossing locations. To further encourage drivers not to park in areas near crossings (typically 20 to 25 feet from the crossing), a curb extension completely restricts the space to motor vehicles with either temporary materials or a complete extension of the concrete curb. Curb extensions have the added benefit of reducing the curb radius at the intersection, therefore decreasing motor vehicle turning speeds. They also narrow the crossing length to shorten the distance a pedestrian must be exposed to traffic. This narrowing of the roadway also creates visual cues for motor vehicle drivers that encourage lower speeds.

Effectiveness

Curb extensions have not been widely studied, though they may be effective at improving motorist yielding as part of a larger package of treatments and countermeasures (Thomas et al., 2016).

Source: pedbikeimages.org / Andy Hamilton

Implementation and Operational Considerations

- **Cost:** $900 to $1,100/curb section for a 10-foot extension on both sides of one road (paint, reflective taping, painting installation equipment), $3,600 to $4,400 for an intersection. Add $600 to $4,000 per side, if using vertical barriers (low-end is concrete buttons, high-end is vertical delimiters). Installation: Staff hours for eight people/day to install (four install, four manage traffic). These costs reflect a quick-build curb extension. For a permanent concrete build, average costs per curb are estimated at $13,000.
- **Planning Time:** Medium - Identify sites based on public input and traffic data analysis, then plan and design the installation. The design time will vary depending upon the permanence of the installation. Permanent installations may approach long-term planning due to engineering requirements.
- **Build Time:** Short to medium - If installing a paint extension, 1 to 3 days is reasonable. For longer-term installations using vertical barriers, the installation process may take 1 to 2 weeks.

Sources and More Information

Zegeer et al., 2013, Curb Extensions chapter

FHWA, 2018b

Thomas, Thirsk, & Zegeer, 2016

6. Median Island

Description

Median islands provide a refuge area for pedestrians to help break up long crossing distances. Typically, median islands are located at crossings along multilane roads so pedestrians can focus on breaking the crossing into two manageable chunks of one, two, or three lanes at a time. These raised medians can be incorporated into continuous medians along a corridor or placed at individual crossing locations. They provide additional space to install other pedestrian crossing countermeasures like rectangular rapid flashing beacons (RRFBs). They can be constructed with temporary materials in some cases, such as "quick curb" or flexible delineators.

Effectiveness

Median islands have been widely studied and are routinely identified as one of the most effective countermeasures to improve pedestrian safety at uncontrolled locations. Studies have shown pedestrian crash reductions between 39 percent and 49 percent following the installation of median islands (Thomas et al., 2016).

Implementation and Operational Considerations

- **Cost:** $2,260 for a 10' x 40' median with delimiters every ~5 feet. Installation: Add staff hours for four people/day to install (two to install, two to manage traffic).
- **Planning Time:** Medium - Identify areas of interest through public input/traffic data analysis and receive approval for installation.
- **Build Time:** Short (1 to 3 days), though installation is complicated by traffic management which may add additional installation time.

Sources and More Information

Zegeer et al., 2013, Raised Medians chapter

FHWA, 2018b

Thomas, Thirsk, & Zegeer, 2016

7. Traffic Calming

Description

Traffic calming can refer to several countermeasures that rely on horizontal or vertical delineation to slow motor vehicle traffic. It can refer to the process of repurposing lane width or narrowing lanes during the resurfacing and restriping process. Traffic calming can also involve preventing motor vehicle traffic from traveling in certain areas, such as closing a particular road or intersection opening to reduce traffic. Traffic calming measures can involve other countermeasures mentioned in this resource or others like mini traffic circles, traffic diverters, chicanes, chokers, and others.

Effectiveness

Due to the variety of traffic calming measures, it is difficult to isolate their effectiveness into one quantifiable figure. Most of them are not associated with specific crash reductions, though most have been shown to reduce operating speeds and improve yielding behaviors (Thomas et al., 2016).

Implementation and Operational Considerations

- **Cost:** Variable based on type of traffic calming. Example of cost range: for an 8-foot curb extension running from crosswalk to stop line: $720 to $900/corner if using paint and plastic delimiters; $470 if using inexpensive planters/paint/cones (commonly seen in demo projects); $920 if using jersey wall and paint; $910 to $1,050 if using paint/tape and concrete buttons; installation costs: approximately 150 staff hours, but often can be managed with volunteers.

Source: pedbikeimages.org / Carl Sundstrom

- **Planning Time:** Medium - Identify sites based on public input and traffic data analysis, then plan and design the installation. The design time will vary depending upon the permanence of the installation. Permanent installations may approach long-term planning due to engineering requirements.
- **Build Time:** Medium - Often short- to medium-term installations can be prepared using volunteer assistance, reducing installation time. If permanent, it may take longer due to road closures, concrete, etc.

Sources and More Information

Institute of Transportation Engineers, n.d.

FHWA, 2018b

Thomas, Thirsk, & Zegeer, 2016

Source: pedbikeimages.org / Dan Burden

8. Restrict Right Turns on Red

Description

Preventing right-turns-on-red (RTOR) will allow pedestrians to establish themselves in crosswalks at signalized intersections before vehicles can turn into their path. RTOR restrictions are paired with other signal timing improvements, like leading pedestrian intervals, to ensure that pedestrians can establish right-of-way before drivers can proceed into the intersection. Accompanying signage can reinforce these restrictions, including “blank-out” signs that illuminate the restriction when pedestrians activate the signal.

Effectiveness

Restricting right-turns-on-red can reduce total crashes and left-turn crashes, but their effects on pedestrian safety have not been quantified.

Implementation and Operational Considerations

- **Cost:** Fixed Signage: $254 to $300 (one sign per leg, four legs) plus the costs of having staff install signage on overhead signals. May require traffic modifications during installation.
- **Planning Time:** Medium - Identify sites and get approval to change traffic behaviors. Can be contentious.
- **Build Time:** Short (1 to 3 days).

Sources and More Information

Zegeer et al., 2013, Right-Turn-on-Red Restrictions chapter

FHWA, n.d.

9. Restrict Permissive Left Turn

Description

A common crash type at signalized intersections involves a motorist turning left and striking a pedestrian crossing in a parallel path. Motorists may be scanning ahead for a gap in oncoming traffic to make the turn, and as a result they may not be looking for crossing pedestrians to their left. To address this problem, permissive left turns can be restricted so that motorists can only turn left with a green arrow. These can be accompanied by other treatments like pavement markings and hardened centerlines to form "left-turn traffic calming." This change separates vehicle and pedestrian movements to eliminate the potential conflict. These changes to signal timing can be used in combination with other geometric design changes to achieve a larger reduction in pedestrian-motor vehicle crashes.

Effectiveness

There is not a demonstrated crash modification factor for restricting left turns for pedestrian safety, though studies performed in support of the PEDSAFE tool's development did identify reductions in conflicts after permissive left turns were restricted (Mead et al., 2014).

Implementation and Operational Considerations

- **Cost:** Staff time to reprogram signal timing/consulting costs if outsourcing. (National Traffic Signal Report Card review estimates $3,000 per intersection) (Intelligent Transportation Systems Joint Program Office, 2007).
- **Planning Time:** Medium - Developing the timing plans typically takes ~30 hours, but the data analysis and collection may take longer beforehand.
- **Build Time:** Short (1 to 3 days), though installation is complicated by traffic management which may add additional installation time.

Sources and More Information

Zegeer et al., 2013, Left Turn Phasing chapter

NACTO, 2013, Turn Restrictions chapter

Mead et al., 2014

10. Turning Vehicles Yield to Pedestrians (R-10-15) Sign

Description

Many crashes involving pedestrians at intersections are associated with a motorist turning left or right across the path of the pedestrian. The R-10-15 sign is a low-cost treatment that communicates to drivers that turning vehicles must yield to pedestrians who are crossing. The sign typically is installed next to the traffic signal head so that drivers see it when approaching the intersection.

Effectiveness

There has not been a safety evaluation of this sign showing reductions in pedestrian crashes, though it is often used in combination with other effective treatments.

Implementation and Operational Considerations

- **Cost:** Fixed signage: $200 (one sign per leg, four legs) plus costs of having staff install signage on overhead signals. May require traffic modifications during installation.
- **Planning Time:** Short - Identify target intersections for installation of signs.
- **Build Time:** Short (1 to 3 days).

Sources and More Information

Mead et al., 2014

11. Leading Pedestrian Interval

Description

To address the problem of motorists striking pedestrians when turning at intersections, mentioned above, agencies can hold vehicle traffic while giving pedestrians a "head start" on the walk phase. This is called a leading pedestrian interval (LPI), and it is an increasingly common strategy to help pedestrians establish their presence in crosswalks before motor vehicle traffic is released. They must be used in combination with right-turn-on-red restrictions, and they should be accompanied with accessible pedestrian signals (APS) to ensure that pedestrians with low vision know when the "walk" phase has begun.

Effectiveness

The LPI is associated with a 60-percent reduction in crashes involving pedestrians (FHWA, 2018b).

Implementation and Operational Considerations

- **Cost:** Staff time to retime signals ($2,500) plus $300 for RTOR restriction signage.
- **Planning Time:** Medium - Developing a timing plan typically tops out at ~30 hours but adding timing to pedestrian signals may be less complex than a full re-timing.
- **Build Time:** Short (Less than 1 week).

Sources and More Information

Zegeer et al., 2013, Leading Pedestrian Interval chapter

FHWA, 2018b

12. Decrease Walking Speed/ Add Time to Pedestrian Phase

Description

Both treatments involve providing pedestrians with extra time to cross at a traffic signal. Some traffic signals assume a walking speed of 4 feet per second to determine the time needed for a pedestrian to cross during a "Walk" phase. However, decreasing that time to 3.5 or 3 feet per second may bring the signal's timing in line with slower pedestrians, such as young children or older adults, who need more time to cross the street. If additional time is needed, time can be added to the pedestrian phase and removed from other phases.

Effectiveness

While pedestrian signals themselves are associated with a lower risk of pedestrian crashes, there has not been a study that determined the effectiveness of reducing walking speed or adding time to the pedestrian phase.

Implementation and Operational Considerations

- **Cost:** Staff time to reprogram intersection signals ($2,500).
- **Planning Time:** Short - Identify sites and get approval to change traffic flow patterns for identified sites.
- **Build Time:** Short (Less than 1 week).

Sources and More Information

Zegeer et al., 2013, Pedestrian Signal Timing chapter

13. Implement "Hot Button" Actuation

Description

Pedestrians often must use a push button to enter the cycle to cross at signalized intersections. If signal timing is fixed, pedestrians may have to wait a long period of time to cross, and they may choose to simply cross against the signal or not push the button. Changing to "hot button" actuation dramatically reduces the amount of time pedestrians have to wait before the "walk" phase begins. Reducing minimum green time to 30 seconds produces higher rates of pedestrian compliance (at 60 and 20 seconds, pedestrian compliance decreases) (Van Houten et al., 2007).

Effectiveness

Hot button actuation has not been studied for its effects on crash reduction, though observational studies have determined that pedestrians are more likely to comply with traffic signals when wait times are reduced.

Implementation and Operational Considerations

- **Cost:** Staff time to reprogram intersection signals ($2,500). If buttons are not already installed, installing traffic push-buttons will add considerable additional costs.
- **Planning Time:** Short - Identify sites and get approval to change traffic flow patterns for identified sites.
- **Build Time:** Short (Less than 1 week).

Source: pedbikeimages.org / Dan Burden

Sources and More Information

Zegeer et al., 2013, Push Buttons and Signal Timing chapter

14. Manage Progression Speed With Signal Timing

Description

Corridors with coordinated signals can be timed so that they are optimized for a slower traffic progression speed. In locations with signal density to support such a change, some cities are implementing these strategies after they make policy changes to lower speed limits citywide or in a downtown area.

Effectiveness

Though no research has documented the safety effects of setting lower progression speeds in terms of crash reduction, there is evidence that these changes do result in lower overall operating speeds which should reduce crash severity.

Implementation and Operational Considerations

- **Cost:** Staff time to reprogram signal timing ($2,500/intersection times the number of intersections in progression). If retiming to a new lower speed, new speed signs: $18/sign (assuming reuse of posts).
- **Planning Time:** Medium - Planning requires study to determine feasibility of traffic flow changes and appropriate speed reductions.
- **Build Time:** Medium (several weeks to a month).

Sources and More Information

Global Designing Cities Initiative, n.d.

15. Advance Stop/Yield Line

Description

At multilane, uncontrolled crossing locations, pedestrians waiting to cross may be obscured by a vehicle that stops near the crosswalk. As a result, other oncoming motorists may not see the pedestrian and the pedestrian may not see the oncoming motorist. By placing the stop bar further back (15 to 25 feet) from the crosswalk, vehicles may stop in a location that allows pedestrians to clearly see oncoming vehicles. Adding these lines, with accompanying signage, can encourage drivers to stop further from the crosswalk and reduce the risk of a "multiple threat" crash. This is different from adjusting the stop bar location at stop- or signal-controlled intersections, as the advance yield or stop line should only be used at uncontrolled crossings.

Effectiveness

Advance stop/yield lines have been shown to reduce pedestrian crashes by 25 percent (FHWA, 2018b).

Implementation and Operational Considerations

- **Cost:** $2,360 to $4,660 (simple paint – thermoplastic, and signage), assuming an 8-foot gap, four-lane roads, and installation on four legs of intersection.
- **Planning Time:** Short - Identify target sites using traffic data.
- **Build Time:** Short (1 to 3 days).

Sources and More Information

Zegeer et al., 2013, Advance Yield/Stop Signs chapter

FHWA, 2018b

Thomas, Thirsk, & Zegeer, 2016

16. In-Road Yield to Pedestrian Sign (R1-6/R1-6a)

Description

The in-street yield to pedestrian sign is a low-cost treatment that can encourage drivers to yield to pedestrians at uncontrolled locations. It is placed in the pavement, usually on the centerline, though it can also be placed on a raised median island.

Effectiveness

While these signs have no associated crash modification factor, they have been shown to "substantially" increase motorist yielding rates (Thomas et al., 2016).

Implementation and Operational Considerations

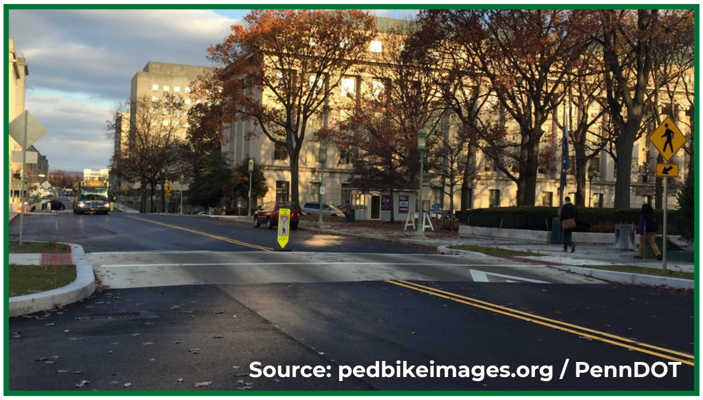
- **Cost:** $529 for the 2 R1-6 signs and one flex-post center sign.
- **Planning Time:** Short - Identify target crossings based on public input and traffic data analysis.
- **Build Time:** Short (1 to 3 days).

Sources and More Information

Zegeer et al., 2013, In-Street Pedestrian Crossing Sign chapter

FHWA, 2018b

Thomas, Thirsk, & Zegeer, 2016



Source: pedbikeimages.org / PennDOT

17. Gateway Arrangement of In-Road Yield to Pedestrian Sign (R1-6/R1-6a)

Description

The gateway treatment uses the R1-6 sign in an arrangement at an uncontrolled crossing by placing one sign in the center of the street and two others in each gutter. The effect is to narrow the path that a vehicle travels through at the crossing location and increase the visibility of these signs.

Effectiveness

While these signs have no associated crash modification factor, they have had promising results in Michigan, where they have been deployed in numerous locations.

Implementation and Operational Considerations

- **Cost:** $529 for the two R1-6 signs and one flex-post center sign.
- **Planning Time:** Short - Identify target crossings based on public input and traffic data analysis.
- **Build Time:** Short (1 to 3 days).

Sources and More Information

Van Houten & Bennett, 2016

Thomas, Thirsk, & Zegeer, 2016

Source: pedbikeimages.org / Michael Frederick

18. Rectangular Rapid Flashing Beacon

Description

RRFBs are pedestrian-actuated conspicuity enhancements used in combination with pedestrian, school, or trail crossing warning signs to improve safety at uncontrolled, marked crosswalks. The device includes two rectangular-shaped yellow indications, each with an LED-array-based light source, that flash with high frequency when activated.

Effectiveness

Numerous studies have documented the safety benefits of RRFBs in terms of motorist yielding and crash reduction. Research indicates RRFBs can result in motorist yielding rates as high as 98 percent at marked crosswalks. Studies also documented that RRFBs can reduce pedestrian crashes by 47 percent (Thomas et al., 2016).

Implementation and Operational Considerations

- **Cost:** $3,600 to $7,200 for one crossing (one sign facing each direction) plus four hours staff time total.
- **Planning Time:** Short - Identify target crossings based on public input and traffic data analysis.
- **Build Time:** Short (1 to 3 days).

Sources and More Information

FHWA, 2018a

Thomas, Thirsk, & Zegeer, 2016

19. Pedestrian Hybrid Beacon

Description

Pedestrian hybrid beacons (PHBs) can warn and control traffic at unsignalized locations and assist pedestrians in crossing a street or highway at a marked crosswalk. Unlike a traffic signal, the PHB rests in dark until a pedestrian activates it via pushbutton or other form of detection. When activated, the beacon displays a sequence of flashing and solid lights that indicate the pedestrian walk interval and when it is safe for drivers to proceed.

Effectiveness

PHBs are effective at increasing motorist yielding rates and reducing pedestrian crashes. One study demonstrated that PHBs reduce pedestrian crashes by 55 percent (FHWA, 2018b).

Implementation and Operational Considerations

- **Cost:** The costs range from $21,000 to $128,000, with an average per-unit cost of $57,680.
- **Planning Time:** Short - Identify target crossings based on public input and traffic data analysis.
- **Build Time:** Medium - Considerations needed for utility work associated with the beacon system.

Sources and More Information

FHWA, 2018a

Thomas, Thirsk, & Zegeer, 2016

Source: pedbikeimages.org / Mike Cynecki

Source: pedbikeimages.org / Toole Design

20. Lighting

Description

Locations without adequate roadway or crosswalk lighting are susceptible to crashes in dark conditions involving pedestrians. LED lights render color and increase visibility of many types of clothing. Attention can be given to lighting at crosswalks themselves and along corridors where pedestrians are traveling. If lighting is not present at an existing crossing, illumination should be placed so that it is angled down toward the side of the pedestrian (rather than directly on top of the pedestrian). Along corridors, agencies should ensure that lighting is frequent enough to illuminate areas where pedestrians may be crossing. On wide streets, lighting should be placed on both sides of the street as one set of lights may not illuminate the entire width of the roadway.

Effectiveness

Lighting is a proven strategy for increasing pedestrian safety. Elvik and Vaa reported crash reductions between 42 percent and 78 percent after adding intersection illumination.

Implementation and Operational Considerations

- **Cost:** Individual street light costs range between $3,602 and $4,882, according to PEDSAFE. Crosswalk lighting can range from approximately $10,750 to $42,000 per crosswalk.
- **Planning Time:** Medium - Time needed to plan and coordinate data collection, and coordinate with utility companies.
- **Build Time:** Short - Once coordination with utility companies has occurred, the time needed to deploy new lighting is relatively minimal.

Sources and More Information

FHWA, 2021

Elvik & Vaa, 2004

Ellis & Van Houten, 2009

Enforcement

1. Targeted Yielding Enforcement Operation

Description

High-visibility operation in which officers perform staged crossings at uncontrolled locations to identify and cite drivers who violate yielding laws.

Effectiveness

While high-visibility enforcement does not have an associated crash modification factor, it has produced promising results in Florida (Van Houten et al., 2013), Michigan (Savolainen et al., 2011), and Minnesota (Morris, 2019). In all these cases, driver yielding increased from a minority behavior to a majority behavior and the changes generalized to unenforced locations. In the Van Houten Gainesville study, driver yielding behavior increased further during a follow-up assessment conducted after the program had ended and there was a significant decrease in pedestrian crashes.

Implementation and Operational Considerations

- **Cost:** Low/Medium - Staff hours for law-enforcement personnel; costs can range depending on how much can be accomplished with regular duties versus overtime.
- **Planning Time:** Short.
- **Build Time:** Medium (longer-term implementation will likely be more successful than a brief demonstration).

Sources and More Information

NHTSA, 2014

Zegeer et al., 2013, Police Enforcement chapter

Richard et al., 2018

2. Lower Speed Limits

Description

Decreasing speed limits on a particular corridor or in an entire area can communicate to drivers that there is a new expectation for driving safely in a particular area. Many communities are using policy changes to decrease speed limits to bring them in line with speeds that are more appropriate for areas where pedestrians and bicyclists are also using the street.

Effectiveness

Studies have shown that higher speeds lead to a higher risk of crashes involving pedestrians and more severe injury outcomes. There is evidence that this strategy does reduce vehicle speeds. Boston, Massachusetts, experienced lower rates of speed after lowering its speed limits from 30 to 25 mph. NHTSA's *Countermeasures That Work* notes that "speed limit reductions can be most effective when introduced to a limited area as part of a visible area-wide change, for example, identifying a downtown area as a special pedestrian-friendly zone through signs, new landscaping or 'streetscaping,' lighting, etc."

Implementation and Operational Considerations

- **Cost:** Medium - Staff time to draft and pass policy; low cost to update signs.
- **Planning Time:** Medium.
- **Build Time:** Short.

Sources and More Information

Richard et al., 2018

Hu & Cicchino, 2020

3. Speed Enforcement

Description

Traditional speed enforcement operations are conducted by law enforcement officers in selected locations where speeding has been an observed problem, or in locations where pedestrian safety has been targeted as a priority (e.g., school zones or a pedestrian zone). Any targeted enforcement campaign should be planned in close coordination with the local community, in such a way that prioritizes equity. Consider how the campaign may disproportionately impact specific populations and take steps to tailor the deployment to ensure an equitable distribution of benefits and burdens of the enforcement program.

Effectiveness

While speed enforcement can be useful in temporarily reducing speeds in certain areas, high-visibility campaigns to deter speeds have demonstrated varied levels of impact. Some studies have shown that well-planned, comprehensive campaigns are effective, while others show little to no effect on speeds and safety.

Implementation and Operational Considerations

- **Cost:** Low/Medium - Staff hours for law-enforcement personnel; costs can range depending on how much can be accomplished with regular duties versus overtime.
- **Planning Time:** Short.
- **Build Time:** Medium (longer-term implementation will likely be more successful than a brief demonstration).

Sources and More Information

Venkatramen et al., 2021

4. Automated Speed Enforcement

Description

Speed enforcement described above can be conducted with automated technologies that use cameras and radar to measure vehicle speeds and issue citations or warnings to drivers. These systems can be difficult to set up due to political and public resistance, or policy hurdles, but can be effective at increasing safety.

Effectiveness

Studies have found that automated enforcement systems substantially reduce the number of injury crashes, although some studies have noted an increase in rear-end collisions at intersections where red light cameras are installed. The use of speed enforcement cameras has also been found to lower the speed of cars and trucks in work zones and school zones.

Implementation and Operational Considerations

- **Cost:** $50,000 to $60,000/camera, plus $25,000 installation.
- **Planning Time:** Long - Requires an implementation plan and approval of plan and expenses.
- **Build Time:** Medium (several weeks), depending on the number of cameras being installed.

Source: pedbikeimages.org / Toole Design

Sources and More Information

Zegeer et al., 2013, Automated Enforcement Systems chapter

Poole et al., 2017

Richard et al., 2018

Education

1. Countermeasure-Specific Outreach

Description

For any design, signal, or other engineering change above, community input is needed. Once the countermeasure has been selected and installed, additional public outreach should be performed to communicate the purpose of the treatment and explain its value to the general public. This is especially true for changes that may not be familiar to the public.

Effectiveness

The research on countermeasure-specific outreach is somewhat limited. The countermeasures themselves are typically evaluated, while the outreach to explain them is not. Still, this is a valuable step to help explain the purpose of the treatment to community members.

Implementation and Operational Considerations

- **Cost:** Low - Staff hours for planning and implementation of outreach.
- **Planning Time:** Medium - Identify opportunities for outreach through the project timeline, develop programming around countermeasure, develop materials.
- **Build Time:** Medium to Long - Public involvement should take place at all project phases.

Sources and More Information

U.S. Department of Transportation, 2022

Source: Charles Pullen

2. Safety Campaigns and Messaging

Description

Specific messages pertaining to documented problems (e.g., yield to pedestrians in crosswalks) can help reinforce the other components of a campaign and build support. Specific statements are better than general statements about safety, especially when derived from the safety problem demonstrated in a particular zone or area. There are three specific types of educational campaigns – public awareness, targeted campaigns, and individual campaigns. Public awareness campaigns can lay the groundwork for subsequent pedestrian safety initiatives and can increase the likelihood of their success. Campaigns to target groups are usually aimed at addressing behavior patterns in specific groups of people (e.g., motorists). Since changing behavior in these groups takes time, these campaigns tend to be ongoing efforts aimed at long-term results. Individual campaigns differ from campaigns that target groups because the audience is reached through an intermediary such as a crossing guard or physician.

Engaging elected officials and decision makers to better explain safety problems and promote changes that will help reduce injuries and deaths can influence policy changes. Using these different approaches in concert reaches a broader audience and increases the likelihood of long-term success in changing attitudes and behaviors.

Effectiveness

There are many types of safety campaigns, so it is difficult to isolate the effectiveness of campaigns in general.

Implementation and Operational Considerations

- **Cost:** Low/Medium - Staff hours for educational initiatives, materials costs for flyers, etc.
- **Planning Time:** Medium - Develop programming around safety issues, identify opportunities for outreach, develop materials.
- **Build Time:** Short-Medium - Need to identify outreach methods and implement; in the case of in-person outreach, this may take longer than distributing flyers (for example).

Sources and More Information

Zegeer et al., 2013, Pedestrian/Driver Education chapter

Richard et al., 2018

Source: Massachusetts SRTS Program

3. Pedestrian Safety Skills Training for Children

Description

Pedestrian safety lessons and practice for a variety of age groups can be built into K-5 curricula. These lessons can take a variety of forms but should be coupled with activities that allow children to practice safe behaviors in controlled settings like traffic gardens. However, due to the wide range of program types and implementation strategies, *Countermeasures That Work* notes that "numerous studies suggest that knowledge and behaviors of young children may be improved through education and training programs, but that behavior in real-world traffic situations is more likely to be modified if the program incorporates interactive training with opportunities for practice and positive reinforcement."

Effectiveness

Child pedestrian safety curricula have been shown to increase knowledge of pedestrian safety concepts among children, and some (WalkSafe in Miami, Florida) have shown to be effective in reducing crashes among child pedestrians.

Implementation and Operational Considerations

- **Cost:** Low - Staff hours to develop skills training, educator hours to perform educational efforts.
- **Planning Time:** Medium-Long - Curriculum development will take time; if adapting to an existing curriculum, it may be shorter than developing a new curriculum.
- **Build Time:** Long - Building skills training into school programming will space out the implementation of the programming over the course of the academic schedule.

Sources and More Information

NHTSA, n.d.

Richard et al., 2018

4. Dynamic Speed Feedback Signs

Description

Dynamic signs display “your speed” beneath a speed limit sign to communicate information to drivers if they are exceeding the speed limit. These signs can be placed in specific locations, for short periods, to result in changes in driver speeds.

Effectiveness

Speed feedback signs have been shown to be most effective at reducing driver speeds when used for short periods of time at specific types of locations (e.g., school zones, transition zones). Studies have shown that they have the greatest effect at reducing speeds upstream, rather than downstream, of the sign location. After several weeks of placement at a site, they generally lose their effectiveness.

Implementation and Operational Considerations

- **Cost:** $3,600/sign, plus approximately 2 hours of labor for installation.
- **Planning Time:** Short - Identify locations for sign placement based on traffic data.
- **Build Time:** Short (1 day).

Sources and More Information

Santiago-Chaparro et al., 2012

5. Automated Speed Warnings

Description

For communities that cannot use automated speed enforcement (ASE), or want to roll out an education program first, use speed cameras to issue warnings and information to drivers who exceed the speed limit. The warning system can be used as a precursor to a full ASE program or in a pilot phase of deployment.

Effectiveness

Studies have found that automated enforcement systems substantially reduce the number of injury crashes, although some studies have noted an increase in rear-end collisions at intersections where red light cameras are installed. The use of speed enforcement cameras has also been found to lower the speed of cars and trucks in work zones and school zones.

Implementation and Operational Considerations

- **Cost:** $50,000 to $60,000/camera, plus $25,000 install
- **Planning Time:** Long - Requires an implementation plan and approval of plan and expenses.
- **Build Time:** Medium (several weeks), depending on the number of cameras being installed.

Sources and More Information

Zegeer et al., 2013, Automated Enforcement Systems chapter

Poole et al., 2017

6. High-Visibility Enforcement Through Media and Progressive Ticketing

Description

Strategies to distribute educational and awareness messages through media and other channels can be coupled with targeted enforcement operations to blend these approaches and expand the reach of a program.

Effectiveness

As described earlier, high-visibility enforcement has shown to be effective in some cases but not in others. This is likely due to the wide range of deployment tactics and implementation strategies used in different programs.

Implementation and Operational Considerations

- **Cost:** Medium - Staff hours for law enforcement and price of any media or educational material development.
- **Planning Time:** Medium.
- **Build Time:** Medium - however longer-term implementation will likely be more successful than a brief demonstration.

Sources and More Information

Richard et al., 2018

7. Media Framing

Description

Media stories about vehicle crashes influence how the public thinks about road safety. If a story gives broader context for a crash – for example, if the story mentions annual crash numbers and systems solutions needed to eliminate future crashes, those who read or hear the media story are more likely to see crashes as preventable. Transportation professionals who might be interviewed for a story can give this context to reporters and use it as a tool to shift public mindsets.

Effectiveness

There are varying amounts of messaging included in news stories, so it is difficult to isolate the effectiveness.

Implementation and Operational Considerations

- **Cost:** Low - Staff time.
- **Planning Time:** Medium - Staff hours for training on framing and messaging development and outreach to media professionals. Develop programming around safety issue, identify opportunities for outreach, develop materials.
- **Build Time:** Short - Staff introductions and interviews with media professionals.

Sources and More Information

Keefe et al., 2022

Goddard & Ralph, 2020

8. Social Norming Community Feedback Signs

Description

Signs posted at crosswalks show drivers what percentage of total drivers in the community yield to pedestrians at crosswalks. Routine data collection is used to update the percentages on the signs and demonstrate that yielding is the "normal" behavior. These signs have more traditionally been used to increase rates of seat belt usage.

Effectiveness

One study in St. Paul, Minnesota, demonstrated that driver yielding rates increased after these signs were posted.

Implementation and Operational Considerations

- **Cost:** Fixed Signs: $115 per intersection per week and $112 per intersection for one-time cost of posts. Data collection costs: three to four hours per week per site to collect data for new yield rates.
- **Planning Time:** Medium - Time needed to plan and coordinate data collection
- **Build Time:** Long - While only taking a short time to install signs, ongoing data collection and sign updates will extend this countermeasure over the long term.

Sources and More Information

Schmitt, 2019

Coordinating Activities

The table can be used to select behavioral programs to accompany selected engineering countermeasures. First select the engineering countermeasures that you will apply from the first column. The X mark in the cells across the various columns offer ideas about behavioral interventions that can accompany the deployment of that engineering countermeasure.

	ENFORCEMENT				EDUCATION							
ENGINEERING COUNTERMEASURE(S)	1. Targeted Yielding Operation	2. Lower Speed Limits	3. Speed Enforcement	4. Automated Speed Enforcement	1. Countermeasure-Specific Outreach	2. Safety Campaigns and Messaging	3. Pedestrian Safety Skills Training for Children	4. Dynamic Speed Feedback Signs	5. Automated Speed Warnings	6. High-Visibility Enforcement through Media and Progressive Ticketing	7. Media Framing (could be used for any countermeasure when describing crash prevention measures)	8. Social Norming Community Feedback Signs
1. High-Visibility Crosswalk Marking	X					X	X			X	X	X
2. Parking Restrictions/ Daylighting	X					X	X			X	X	X
3. Adjust Stop Bar at Intersection	X					X	X				X	X
4. Speed Humps or Tables		X		X		X					X	X
5. Curb Extension						X	X				X	X
6. Median Island	X					X	X			X	X	
7. Traffic Calming		X	X	X	X	X	X	X	X		X	
8. Restrict Right Turns on Red	X				X	X	X			X	X	X
9. Restrict Permissive Left Turn						X	X				X	X
10. Turning Vehicles Yield to Pedestrians (R-10-15) Sign	X					X	X			X	X	X
11. Leading Pedestrian Interval					X	X	X				X	X
12. Decrease Walking Speed/ Add Time to Pedestrian Phase						X	X				X	X
13. Implement "Hot Button"					X	X	X				X	X
14. Manage Progression Speed With Signal Timing		X	X	X	X	X	X	X	X		X	
15. Advance Stop/Yield Line	X					X	X			X	X	X
16. In-Road Yield to Pedestrian Sign (R1-6/R1-6a)	X					X	X			X	X	X
17. Gateway Arrangement of R1-6/R1-6a	X	X			X	X	X			X	X	X
18. Rectangular Rapid Flashing Beacon	X					X	X			X	X	X
19. Pedestrian Hybrid Beacon	X				X	X	X			X	X	X
20. Lighting	X					X	X			X	X	X

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[Editor's note: PEDSAFE 2013 is an online collection of 67 engineering, education, and enforcement countermeasures. Seventeen of those countermeasures are listed in this report. Here are those 17 "chapters" in alphabetical order, each with its web page URL:]

Advance yield/stop signs, http://pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=13

Advanced stop lines at traffic signals, www.pedbikesafe.org/pedsafe/countermeasures_detail.cfm?CM_NUM=50

Automated enforcement systems, http://pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=63

Curb extensions, www.pedbikesafe.org/pedsafe/countermeasures_detail.cfm?CM_NUM=5

In-street pedestrian crossing sign, www.pedbikesafe.org/pedsafe/countermeasures_detail.cfm?CM_NUM=69

Leading pedestrian interval, www.pedbikesafe.org/pedsafe/countermeasures_detail.cfm?CM_NUM=12

Left turn phasing, www.pedbikesafe.org/pedsafe/countermeasures_detail.cfm?CM_NUM=51

Marked crosswalks, http://pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=4

Parking restrictions, www.pedbikesafe.org/pedsafe/countermeasures_detail.cfm?CM_NUM=9

Pedestrian/driver education, http://pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=61

Pedestrian signal timing, www.pedbikesafe.org/pedsafe/countermeasures_detail.cfm?CM_NUM=47

Police enforcement, http://pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=62

Push buttons and signal timing, www.pedbikesafe.org/pedsafe/countermeasures_detail.cfm?CM_NUM=52

Raised medians, www.pedbikesafe.org/pedsafe/countermeasures_detail.cfm?CM_NUM=22

Right-turn-on-red restrictions, www.pedbikesafe.org/pedsafe/countermeasures_detail.cfm?CM_NUM=49

Speed humps, www.pedbikesafe.org/pedsafe/countermeasures_detail.cfm?CM_NUM=35

Speed tables, www.pedbikesafe.org/pedsafe/countermeasures_detail.cfm?CM_NUM=36

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15991-070323-v2