NCHRP 17-97

Strategies to Improve Pedestrian Safety at Night

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TRB Safety Performance Mid-Year Meeting - June 28, 2023

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Agenda

- Phase I
  - Literature Review
  - State of the Practice Survey
- Phase II
  - Macro-level Analysis
  - Micro-level Analysis
  - Driver Simulation
- Next Steps
  - Focus Groups
  - Practitioner Interviews
  - Phase III

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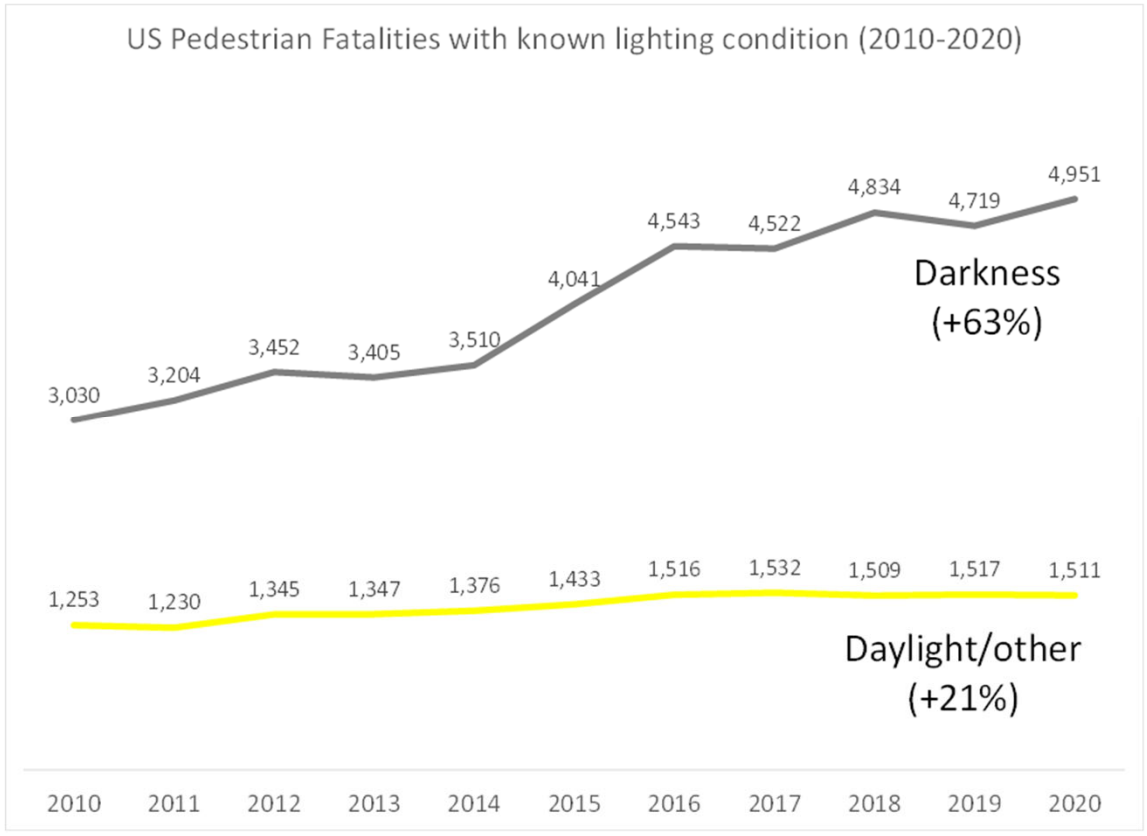

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Themes

- Over-emphasis on pedestrian responsibility for safety at night
- Under-emphasis on driver behavior
- Under-utilization of proven safety countermeasures and the Safe System Approach

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Literature Review

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Findings – Overall

- Darkness increases pedestrian risk
- Problem has been known for 50+ years
  - US pedestrian fatalities are increasingly at night (now 77%).
  - Highest proportions in Southern states.
- Main research emphases
  - Historic: lighting, pedestrian visibility, pedestrian behavior, driver detection
  - More recent: roadway design

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Key references: Sullivan & Flannagan 2002; Ferenchak & Abadi 2021; Tefft, Arnold & Horrey 2021

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Findings – Safe Speeds

- Darkness exacerbates additional risk created by higher speeds
- High speed limits (and faster roadway design speed) appear to be more influential than driver speeding behavior
- Almost no applications of night speed limits (exception = Tucson), and no evaluations of them

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Key references: Sullivan & Flannagan 2001; Zhang & Ma 2014; Sanders, Schneider & Proulx 2022

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Findings – Safe Roads

- High-speed, multilane = high nighttime risk
  - Arterial roadways (similar to daytime, but worse)
- Roadway lighting
  - Generally brighter is better
  - Lighting direction and contrast matter
- PHBs & RRFBs are effective (high yield rates) at night

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Key references: Sullivan & Flannagan 2001; Kim et al. 2010; Long & Ferenchak 2021; Fitzpatrick & Park 2021; Sanders, Schneider & Proulx 2022

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Findings – Safe Vehicles

- Headlights
  - Brighter lights generally improve driver detection
  - Drivers overdrive headlights, underuse high beams
- Glare from opposing vehicles reduces visibility
- Adaptive headlights & automated detection systems have potential to reduce risk
- Interior lighting may reduce driver ability to detect pedestrians

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Key references: Devonshire & Flannagan 2008; Bullough & Skinner 2012; Bhagavathula, Gibbons & Nussbaum 2020

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Findings – Safe Road Users

- Drivers tend to focus directly in front of them at night
- Drivers tend *not* to drive slower at night to compensate for reduced ability to see
- Overrepresented drivers: male, age 16-64
- Alcohol & drug use (drivers & pedestrians)

Key references: Olson et al. 1989; Owens, Wood, & Owens 2007; Moskowitz 2016; Yuan and Dulaski 2017; Sanders, Schneider & Proulx 2022

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Findings – Safe Road Users

- Easier pedestrian detection:
  - White, bright & retroreflective clothing
  - "Biological motion"
- Overrepresented pedestrians: Black, Native American, male, age 16-64
- Other possible high risk: child, wheelchair, unhoused, rural

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Key references: Muttart 2000; Tyrrell et al. 2006; Balk et al. 2008; Uttley & Fotios 2017; Guerra et al. 2020

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State of the Practice Review

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Key Findings

- 64% of respondents identified pedestrian safety at night as a problem (N=76)
- Track a variety of risk factors and trends
- Little known about pedestrian safety in rural areas

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Key Findings

- 20 respondents had implemented policy and program CMs
  - **70%** had conducted a pedestrian visibility campaign
  - **35%** had focused on deterring risky driver behaviors

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Key Findings

- 34 respondents had implemented infrastructure CMs
  - **85%** had pursued street lighting
  - **53%** had installed pedestrian crossing enhancements to increase visibility
  - **35%** had installed pedestrian countermeasures that force drivers to stop
  - **26%** had installed measures to slow traffic

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Phase II: Analysis

Multi-Pronged Approach

- Macro-level Crash Analysis
- Micro-level Crash Analysis
- Pedestrian and Driver Focus Groups
- Driver Simulation
- Practitioner Interviews

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Macro Analysis

Overview

- What factors were associated with pedestrian fatalities in darkness?
- What might have contributed to the change in pedestrian fatalities in darkness during the 2010s?
- Safe System Approach framework

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Method

- Fatality Analysis Reporting System: 2010-20
  - ~60K pedestrian fatalities: darkness (74%), daylight (22%), dawn (1.6%), dusk (2.0%)
- Binomial logistic regression
  - Darkness vs. Daylight/dawn/dusk
  - 2010-2014 vs. 2015-2019
- No exposure data

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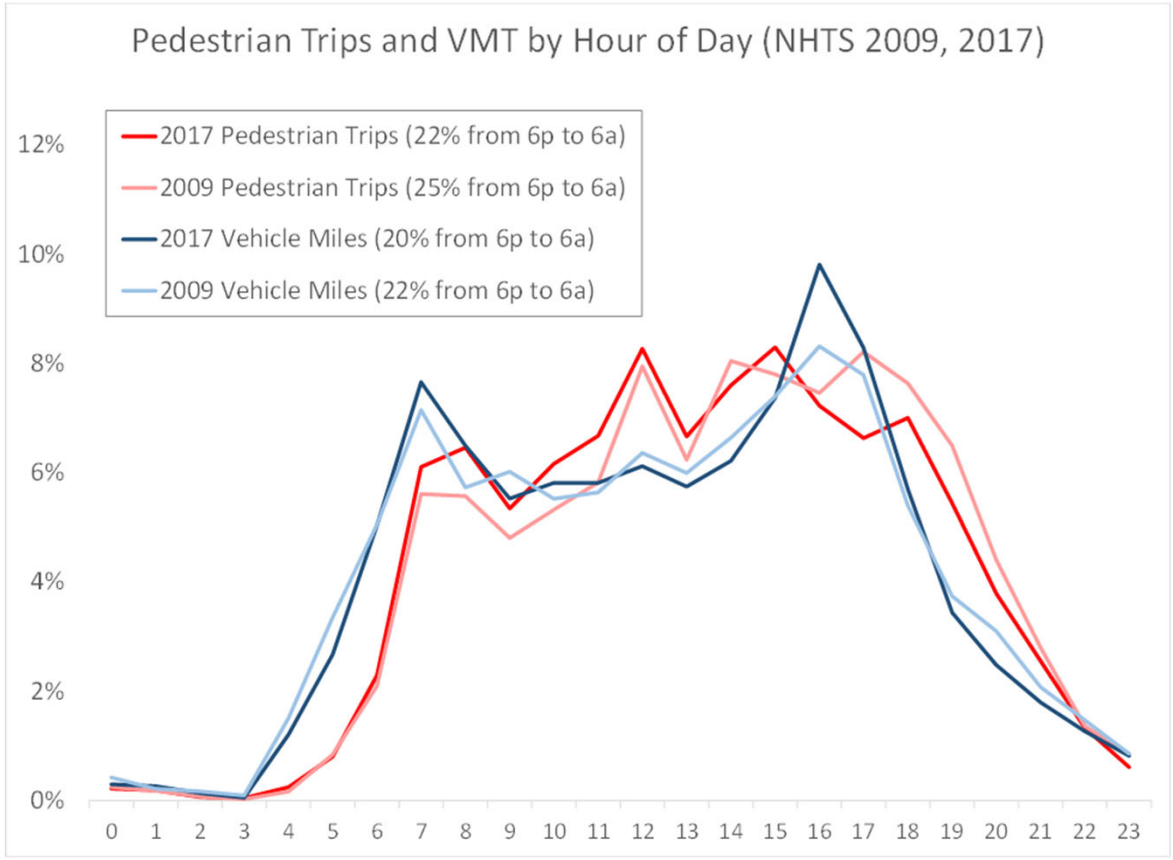

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Four Models (darkness vs. other)

- All pedestrian fatalities
- Non-intersection locations
- Intersection locations
- Intersection locations (2014-2020)
  - Odds ratios >1 indicate positive association
  - *See report for statistical significance

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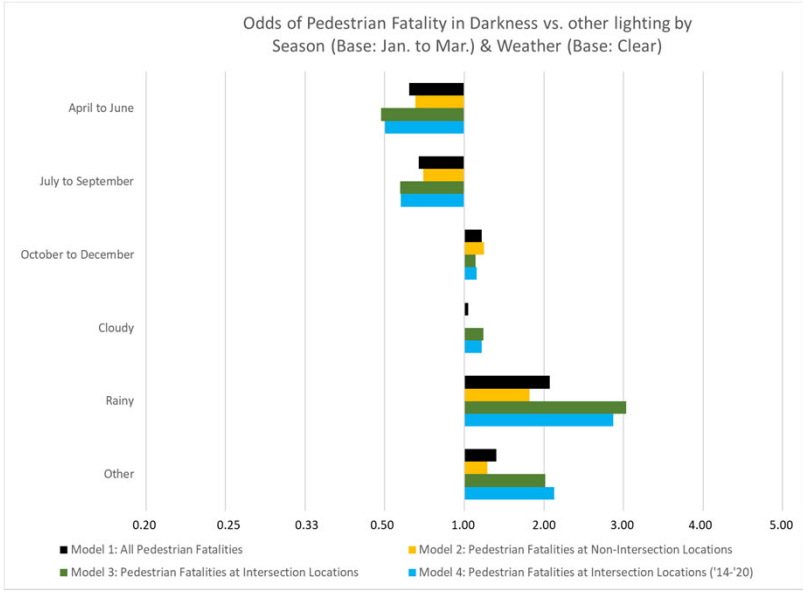
Temporal and Weather

- During 2010s (+)
- October through December (+)
- Rainy conditions (+)
- Friday and Saturday overnight (12:00 pm – 11:59 am) (+)



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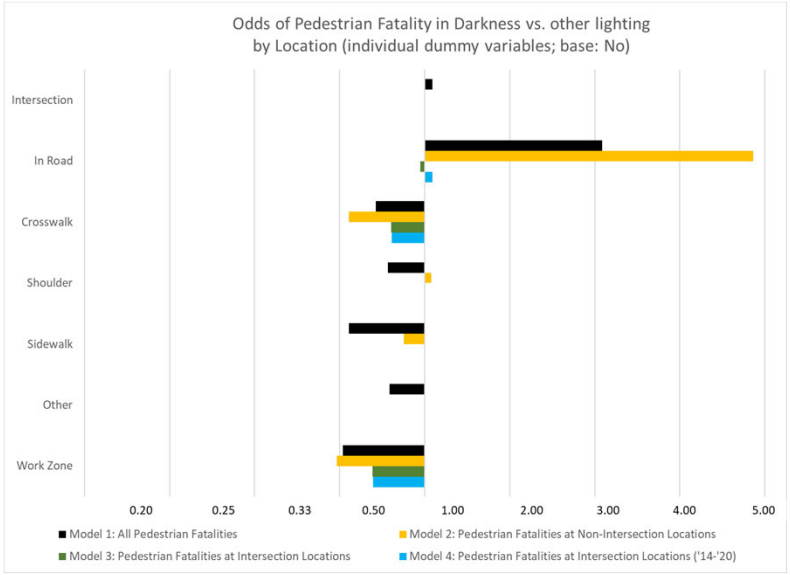
Crash Location

- In roadway (non-intersection) (+)
- Not at marked crosswalks (+)
- Work zone (-)



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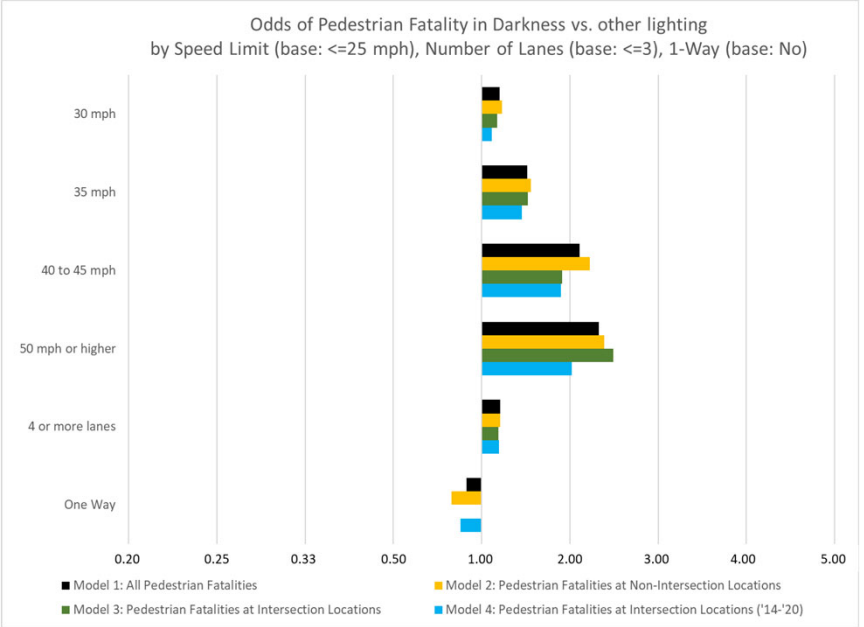
Roadway

- Higher speed limit (+)
- Arterial roadway (non-intersection locations) (+)
- Freeway (+)
- Multilane roadway (+)
- No traffic control (+)



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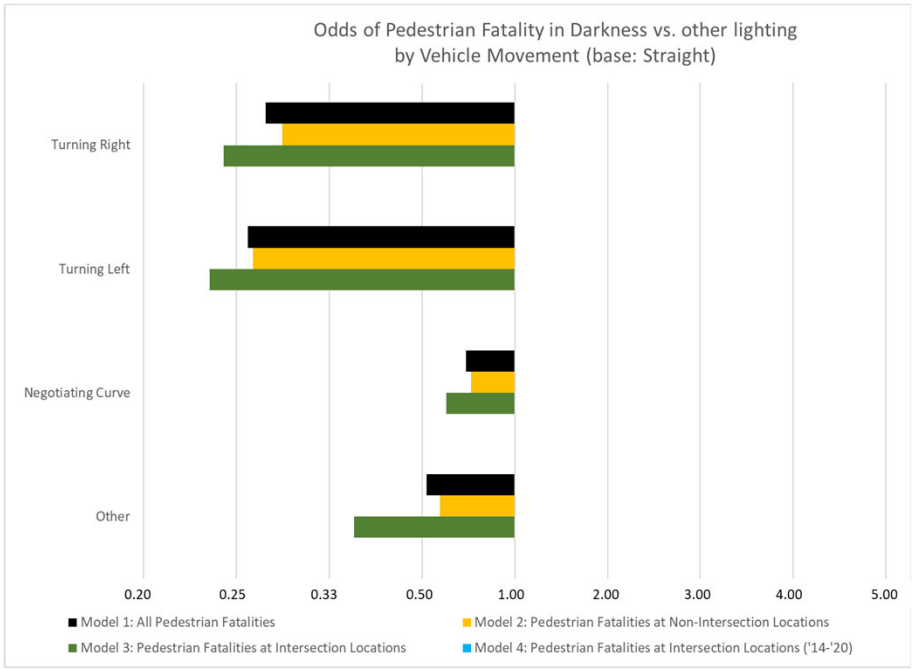
Vehicle & Movement

- Car/sedan more likely (+)
  - Night exposure by vehicle type?
  - Increase in large vehicles over time
- Straight movement (rather than turning) (+)
- *Same direction (+)



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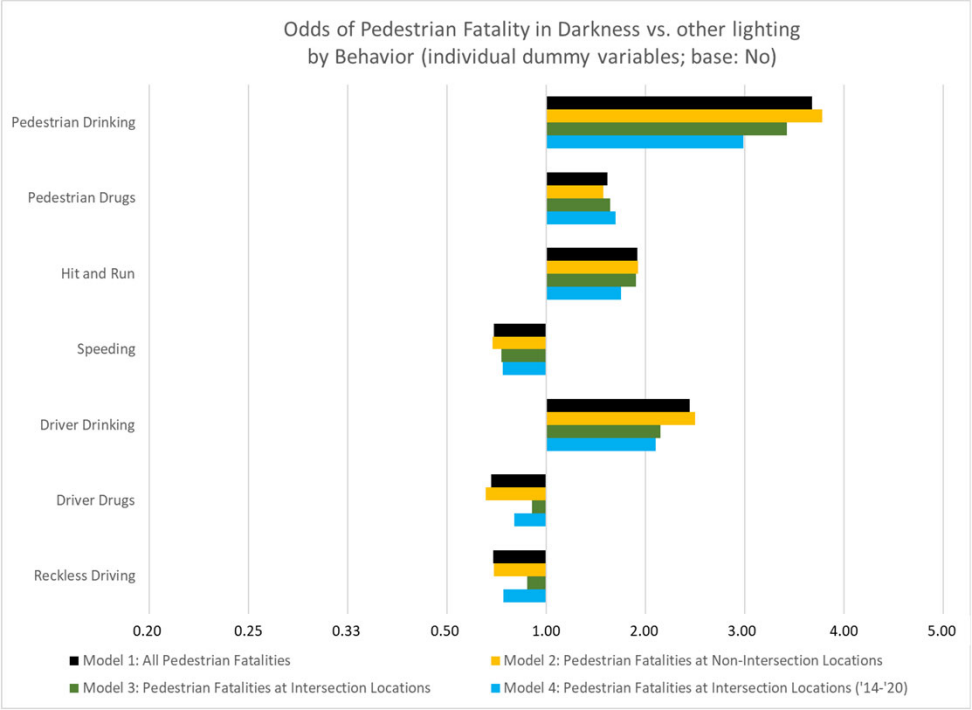
Behavior

- Driver drinking (+)
- Driver hit-and-run (+)
- Pedestrian drinking (+)
- Pedestrian drug use (+)
- Speeding and reckless driving (-)



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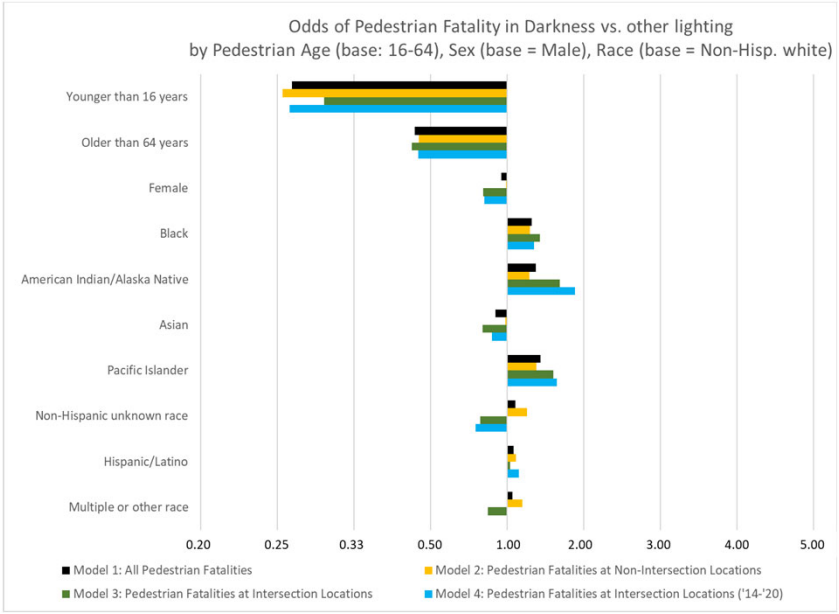
Demographic

- Pedestrians
  - Ages 16-64 (+)
  - Male (+)
  - American Indian/Alaska Native, Black, Pacific Islander, Hispanic/Latino (non-intersection) (+)
- Drivers
  - Ages 15-19 (+)
  - Male (+)
- Exposure influences; other system effects?



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2010-2014 vs. 2015-2019

2010-2014 vs. 2015-2019

- Dependent variable is not likelihood of fatality occurring in darkness; it is likelihood of occurring in 2015-2019
- After controlling for many other factors, **darkness was positively associated with fatalities** in 2015-2019
- Other notable results...

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2010-2014 vs. 2015-2019

- Increases in:
  - Locations on arterial roadways and freeways
  - Pedestrians using drugs
  - One-way roadways
  - Pedestrians who were Hispanic/Latino or Black
- This does **not** mean that these factors are riskier for pedestrians; just that they became rel. more prevalent in 2015-2019

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Micro Analysis

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Micro-Level Crash Analysis

Key questions:

- How do nuanced contextual data change our understanding?
- What previously unrecognized factors emerge as significant correlates of pedestrian safety in darkness?

Method:

- Case-control analysis
- Conditional logistic regression

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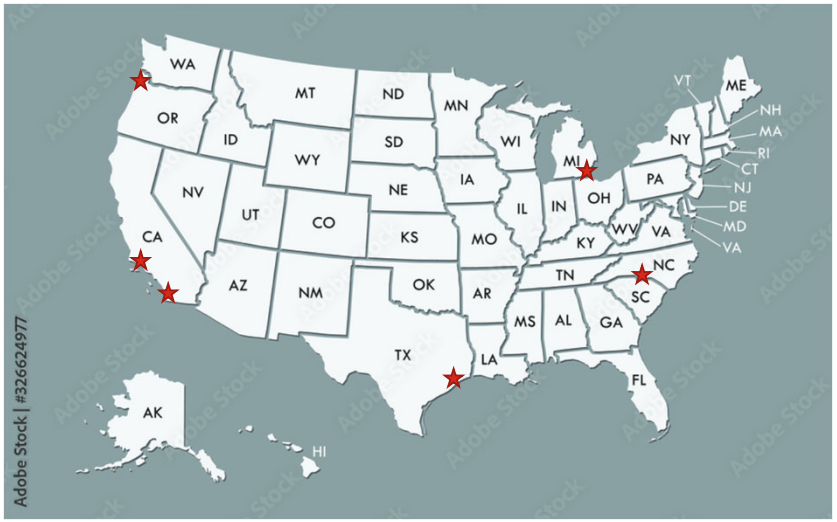
Data Collection & Analysis

- ~100 cases
  - Arterial and collector segments and unsignalized intersections
  - Pedestrian fatality or severe injury in darkness
  - 2015-2019
- ~100 controls
  - All of the above criteria, except no pedestrian KSI
- ~1200 cases and controls across six cities



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Data Collection & Analysis

- Appending
  - Available roadway information from database files, e.g.,
    - Local population characteristics
    - Transit stop proximity
    - EPA SLD data
    - HPMS data
  - Manually-gathered built environment information, e.g.,
    - Presence of street lighting
    - Presence and type of pedestrian countermeasures
    - Presence and completeness of sidewalks

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Driver Simulation

Driver Simulation

- Explore driver eye focus and reaction time
  - At varying speeds
  - In different lighting conditions
  - Relative to different skin colors
  - Relative to various countermeasures
- 24 scenarios

Speed Limit	Pedestrian Skin Color	Counter-measure	Lighting Condition
25	Black	Baseline	Lit
			Dark
		High-vis marked xwalk	Lit
			Dark
		RRFB	Lit
			Dark
	White	Baseline	Lit
			Dark
		High-vis marked xwalk	Lit
			Dark
		RRFB	Lit
			Dark
35	Black	Baseline	Lit
			Dark
		High-vis marked xwalk	Lit
			Dark
		RRFB	Lit
			Dark
	White	Baseline	Lit
			Dark
		High-vis marked xwalk	Lit
			Dark
		RRFB	Lit
			Dark

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Next Steps

Pedestrian & Driver Focus Groups

- Key topics
  - Factors influencing crossing and driving behavior at night
  - Factors influencing acceptable risk
  - Expectations and behavior related to conspicuity
- Planned set-up
  - Four focus groups in each of two cities (total = 8)
  - 6-8 people per focus group

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Practitioner Interviews

- Explore refined problem understanding
- Investigate practices and policies related to analysis findings
- Ground-truth proposed design solutions
- Targeting 10-20 agencies
  - Balance of state and local perspectives

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Data Analysis Schedule

- Data collection & analysis – now through fall 2023
  - Micro analysis finish late summer
  - Driver simulation finish early fall
  - Focus groups finish mid fall
  - Practitioner interviews finish late fall
- Phase III begin early 2024

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