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Research and Guidance to Improve Pedestrian Safety

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2020 Texas Pedestrian Safety Forum: Pedestrian Safety Countermeasures that Work
August 6, 2020

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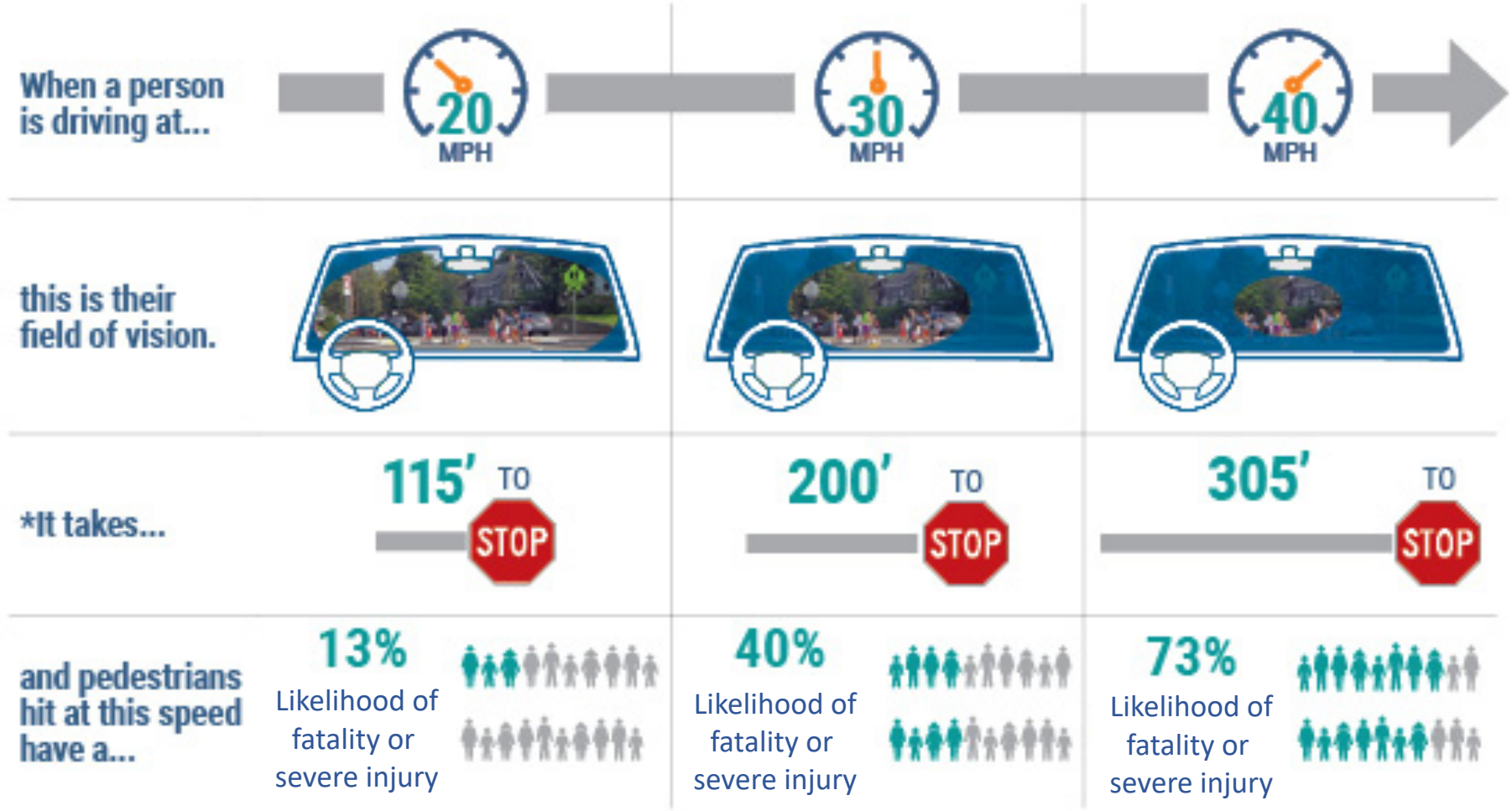
Overview

- Recent research on pedestrian fatalities in darkness
- NCHRP 926 “Guidance to Improve Pedestrian and Bicyclist Safety at Intersections”

Speed and Safety

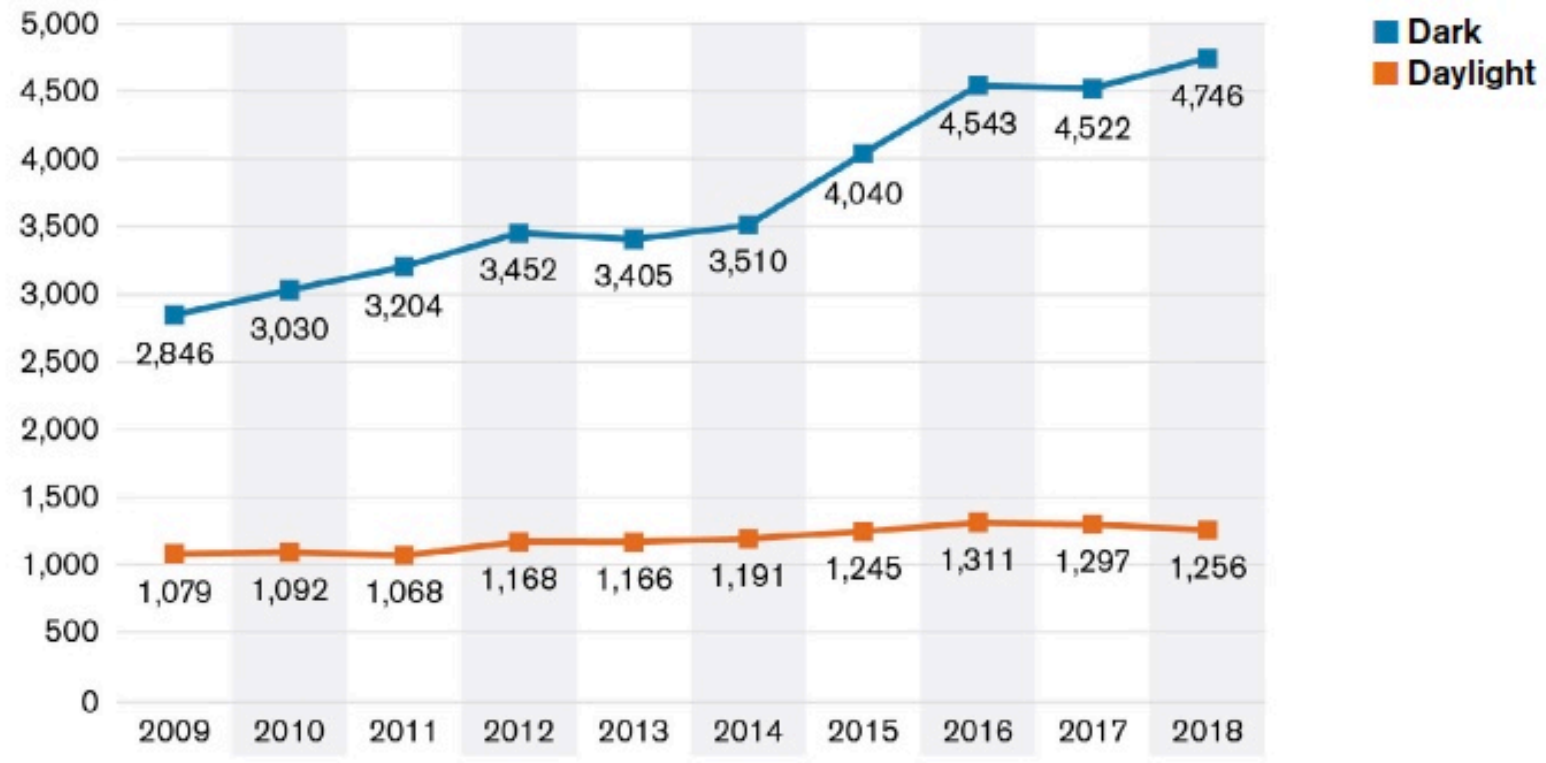


*Braking distance includes 2.5 sec of reaction time

Image Source: Toole Design

Pedestrian Safety Trends

Figure 9 Pedestrian Fatalities by Light Condition: 2009-2018

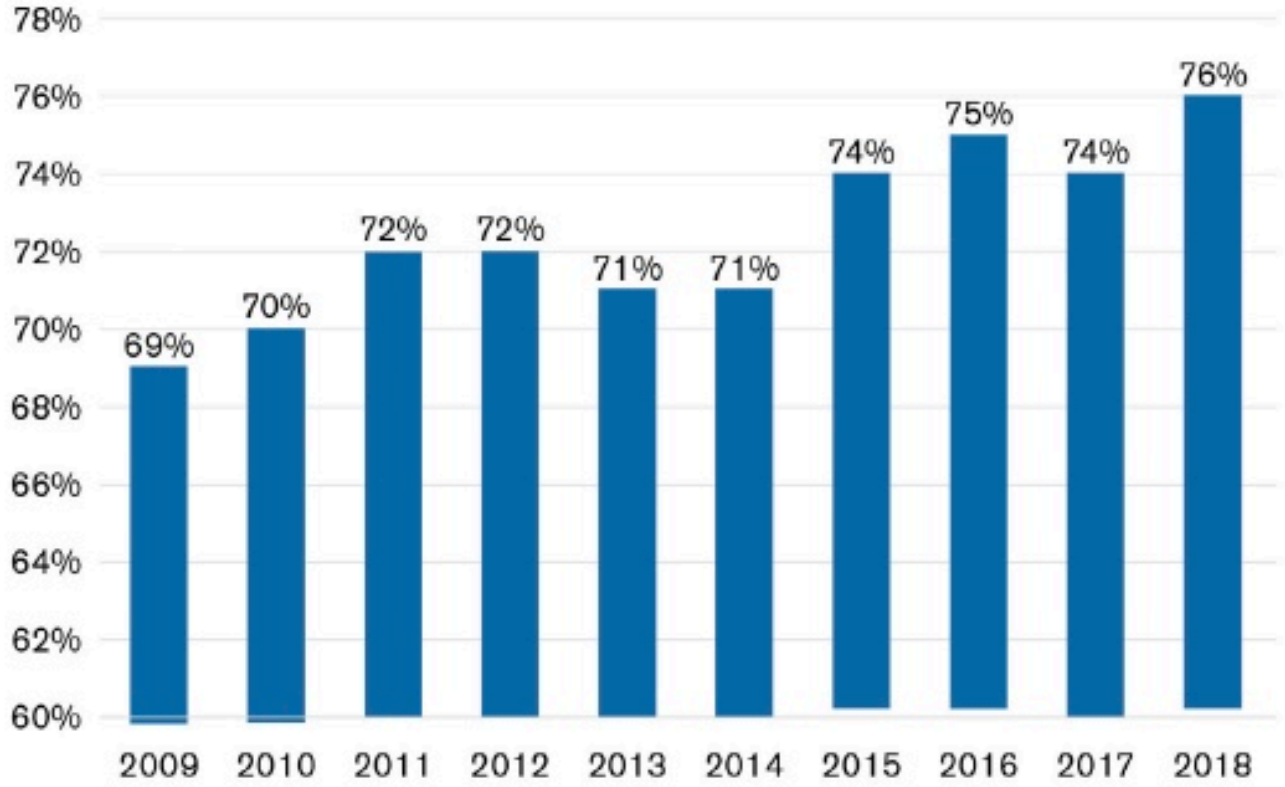


Source: FARS

Data Source: GHSA Pedestrian Safety Spotlight Report

Pedestrian Safety Trends

Figure 10 Percentage of Pedestrian Fatalities That Occurred in the Dark: 2009-2018



Source: FARS

Data Source: GHSA Pedestrian Safety Spotlight Report

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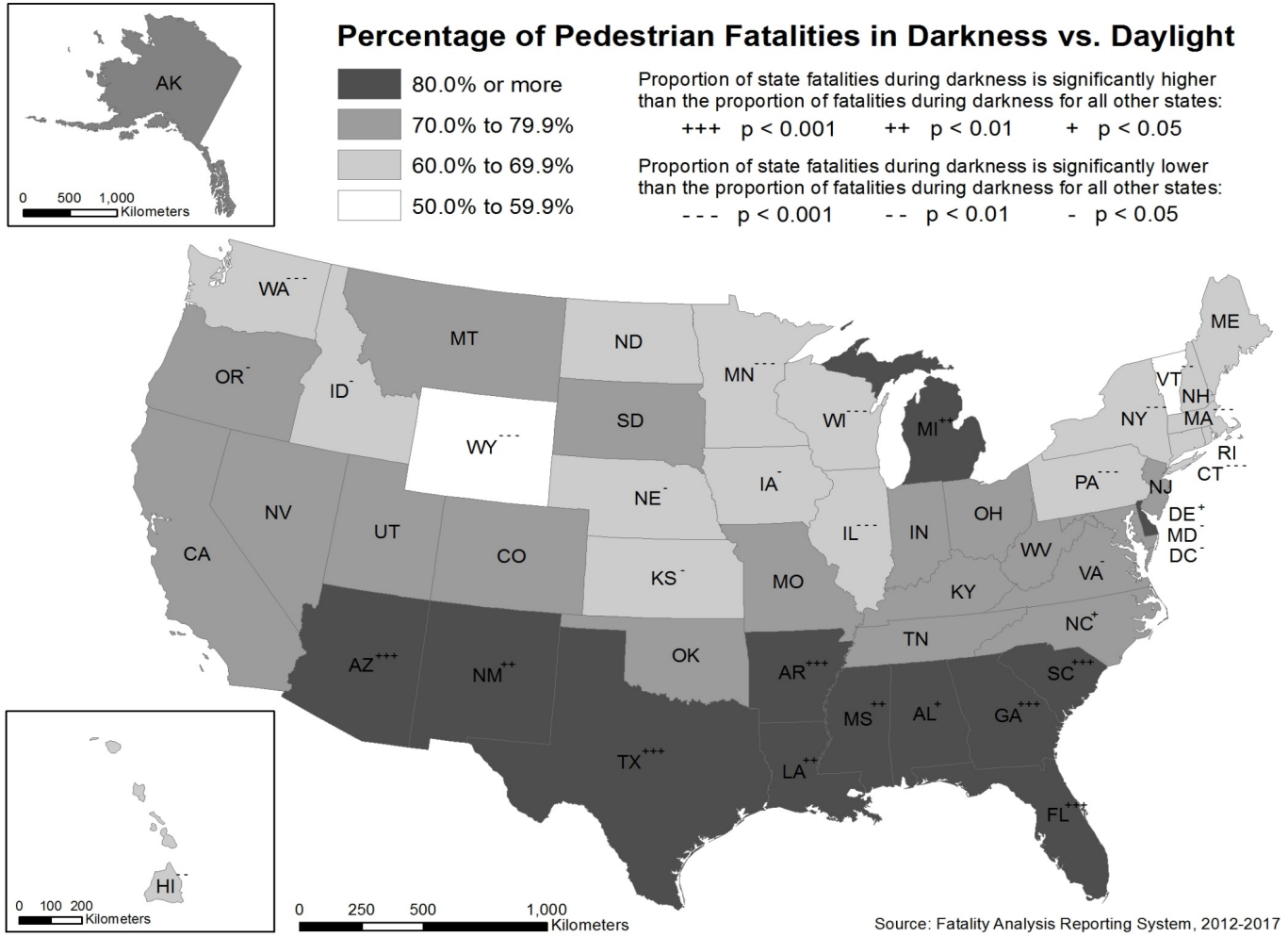
Pedestrian Fatalities in Darkness



Source: Sanders, Schneider, & Proulx, 2019

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Pedestrian Safety in Darkness

- Bivariate analysis examining correlates with fatalities in darkness
- Logit models
  - Fatalities in darkness versus daylight (national level)
  - Fatalities versus severe injuries in darkness versus daylight (California)
- Short story: design (speed), visibility (speed), behavior

Pedestrian Safety in Darkness

Visibility
- Clear weather (-)

Speed
- Crash occurring at ≥ 35mph speed (+)
- Crash occurring with a functioning traffic control device (-)
- Crash occurring at an intersection (-)
- Driver going straight (+)
- Pedestrian being hit in the roadway (+)

Design
- Pedestrian crossing in a crosswalk (-)
- Crash occurring on multilane road (+)

Pedestrian Safety in Darkness

Pedestrian characteristics

- Pedestrian being Black (+)
- Pedestrian being Hispanic (+, CA only)

Behavior

- Pedestrian and driver drinking (+)

Other

- Increased mobile phone usage?
- Increase in larger vehicles?

NTSB Recommendations

- Vehicle-based safety countermeasures
  - Vehicle headlights
  - Vehicle design
  - Collision avoidance technology
- Infrastructure planning
  - Pedestrian safety action plans
  - Design guides
  - Site-specific planning
- Improve pedestrian safety data

NTSB Recommendations

- Vehicle-based safety countermeasures
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- Infrastructure planning
  - Pedestrian safety action plans
  - Design guides
  - Site-specific planning
- Improve pedestrian safety data
- Lighting plans
- Bars/entertainment districts

NCHRP 926: Guidance to Improve Pedestrian & Bicyclist Safety at Intersections

- Succinct process for selecting safety countermeasures for pedestrians and bicyclists
- Includes contextual considerations
- Draws from and works with key countermeasure and safety resources

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Countermeasure Selection Tool

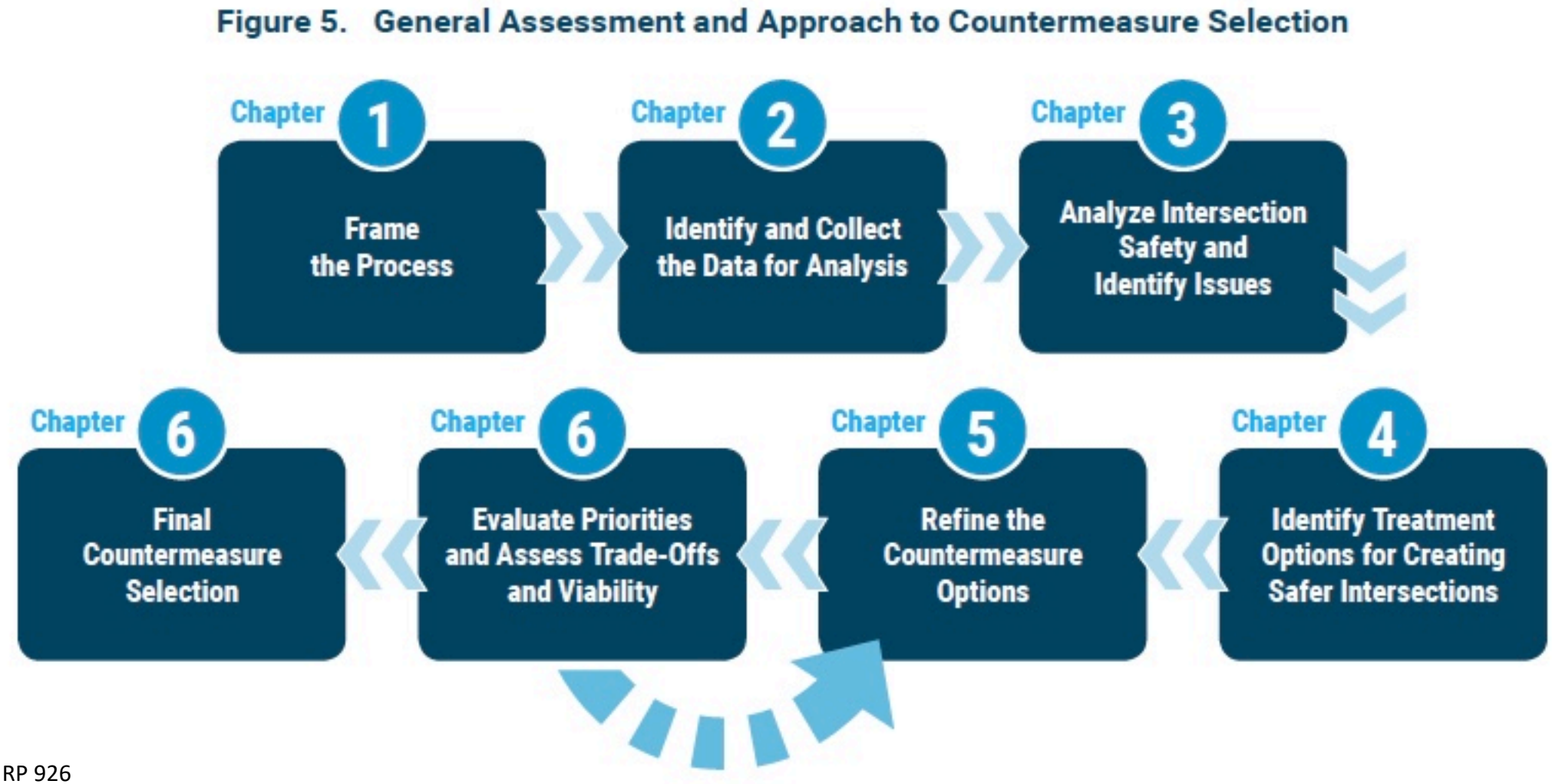


Image source: NCHRP 926

Countermeasure Tiers

Table 14. Recommended Countermeasure Tiers Depending on Traffic Context

Roadway Type	Vehicle ADT < 9,000			Vehicle ADT 9,000–12,000			Vehicle ADT 12,000–15,000			Vehicle ADT ≥ 15,000		
(Number of Travel Lanes and Median Type)	Speed Limit (mph)											
	≤30	35	≥40*	≤30	35	≥40*	≤30	35	≥40*	≤30	35	≥40*
2 Lanes	1	1	2	1	1	2	1	1	3	1	2	3
3 Lanes	1	1	2	1	2	2	2	3	3	2	3	3
4 Lanes with raised median**	1	1	2	1	2	2	2	3	3	3	3	3
4+ Lanes without raised median	1	2	3	2	2	3	3	3	3	3	3	3

Legend:

1 — ***Tier 1:*** Traffic context generally supports motorist yielding; countermeasures are generally less expensive and require less process than other two tiers to implement

2 — ***Tier 2:*** Traffic context generally requires intervention to induce motorist yielding; countermeasures are generally less expensive and require less process than Tier 3 to implement

3 — ***Tier 3:*** Traffic context generally requires intervention to require motorist to stop or to physically separate pedestrians and bicyclists from traffic; often the most expensive and may require extensive public process

* Where the speed limit exceeds 40 mph, Tier 3 should be considered.

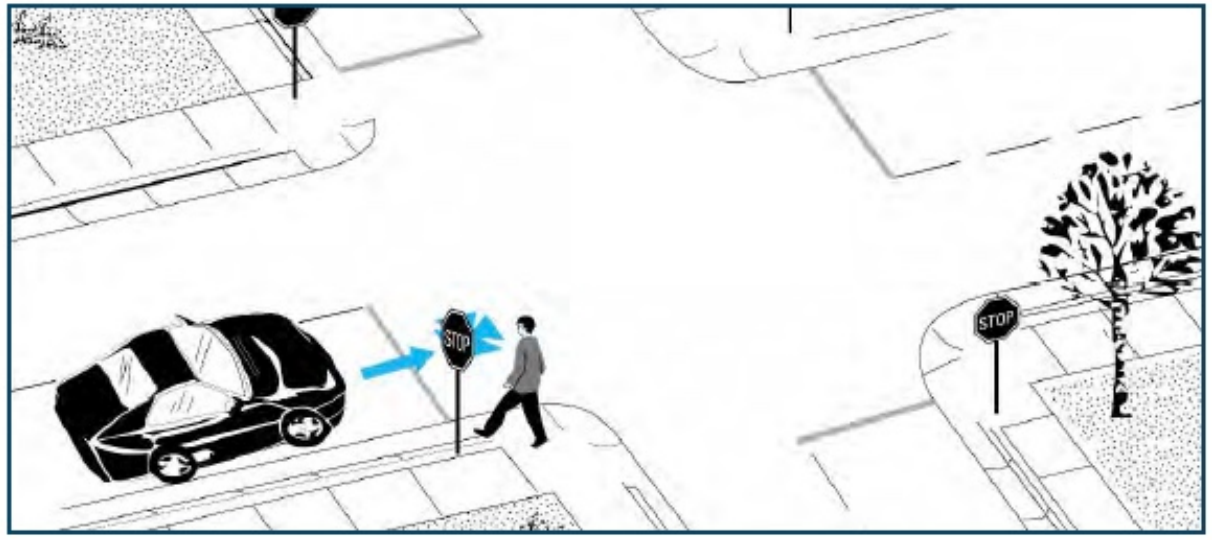
** Raised medians must be at least 6 feet wide to serve pedestrians. See the AASHTO *Bicycle Guide* for lengths to serve bicyclists. Where median width is less than these values, review category of 4+ lanes without raised median.

Table adapted from AASHTO *Bicycle Guide* and the FHWA *STEP Guide*

Image source: NCHRP 926

Example Crash Type & Countermeasures

Figure 26. Motorist failed to yield to pedestrian.



Source: PBCAT

Image source: NCHRP 926

Table 15. Potential Countermeasures for Motorist Failed to Yield to Pedestrian

Effectiveness	Tier 1: Supports Motorist Yielding	Tier 2: Requires Intervention to Induce Motorist Yielding	Tier 3: Separate Modes or Requires Motorists to Stop
High	Active warning beacons In-street pedestrian crossing signs Mini traffic circles Raised crossings Rectangular rapid flash beacon Roundabout Traffic signal	Active warning beacons Grade-separated crossing Channelizing fence or barrier Pedestrian hybrid beacon Rectangular rapid flash beacon Roundabout Traffic signal	Grade-separated crossing Channelizing fence or barrier Pedestrian hybrid beacon Roundabout Traffic signal
Moderate	Advance stop/yield lines Crossing island Curb extensions Gateway treatments High-visibility crosswalk markings Lighting Parking restrictions/daylighting Raised median Road diet/rechannelization	Advance stop/yield lines Crossing island Curb extensions Gateway treatments High-visibility crosswalk markings In-street pedestrian crossing signs Lighting Parking restrictions/daylighting Raised median Road diet/rechannelization Signal timing*	Active warning beacons Advance stop/yield lines Lighting Parking restrictions/daylighting Rectangular rapid flash beacon Road diet/rechannelization Signal timing*

*Countermeasures only appropriate for a signalized location.

Countermeasures by Tier & Crash Type

Table 25. Countermeasure Summary Matrix

Countermeasure	Effectiveness			Public Process	Motorist Traveling Straight							Motorist Turning			
	Tier 1: Supports Motorist Yielding	Tier 2: Requires Intervention to Induce Motorist Yielding	Tier 3: Separates Modes or Requires Motorists to Stop	1 to 5 Scale: 1 = No Public Process and 5 = Extensive Public Process	Motorist Failed to Yield to Pedestrian	Pedestrian Failed to Yield	Pedestrian Dash	Bike Crossing Paths With Uncontrolled Motorist	Bike Rides Through/Out–STOP sign	Motorist Drives Out Into Bike–Stop Controlled	Bike Rides Through/Out–Signalized Intersection	Motorist left Turning Into Pedestrian Parallel Path	Motorist Right Turning into Pedestrian Parallel Path	Motorist Right Turning into Bike–Same Direction	Motorist Left Turning into Bike–Opposite Direction
Active warning beacons	M	M	L	1	●	●	●	●	●			●	●	●	●
Advance stop/yield lines	H	M	L	1	●	●	●	●	●						
All-walk phase	M	H	H	3	●	●	●					●	●		
Bicycle lane extension through intersections	M	L	L	1				●		●				●	●
Bicycle signals	M	M	H	1							●			●	●
Bike boxes	M	M	M	1										●	
Continuous raised medians	H	H	H	4	●	●	●	●	●		●	●			●
Hardened centerlines	H	H	H	1								●			●
Crossing barriers	L	M	H	5	●	●	●	●							
Crossing islands	H	H	H	3	●	●	●	●	●		●	●			●
Curb extensions	M	M	M	1	●	●	●	●	●	●	●	●	●	●	●

Image source: NCHRP 926

Countermeasure Trade-offs

	Spatial Impact	Estimated Cost	Maintenance Cost	Public Process	Motorists			Pedestrians			Bicyclists		
					Operations	User Comfort	Safety	Operations	User Comfort	Safety	Operations	User Comfort	Safety
Mini-Traffic Circles	Large	$$	$$	4	-	-	+	-	-	+	-	-	+/-
Mixing Zone Treatments	Moderate	$$	$$	3	+	+/-	+/-	+/-	+/-	+/-	+/-	-	+
No-Turn-on-Red Signs	Small	$	$	1	--	+/-	++	++	++	++	++	++	++
Parking Restrictions at Crossing Locations/ Daylighting	Moderate	$	$	2	+/-	+	++	+	+	++	+	+	++
Passive Bicycle Signal Detection	Small	$$	$$	1	+/-	+/-	+/-	+/-	+/-	+/-	++	++	+
Pedestrian Countdown Signals	Small	$$	$$	1	+/-	+/-	+/-	+	++	++	+	++	++
Pedestrian Hybrid Beacon	Small	$$$	$$$	4	-	+	+	+	++	++	+	++	++
Protected Intersections	Large	$$$$	$$$$	3	-	++	+	+	++	++	++	++	++
Protected Phases	Small	$	$	4	--	++	+	--	++	++	--	++	++
Raised Crossings	Moderate	$$	$$	3	-	-	+	++	++	++	++	++	++
Rectangular Rapid Flashing Beacon	Small	$$	$$	1	+/-	+/-	+/-	+/-	+	+	+	+	+
Road Diet/ Rechannelization	Large	$$	$$	5	-	+/-	++	++	++	++	++	++	++
Roundabouts	Large	$$$$	$$$$	5	++	+	++	+	-	+/-	+	-	+/-
Signal Timing	Small	$	$	3	+/-	+/-	+	+	+	+	+	+	+
Traffic Signals	Small	$$$$	$$$$	3	+/-	+	+/-	+/-	+	+/-	+/-	+	+/-
Two-Stage Bicycle Turn Queue Boxes	Small	$	$	1	+/-	+	+/-	+/-	+	+/-	+/-	+	+/-

KEY

++ very positive benefit
+ positive benefit
+/- neutral
- disbenefit
-- strong disbenefit

Relative Cost

$ = <2,500
$$ = 2,500–49,999
$$$ = 50,000–150,000
$$$$ = >150,000

Public Process

1. No public process, engineering decision
2. Public notice, engineering decision
3. Minimal public process, engineering decision
4. Moderate public process needed to build partner agency and community support
5. Extensive public process needed to build community and political support

Image source: NCHRP 926

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Example Cut-Sheet

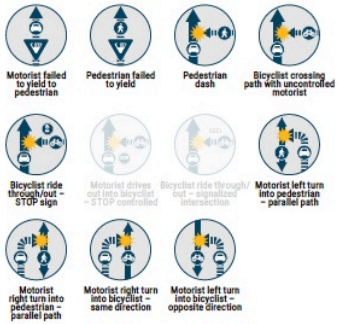
Active Warning Beacons

CMF/Rating
A CMF for this treatment has not been developed. Existing studies indicate motorist yielding varies from 25 to 76 percent, with an unclear relationship to roadway characteristics. Actuated beacons are typically more effective than continuous flashing beacons (Fitzpatrick et al. 2006).

Active warning beacons are user-actuated flashing lights that supplement warning signs at unsignalized crossings (NACTO 2012), including path and road crossings. Active warning beacons are distinguished from rapid flashing beacons and pedestrian hybrid beacons by their flash rate which may only vary from 50 to 60 flashes per minute (MUTCD). Active warning beacons can be actuated manually by a button or automatically with passive detection. The purpose of an active warning beacon is to alert drivers to the presence of people crossing the road. Active warning beacons can be a lower-cost alternative to rapid flashing beacons or pedestrian hybrid beacons.

Figure 1. Active warning beacons (image source: Toole Design Group).

Applicable Crash Types



Applicable Contexts

- Unsignalized crossings.
- High pedestrian and/or bicycle volumes.
- Crossings where driver yielding is low.

ACTIVE WARNING BEACONS — COUNTERMEASURES

Complementary Countermeasures

Should be installed with the following treatments:

- High-visibility crosswalk markings.
- Curb ramps.
- Pedestrian detection—either active (button) or passive detection.
- Warning sign (MUTCD W11-1, W11-2, W11-15, or S1-1).
- Advance stop/yield lines on multilane approaches.
- Stop Here for Pedestrians or Yield Here to Pedestrians signs (MUTCD R1-5 series) on multilane approaches.

May be installed with the following treatments:

- Raised median refuge island.
- Yield to Pedestrian sign (MUTCD R1-5 series).
- Lighting.
- In-street pedestrian crossing signs.
- Gateway treatment.
- Passive bicycle detection.

Considerations

- Most effective when actuation is required.
- Active beacons may be useful for advance warning conditions, such as when drivers are heading around a curve or approaching an intersection or crossing with poor sightlines.
- Beacons should be dark when not in use.
- Beacons should not be applied to crossings already controlled by YIELD signs, STOP signs, or traffic signals.
- This treatment is appropriate for both intersection and midblock crossings.
- If intended for use by bicyclists, push button actuation should be located so bicyclists can activate the signal without dismounting (NACTO 2012).
- Active beacons are most effective when user actuation (active or passive) is required, resulting in the beacon flashing only when a crossing pedestrian is present.
- Beacons may be used on warning signs placed in advance of intersection to alert turning motorists to the potential presence of crossing pedestrians or bicyclists.

Systemic Safety Potential

This type of treatment is best suited for spot treatments; installing active warning beacons in too many places may reduce compliance.

Estimated Cost

The cost of an active warning beacon varies by type of treatment installed, with costs between $5,000 and $10,000.

Potential Effects on Travel Modes

Mode	Effect
Motorists	• May reduce travel speed when beacons are activated (Carson et al. 2005) • Occasional slight delay
Bicyclists	• May increase safety • May reduce multiple-threat crashes • May reduce delay
Pedestrians	• May increase safety • May reduce multiple-threat crashes • May reduce delay
Large Trucks	• Occasional slight delay

Alternative Treatments

- Rectangular rapid flash beacon.
- Pedestrian hybrid beacon—appropriate if MUTCD requirements are met.
- Full traffic signal—appropriate if MUTCD requirements are met.

Additional Information

- NACTO *Urban Bikeway Design Guide*
- *Manual on Uniform Traffic Control Devices*

Image source: NCHRP 926

Additional Considerations

Incorporating equity into our analyses and countermeasure selection

- Racial
- Gender
- Ability
- Income

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Resources & Contact Information

NCHRP 926:
https://www.nap.edu/catalog/25808/guidance-to-improve-pedestrian-and-bicyclist-safety-at-intersections

GHSA 2019 Pedestrian Safety Spotlight:
https://www.ghsa.org/sites/default/files/2020-02/GHSA-Pedestrian-Spotlight-FINAL-rev2.pdf

NTSB Pedestrian Safety Special Investigation:
https://www.ntsb.gov/safety/safety-studies/Documents/SIR1803.pdf

Pursuing Equity in Transportation:
https://usa.streetsblog.org/2020/07/27/opinion-urbanism-is-complicit-in-infra-structural-racism-and-reparations-have-a-place-in-the-built-environment/

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