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Recent Research in Pedestrian Crash Prediction and Countermeasures

We are all pedestrians!

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Where We Are

- Safety of pedestrians is of high concern
- Pedestrians are very vulnerable in crashes with vehicles
- Veh-Ped crashes are typically of higher severity
- With aging population and encouragement of active transportation, potential for veh-ped crashes may increase

Where We Are

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- Safety management is rightfully moving towards quantitative methods backed by empirical evidence
- Significant research has been undertaken into predicting vehicle crashes and effectiveness of countermeasures
- AASHTO's Highway Safety Manual is a result of much of this research
- Analysis methods and knowledge mostly related to vehicle-vehicle or single-vehicle crashes

Where We Are

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- Knowledge for veh-ped crashes is limited
- Relative rarity of veh-ped crashes is a factor
- Popularity of Vision Zero type plans increasing
- With higher severity, veh-ped crashes need to be a focus area
- More research into developing quantitative methods for veh-ped crashes is needed

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Recent Efforts

- Study 1 – Development of Safety Performance Functions (SPFs) for vehicle-pedestrian crashes in Region of Waterloo
- Study 2 – Development of Crash Modification Factors (CMFs) for vehicle-pedestrian crashes

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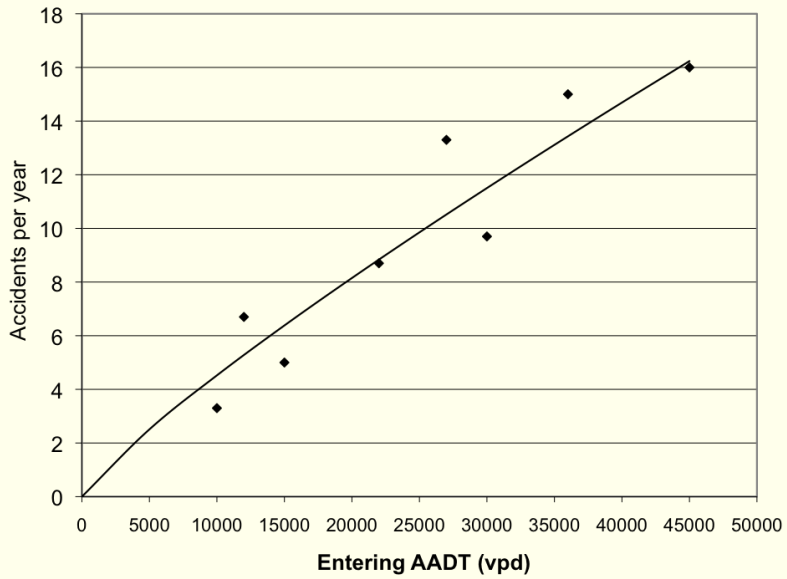
Veh-Ped Crash SPFs for Region of Waterloo

- SPF is an equation that predicts the average crash frequency at a site

Crashes per year $= \exp^{(-5.5368)} \text{AADT}^{0.6622}$



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Veh-Ped Crash SPFs for Region of Waterloo

- SPFs are applied in various safety management tasks
  - Methods for ranking sites for improvement
  - Selection of countermeasures
  - Economic appraisal
  - Evaluation of countermeasures

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Veh-Ped Crash SPFs for Region of Waterloo

- Study led by CIMA+
- Objective was to develop SPFs for crashes for segments and intersections in Waterloo
- Included SPFs for veh-ped and veh-bike crashes
- Sought to relate the number of crashes expected to a site's traffic volume and other road characteristics

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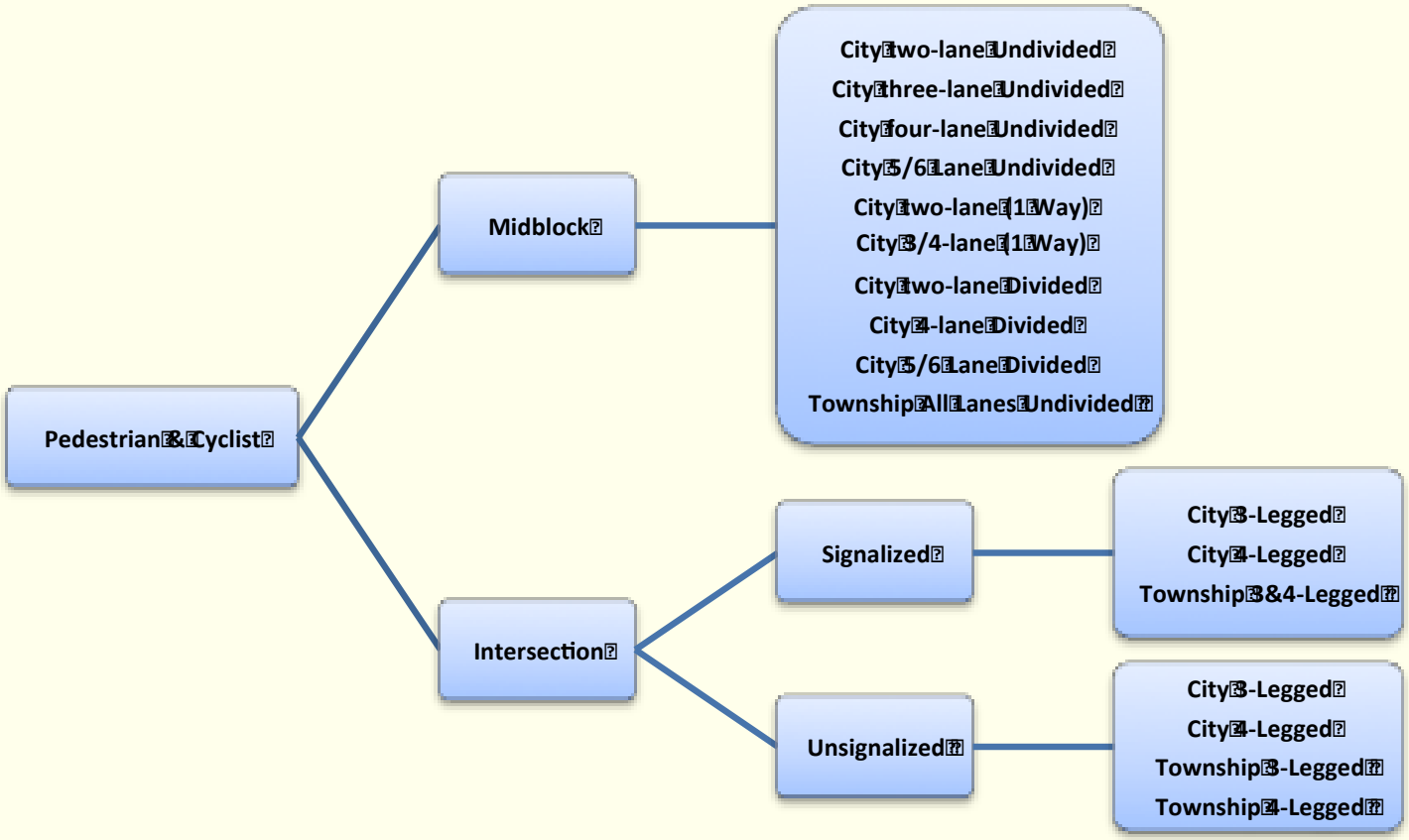
Veh-Ped Crash SPFs for Region of Waterloo



Veh-Ped Crash SPFs for Region of Waterloo

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Waterloo Segment SPFs

$$E(Y)=exp^{-11.0672}\times F^{0.7056}\times L^{0.2901}\times exp^{-0.6933\times LANES+0.4845\times MEDIAN+0.7335\times LOC}$$

Where,

E(Y): Predicted number of vehicle-pedestrian crashes per year;

F: average annual daily traffic;

L: segment length in kilometres;

LANES: 1 if a 2 or 3 lane roadway; 0 if greater than 3 lanes;

MEDIAN: 1 if no median present; 0 if median present; and,

LOC: 1 if a city location; 0 if a township location.

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Waterloo Signalized Intersection SPFs

$$E(Y)=exp^{-7.8958}\times Ftot^{0.4473}\times exp^{-0.5970\times LEGS+1.8684\times LOC}$$

Where,

E(Y): Predicted number of vehicle-pedestrian crashes per year;

F_{tot}: Total entering volume of intersection per day*;*

LEGS: 1 if a 3 leg intersection; 0 if 4 leg intersection, and

LOC: 1 if a city location; 0 if a township location.

Veh-Ped Crash SPFs for Region of Waterloo

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Waterloo Unsignalized Intersection SPFs

$$E(Y)=exp^{-12.7878}\times Fmaj^{0.5429}\times Fmin^{0.4111}\times exp^{-1.3915\times LEGS+1.3939\times LOC}$$

Where,

E(Y): Predicted number of vehicle-pedestrian crashes per year;

F_{maj}: Total entering volume of major road per day*;*

F_{min}: Total entering volume of minor road per day*;*

LEGS: 1 if a 3 leg intersection; 0 if 4 leg intersection, and

LOC: 1 if a city location; 0 if a township location.

Development of Veh-Ped CMFs

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NCHRP 17-56 [Active]

Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments

Project Data	
Funds:	$500,000
Staff Responsibility:	Lori L. Sundstrom
Research Agency:	University of North Carolina - Chapel Hill
Principal Investigator:	Charles Zegeer
Effective Date:	11/1/2012
Completion Date:	10/31/2014

BACKGROUND

There is considerable uncertainty and confusion surrounding the use of pedestrian crossing treatments at uncontrolled locations. Research shows that marking crosswalks without maki improvements is associated with higher pedestrian crash rates under certain roadway configurations and operating characteristics (Zegeer, C.H., Stewart, J.R., Huang, H.H., and Lagerway *Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations,* Federal Highway Administration, 2001). However, failing to provide crossing opportunities or over-improving an a undesirable solutions. Where a crosswalk alone might lead to increased pedestrian crashes, Zegeer et al. recommend enhanced crossing treatments, noting that "pedestrian crossing problem should be routinely identified, and appropriate solutions should be selected to improve pedestrian safety and access."While several studies have examined pedestrian safety at uncontro locations, robust crash modification factors (CMFs) are generally lacking. Research is needed to enable state and local transportation agencies to quantify the safety benefits of pedestr treatments and to incorporate these treatments into their safety programs.

OBJECTIVES

The objectives of this research are to (1) quantify the relationships between pedestrian safety and crossing treatments at uncontrolled locations (excluding roundabouts) and (2) develop CMFs b and severity for (a) unsignalized pedestrian crosswalk signs and pavement markings, including advance yield markings; (b) high-intensity activated crosswalk (HAWK) signals; (c) rectangular r beacons; (d) pedestrian refuge areas; (e) curb extensions; (f) in-pavement warning lights; and (g) high-visibility crosswalk marking patterns. The quality of data used should facilitate inclusion into the AASHTO Highway Safety Manual.

Development of Veh-Ped CMFs

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- A CMF is a multiplier representing expected change in crashes due to treatment
- CMFs can be used to estimate safety benefit when implemented at a site

4-legged signalized intersection on rural multilane road; major road AADT of 30,000 and minor road AADT of 5,000; no turn lanes

Consider adding a left-turn lane on one approach of major road.

CMF = 0.82

Expected crashes without left-turn lane = 6.3

Expected crashes with left-turn lane = (6.3)(0.82) = 5.2

Development of Veh-Ped CMFs

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- CMFs developed for pedestrian crossing treatments at unsignalized crossings
- Data represents multiple cities in U.S.
- Treatments include:
  - Rectangular Rapid Flashing Beacons (RRFBs)
  - Pedestrian Hybrid Beacons (PHBs)
  - Pedestrian Refuge Islands
  - Advance Yield or Stop Markings or Signs

Development of Veh-Ped CMFs

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RRFB

Development of Veh-Ped CMFs

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PHB (HAWK)

Development of Veh-Ped CMFs

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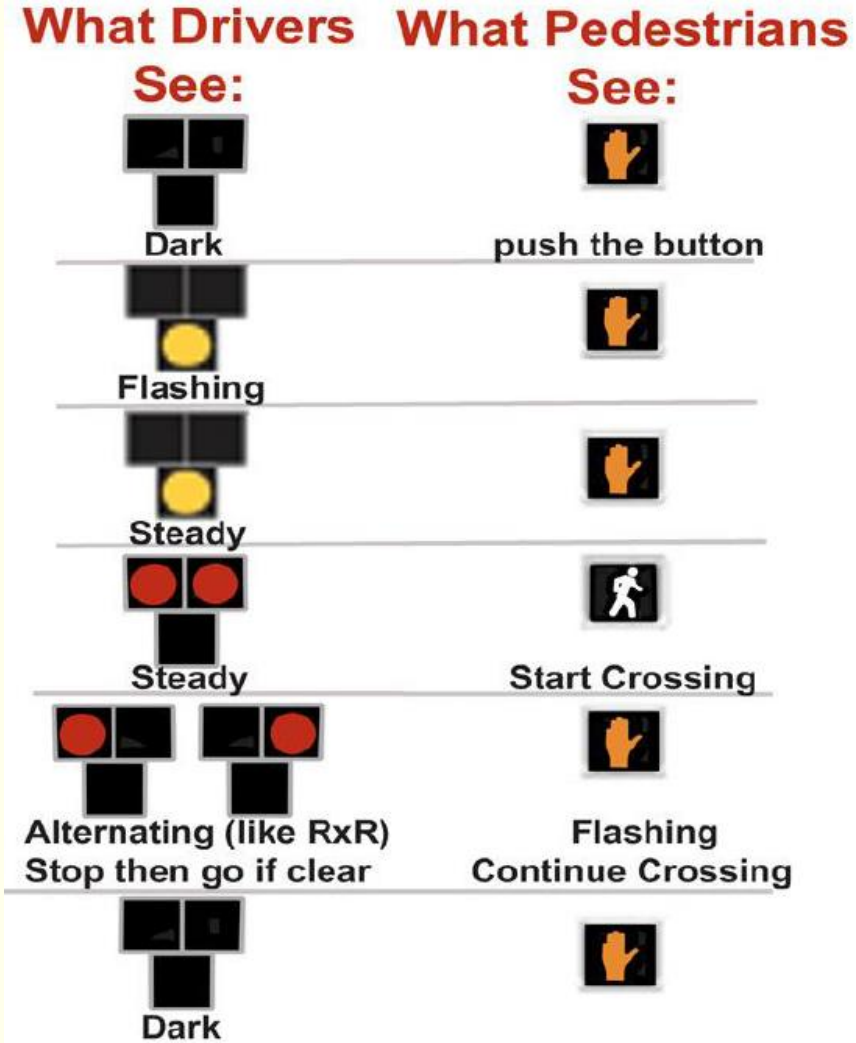

PHB (HAWK) (High intensity Activated crossWalK)

Development of Veh-Ped CMFs

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Refuge Islands

Development of Veh-Ped CMFs

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Advance Stop

Advance Yield

Development of Veh-Ped CMFs

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- 975 Treatment and Comparison sites collected from 14 cities
- Most sites on multi-lane streets
- Treatment, geometric, traffic and pedestrian exposure characteristics collected
- Results based on cross-sectional regression models
- Some limited EB before-after results confirmed logic of results

Development of Veh-Ped CMFs

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$$PEDCRASH/yr = exp^{-7.1959+City-0.3930*PHB\ Presence-0.5695*AreaType} AADT^{0.3802} PEDAADT^{0.3141}$$

Where,

AADT = total AADT on roadway being crossed

PEDAADT = total pedestrian AADT for midblock or intersection

AreaType = 1 if Suburban; 0 if Urban

City = represents an intercept term specific for each city

PHB Presence = 1 if present; 0 if not present

$CMF = exp^{-0.3930} = 0.675$

Development of Veh-Ped CMFs

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Treatment	Crash Type	Recommended CMF	
		Estimate	Standard Error
Refuge Islands	Pedestrian	0.685	0.183
	Total	0.742	0.071
	All Injury	0.714	0.082
	RE+SS	0.741	0.093
	RE+SS Injury	0.722	0.106
Advance Yield/Stop	Pedestrian	0.750	0.230
	Total	0.886	0.065
	RE+SS	0.800	0.076
PHB	Pedestrian	0.675	0.192
PHB+Advance Yield/Stop	Pedestrian	0.432	0.134
	Total	0.820	0.078
	RE+SS	0.876	0.111
RRFB	Pedestrian	0.526	0.377

Conclusions

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- Reducing veh-ped crashes is a high priority
- Considering the higher severity and Vision-Zero type goals is especially true
- Quantitative measures needed for veh-ped safety management tasks, including SPFs and CMFs
- Rarity of crash type presents challenges
- Recent research is beginning to fill the knowledge gaps