Detailed Field Research Findings from the FHWA Crosswalk Marking Selection Guide

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Housekeeping

- ⇨ Submit your questions
- ⇨ Webinar archive: www.pedbikeinfo.org/webinars
- ⇨ Live transcript: https://link.ai.media/session?plink=HSRC
- ⇨ Certificates and professional development hours
- ⇨ Follow-up email later today
- ⇨ Review previous episodes and sign up for upcoming sessions

Crosswalk Marking Webinar Series

Part 1 is archived at www.pedbikeinfo.org/webinars

Part 1 – Tuesday, February 15

Preview of the FHWA Crosswalk Marking Selection Guide

- Guide purpose and organization
- State of practice
- Original research
- Guide recommendations

Today's Panel

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Webinar Part 2

Crosswalk Marking Guide: Detailed Field Research Findings

Thursday, February 17, 2022

1:00 PM EST

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Research Team

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Outline

- Introduction and Purpose
- Field Data Intent and Outcomes
- Analysis and Results
- Key Take Aways
- Q&A

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Introduction and Purpose

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Guide Purpose

Is a decision support tool for transportation professionals and agencies selecting crosswalk marking designs

Considers various aspects including Safety, Visibility, Effectiveness, Materials, Maintenance, and Cost

Builds on existing research and guidance on these factors, highlights gaps in knowledge, and documents original research conducted

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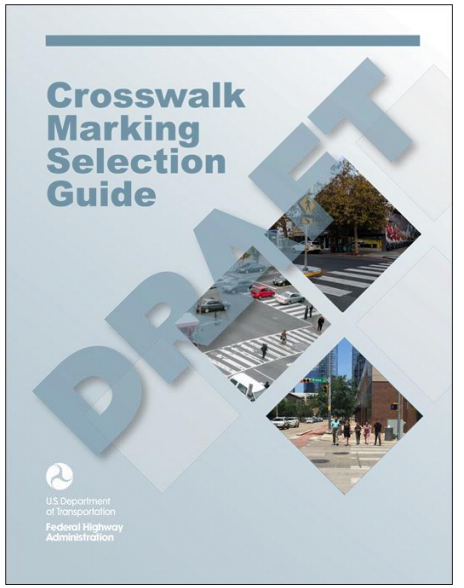
Guidebook Development Process

Literature and State of Practice Review

Agency Interviews

Field Study

Guide Development



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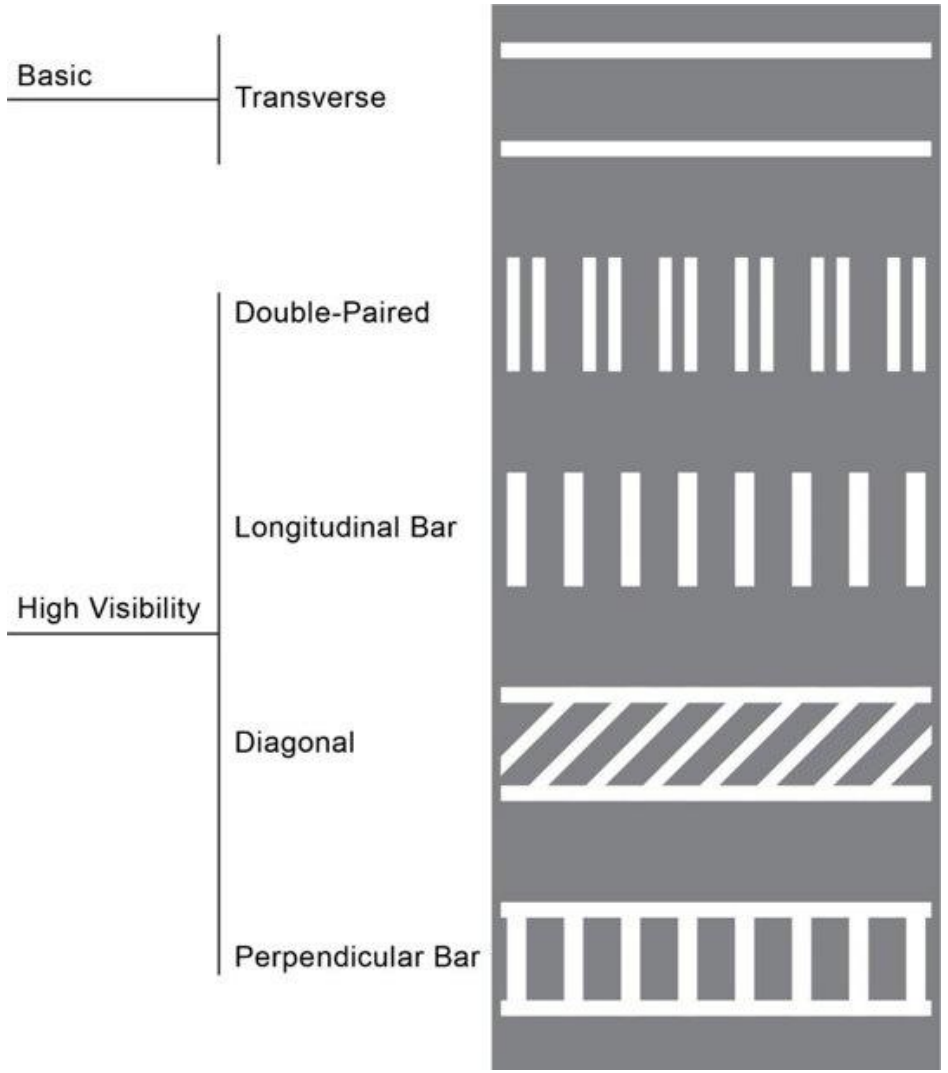
Purpose of Crosswalks

- **What are crosswalks?**
  - Areas where pedestrians are granted the right of way when crossing a roadway.
  - May be marked or unmarked
- **Why do we mark them?**
  - Alert drivers to pedestrians' potential presence and right of way
  - Establish pedestrian right of way at midblock locations
  - Establish pedestrian right of way at crossings lacking sidewalk connections on both sides (in some states)
  - Provide wayfinding cues to pedestrians with low vision

Crosswalk Marking Designs



Examples of crosswalk markings.

Source: Adapted from Federal Highway Administration. Manual on Uniform Traffic Control Devices for Streets and Highways. Section 3B.18(04). Washington, D.C., 2009

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Key Research Questions

This is the focus of today's discussion.

1. Does the increased visibility of HVCs lead to increased **effectiveness**?
   - If so, where are they recommended? (i.e., why not use them for all marked crosswalks?)
2. What are agency criteria for selecting marking types, and which criteria should be included in guide recommendations?

Research Overview

- Conducted staged pedestrian crossings to measure and compare driver yielding of high visibility crosswalks (HVCs) compared to basic (transverse parallel lines)
- Research findings and recommendations
  - HVCs are associated with increased driver yielding than basic
  - Yielding rates showed robust negative relationship with driver speeds
    - HVC effectiveness strongest with lower driver speeds (sites with 85th percentile speeds ≤ 30 mph)
  - **HVCs are recommended over basic patterns anywhere crosswalks are marked**

If a crosswalk is worth marking, **it is worth marking as HVC**

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Guide Recommendations

- The Guide also presents research findings and recommendations related to:
  - Materials selection
  - Maintenance procedures and implications
  - Installation versus life-cycle costs
- Find our 2/15/22 "Guide Preview" webinar at https://www.pedbikeinfo.org/webinars/

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Field Data Intent and Outcomes

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Key Research Questions for Field Data Collection

- **Key Research Questions Identified for Original Research:**
  1. Does the increased visibility of HVCs lead to increased effectiveness?
  2. If so, what are the location types where they may be strongly recommended? (i.e., why not use them for all marked crosswalks?)

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Field Study Approach

- Research Approach:
  - Conducted staged pedestrian crossings
  - Compared yielding at HVC and basic sites
    - Marked crosswalks on uncontrolled legs of two-way stop-controlled intersections on undivided two-lane roadways with low speeds and volumes
  - Established internal protocol for crossing consistency (pedestrian, body language, influence area, etc.)
  - Collected volumes and speeds for all vehicles while in field for post-hoc evaluation
  - Through vehicles only

Field Study Approach

Table 1. Application of pedestrian crash countermeasures by roadway feature.

Roadway Configuration	Posted Speed Limit and AADT								
	Vehicle AADT <9,000			Vehicle AADT 9,000–15,000			Vehicle AADT >15,000		
	≤30 mph	35 mph	≥40 mph	≤30 mph	35 mph	≥40 mph	≤30 mph	35 mph	≥40 mph
2 lanes (1 lane in each direction)	● 2 4 5 6	● 5 6 7 9	○ 5 6 ● ●	● 4 5 6	● 5 6 7 9	○ 5 6 ● ●	● 4 5 6 7 9	○ 5 6 7 9	○ 5 6 ●
3 lanes with raised median (1 lane in each direction)	● 2 3 4 5	● ● 5 7 9	○ ● 5 ● ●	○ 3 4 5 7 9	○ ● 5 ● ●	○ ● 5 ● ●	○ ● 4 5 7 9	○ ● 5 ● ●	○ ● 5 ●
3 lanes w/o raised median (1 lane in each direction with a two-way left-turn lane)	● 2 3 4 5 6 7 9	● ● 5 6 7 9	○ ● 5 6 ●	○ 3 4 5 6 7 9	○ ● 5 6 ● ●	○ ● 5 6 ●	○ ● 4 5 6 7 9	○ ● 5 6 ●	○ ● 5 6 ●
4+ lanes with raised median (2 or more lanes in each direction)	● ● 5 7 8 9	● ● 5 7 8 9	○ ● 5 8 ●	○ ● 5 7 8 9	○ ● 5 ● 8 ●	○ ● 5 8 ●	○ ● 5 ● 7 8 9	○ ● 5 8 ●	○ ● 5 8 ●
4+ lanes w/o raised median (2 or more lanes in each direction)	● ● 5 6 7 8 9	○ ● 5 ● 7 8 9	○ ● 5 ● 8 ●	○ ● 5 ● 7 8 9	○ ● 5 ● ● 8 ●	○ ● 5 ● 8 ●	○ ● 5 ● 7 8 9	○ ● 5 ● 8 ●	○ ● 5 ● 8 ●

Given the set of conditions in a cell,

- # Signifies that the countermeasure is a candidate treatment at a marked uncontrolled crossing location.
- ● Signifies that the countermeasure should always be considered, but not mandated or required, based upon engineering judgment at a marked uncontrolled crossing location.
- ○ Signifies that crosswalk visibility enhancements should always occur in conjunction with other identified countermeasures.*

The absence of a number signifies that the countermeasure is generally not an appropriate treatment, but exceptions may be considered following engineering judgment.

1 High-visibility crosswalk markings, parking restrictions on crosswalk approach, adequate nighttime lighting levels, and crossing warning signs
2 Raised crosswalk
3 Advance Yield Here To (Stop Here For) Pedestrians sign and yield (stop) line
4 In-Street Pedestrian Crossing sign
5 Curb extension
6 Pedestrian refuge island
7 Rectangular Rapid-Flashing Beacon (RRFB)**
8 Road Diet
9 Pedestrian Hybrid Beacon (PHB)**

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Site Criteria

- Site criteria
  - Uncontrolled crosswalks at intersections
  - Undivided two-lane roadways
  - Outside urban core
  - "Low" or "Medium" expected level of pedestrian activity
  - Low roadway volumes/speeds
- Site selection considerations
  - Bike lane presence
  - Presence of on-street parking
  - Crossing distance
  - "Grid" or "collector" context
  - Posted speed
  - Presence of Warning signs at the crossing

Site selection example

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Field Work

Staged crossing

Data recording

Data collection example

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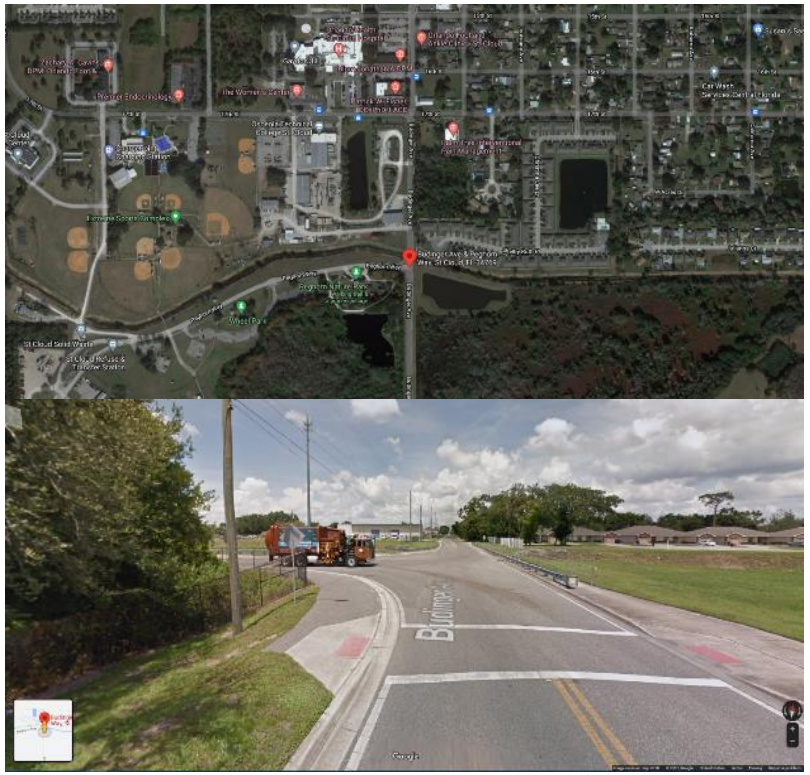
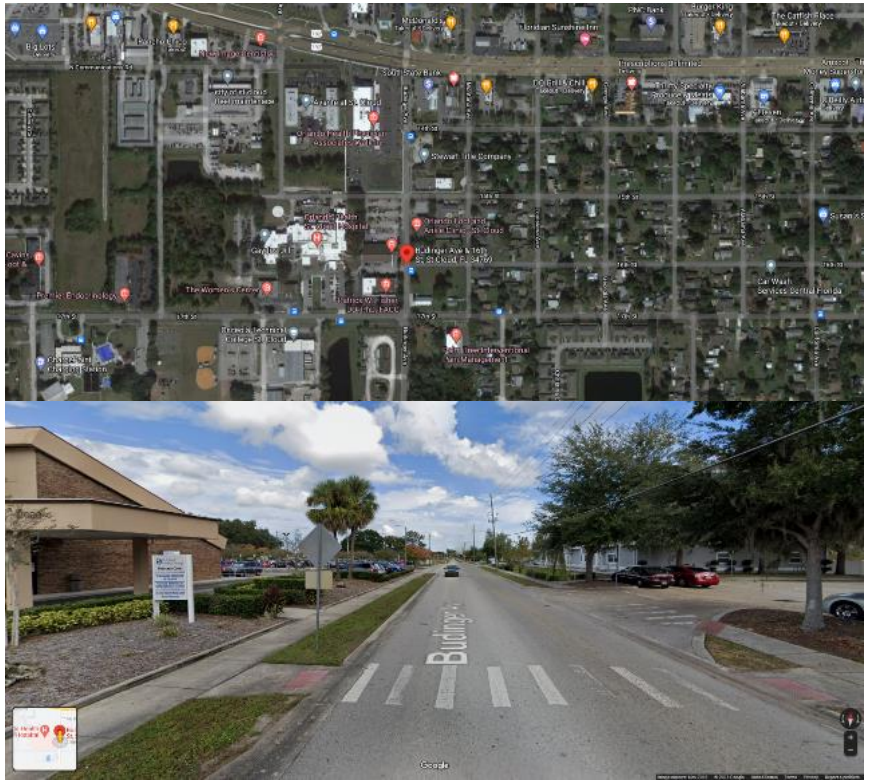
Example Site: Florida Pair 1

Basic crosswalk in a collector context



HVC crosswalk in grid context



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Site Selection Overview

- A total of 32 sites were selected to conduct field observations across four States, in and around the following four cities:
  - Oakland, California
  - Portland, Oregon
  - Raleigh, North Carolina
  - Orlando, Florida

- 4 basic and 4 HVC in each region
- Identified site pairs – all similar as possible but for markings
- Targeted speed/volumes
- Evaluate and compare speeds/volumes after collection

Analysis and Results

Analysis Approach

- Evaluated sites on speed, volume, and additional supplemental variables
  - Two-way hourly volume for collection periods
  - Speed – posted speed and 85th percentile speed
  - Presence of warning signs: W11-2 and S1-1
  - "Grid" versus "collector" contexts
- Compared basic vs. HVC yield rates
- Modeled logistic regression to evaluate yield behavior

W11-2

S1-1

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Characteristics Across Sites

- 32 sites in total
  - 26 with posted or prima facie speed 25mph
  - One with 30 mph
  - Five with 35 mph
- All five 35 mph sites were in North Carolina – difficult to find ideal site pairs!

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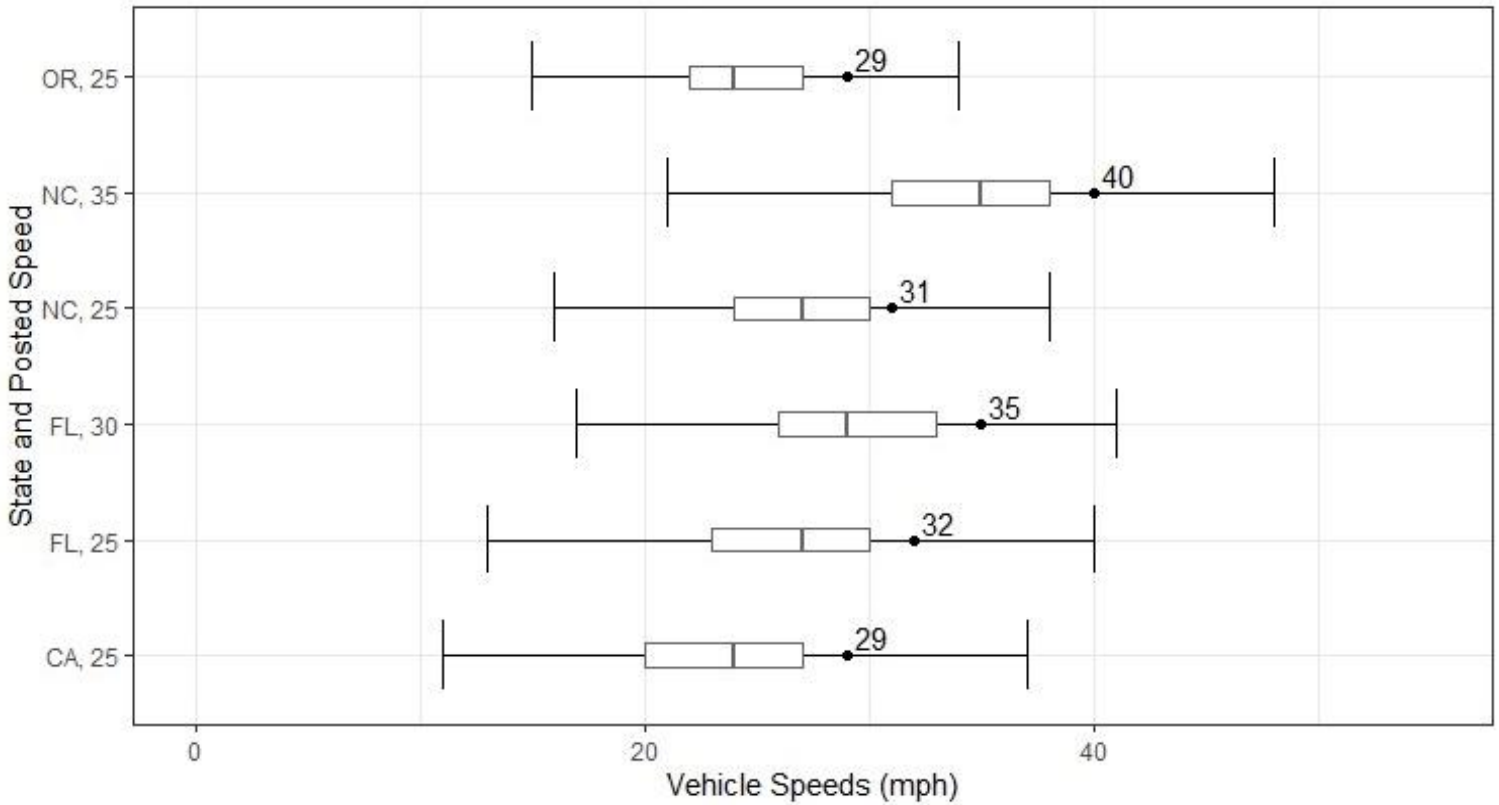
Speed



Observed Speed Distribution. Data labels indicate 85th Percentile speeds (Two Lane Undivided Roads)

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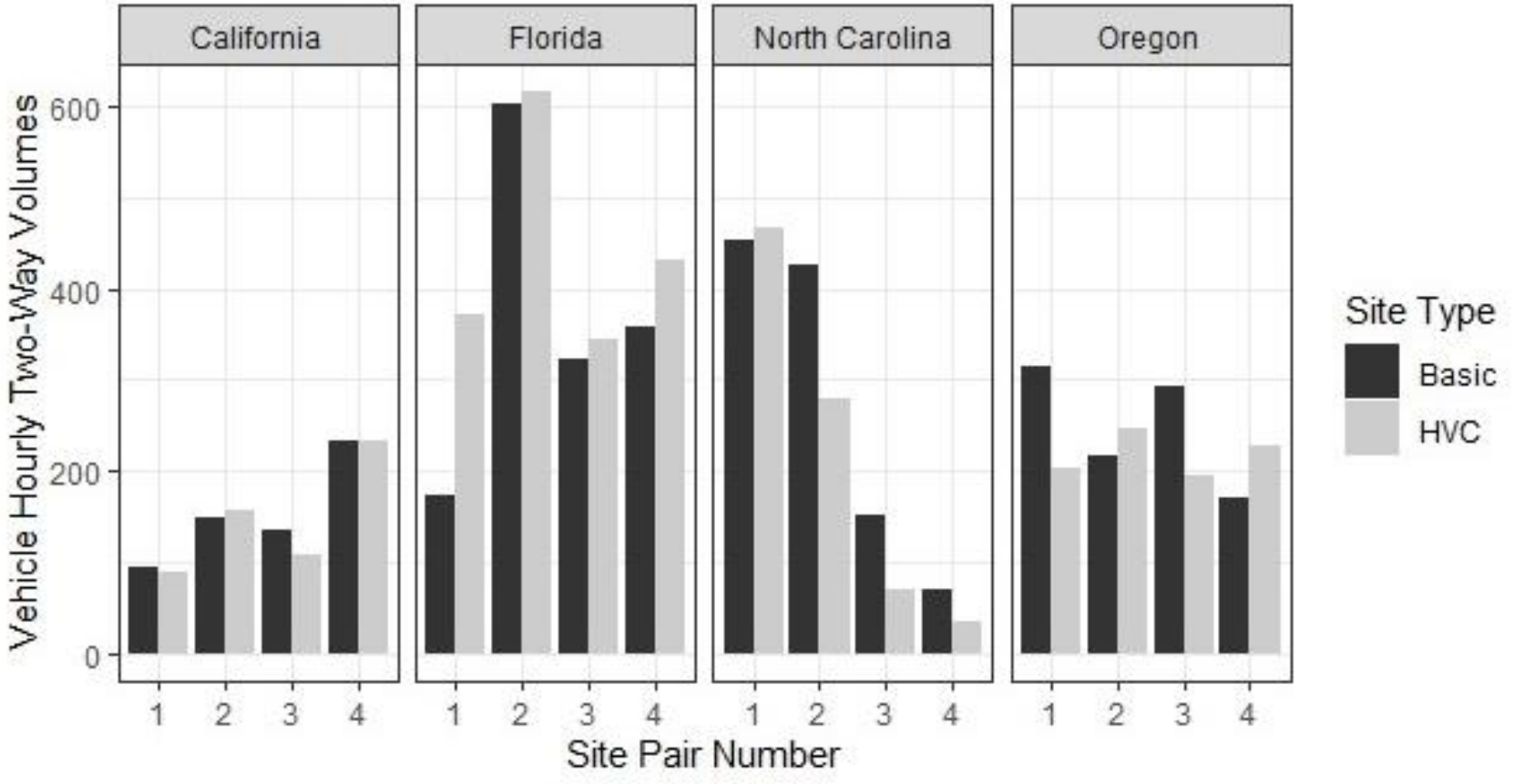
Volumes



Observed Hourly Vehicle Volume for Each Site (Two Lane Undivided Roads)

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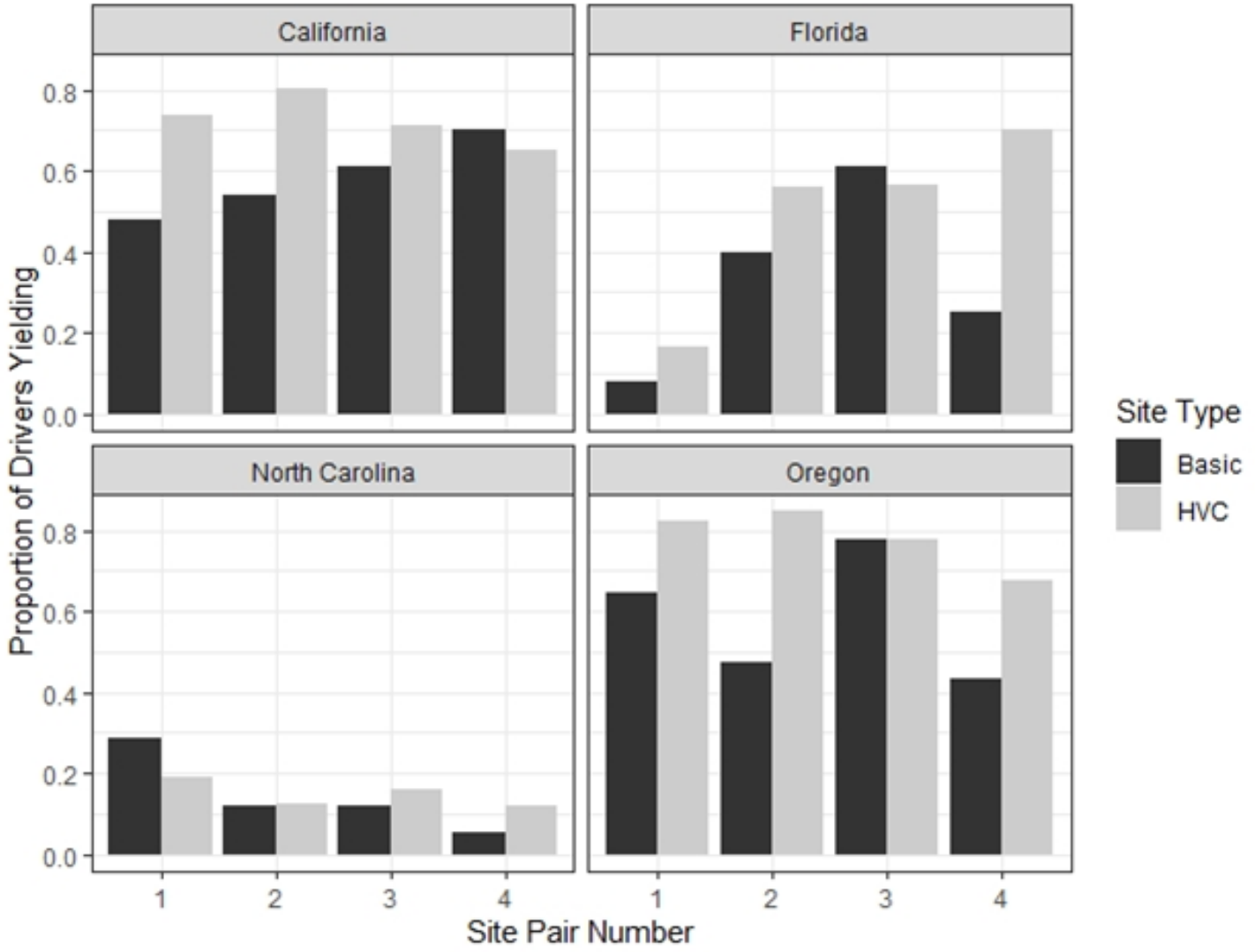
Yield Rates



Yield Rate by Region and Site Type

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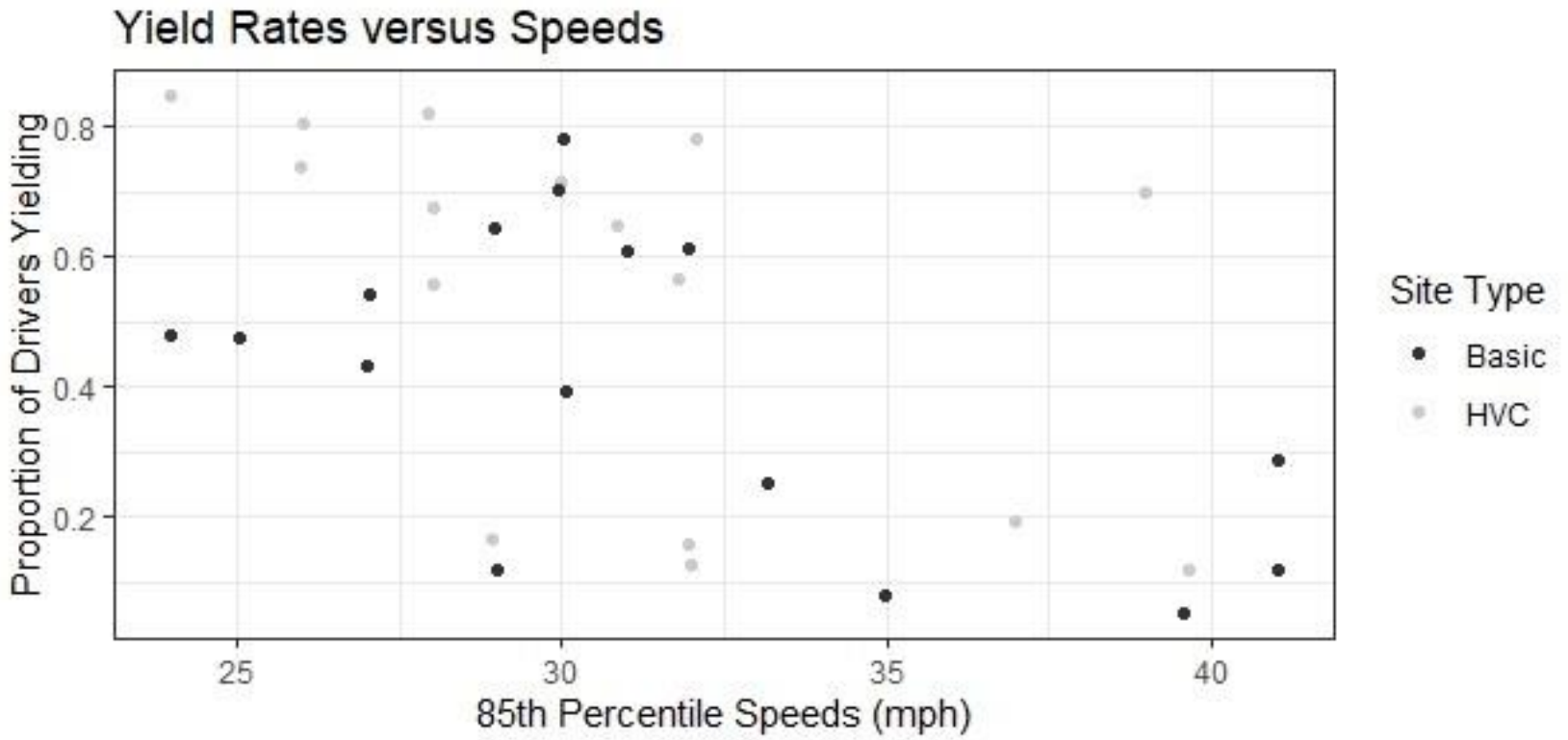
Speed Matters!

Yield Rates and Speed



Yield Rates versus Speeds by Site Type (Two Lane Undivided Roads)

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Statistical Modeling

- Wanted to model interaction of elements observed
- Increase number of observations and explanatory power
  - Previous analysis is based on 32 data points (each site)
  - Modeling is based on 1,188 staged crossings
- Modeled yielding behavior as binary outcomes (1 = yield, 0 = non-yield)

Models tested:

- Model 1: Marking Type, Speed*, and Warning Sign Presence
- Model 2: Marking Type and Speed*
- Model 3: Marking Type and Speed* by Region
- Model 4: Marking Type and Warning Sign Presence
- Model 5: Marking Type and Corridor Context
- Model 6: Marking Type and 85th Percentile Speeds* (Binned)

*Speed *refers to each vehicle's recorded approach speed.*

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Model Approach

$$logit[P(Y=1)] = log\left[\frac{P(Y=1)}{1-P(Y=1)}\right] = \alpha + \beta_1 \times OperatingSpeed + \beta_2 \times HVC + \beta_3 \times Warning\ Sign$$

where :

$OperatingSpeed = Speed\ (mph)$

$HVC = 1,\ if\ High\ Visibility\ Crosswalk; 0,\ if\ Basic\ Crosswalk$

$Warning\ Sign = 1,\ if\ Present; 0,\ if\ Not\ Present$

$$P(Y=1) = \frac{exp^{(\alpha + \beta_1 \times OperatingSpeed + \beta_2 \times HVC + \beta_3 \times Warning\ Sign)}}{1 + exp^{(\alpha + \beta_1 \times OperatingSpeed + \beta_2 \times HVC + \beta_3 \times Warning\ Sign)}}$$

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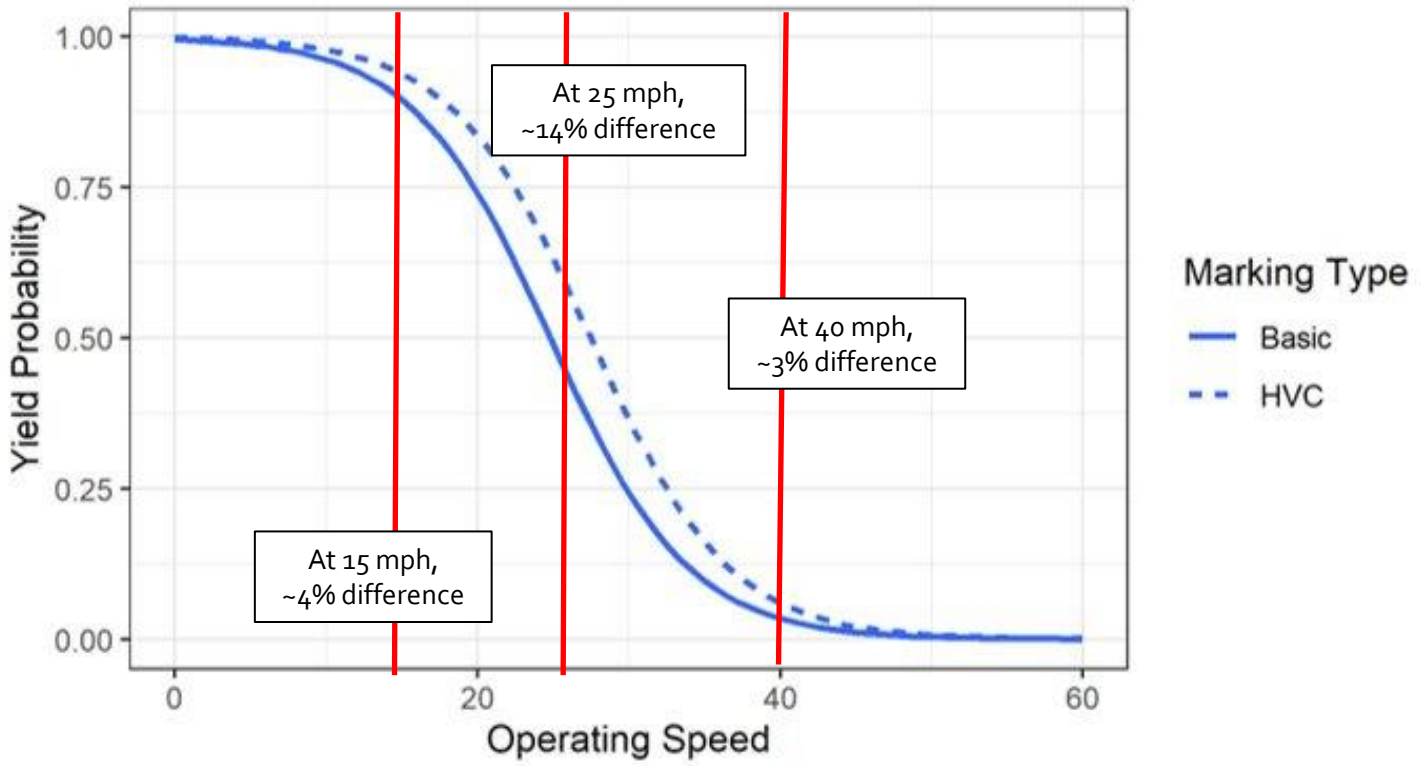
Statistical Modeling Results

- Vehicle speeds have a negative, statistically significant effect on yielding
  - Effect is strong and present in all models
- HVC markings have a positive, statistically significant effect on yielding
  - Effect holds when controlling for speeds and warning sign presence
  - Loses explanatory power:
    - At sites with 85th percentile speed > 30 mph
    - At sites strictly in "grid" context
- Warning signs have a positive and statistically significant effect on yielding

Analysis – Statistical Modeling

- Produced probability plots for all models (form shown below)
  - Shows sensitivity of yielding behavior to marking type and speed



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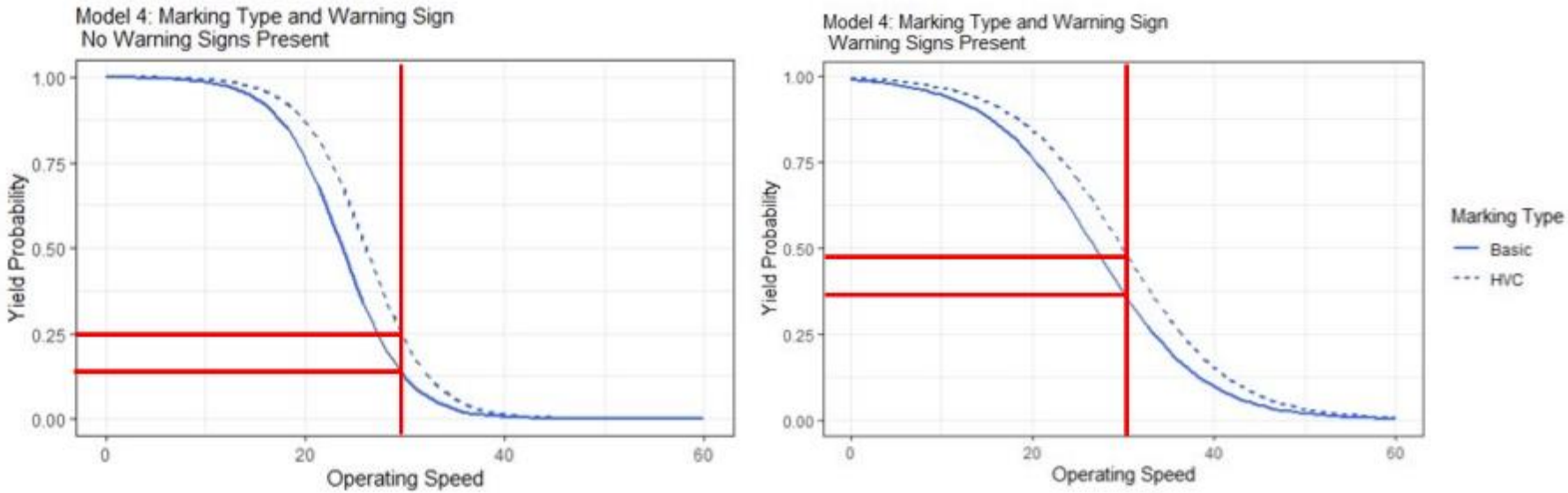
Analysis – Statistical Modeling

Compare Relationship in Presence of Warning Signs



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Major Findings

- Vehicle speeds have a negative, statistically significant effect on yielding
  - Effect is strong and present in all models
- HVC markings have a positive, statistically significant effect on yielding
  - Effect holds when controlling for speeds and warning sign presence
  - Loses explanatory power:
    - At sites with 85th percentile speed > 30 mph
    - At sites strictly in "grid" context
- Warning signs have a positive and statistically significant effect on yielding

Implications for the Guide – 1 of 3

Site Characteristic	HVC Effect Compared to Basic	Implication
Operating Speed		
85th Percentile Speed >30 mph	No Effect	At sites with higher operating speeds (>30 mph), HVCs alone are no more impactful on driver yielding than basic crosswalk markings. Other treatments in addition to an HVC are needed to encourage drivers traveling at higher speeds to yield.
85th Percentile Speed ≤30 mph	Increased Yielding	

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Implications for the Guide – 2 of 3

Site Characteristic	HVC Effect Compared to Basic	Implication
Corridor Context		
Grid Context	No Effect	HVCs are associated with increased driver yielding at sites that serve a collector function. Where already low speeds and other environmental cues do not provide indication of potential pedestrian crossings, HVCs are effective at inducing driver yielding.
Collector Context	Increased Yielding	

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Implications for the Guide – 3 of 3

Site Characteristic	HVC Effect Compared to Basic	Implication
Presence of Warning Signs		
Warning Signs Absent	Increased Yielding	HVC markings provide benefit to induce yielding in the presence of other treatments but appear to have a stronger positive effect on driver yielding in the absence of other treatments (e.g., warning signs).
Warning Signs Present		

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Limitations and Future Research Opportunities

- Narrow range of test sites
  - Low-speed
  - Low-volume
  - Unsignalized intersections
  - No additional treatments
- Tested with white male pedestrian -- research has shown yielding rates related to sociodemographic characteristics
- Tested through vehicle movements only
- Dilution effect?

Q&A

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Discussion

- ⇨ Send us your questions
- ⇨ Follow up with us:
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