Driver Yielding at Midblock Crossings Based on Roadway, Traffic, and Crosswalk Characteristics

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Mid-Content Transportation Research Symposium

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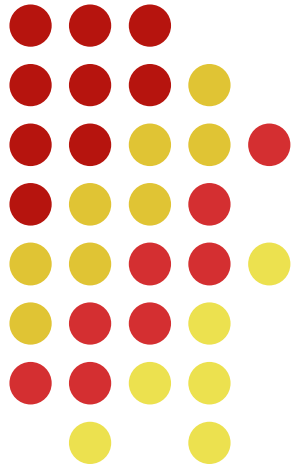

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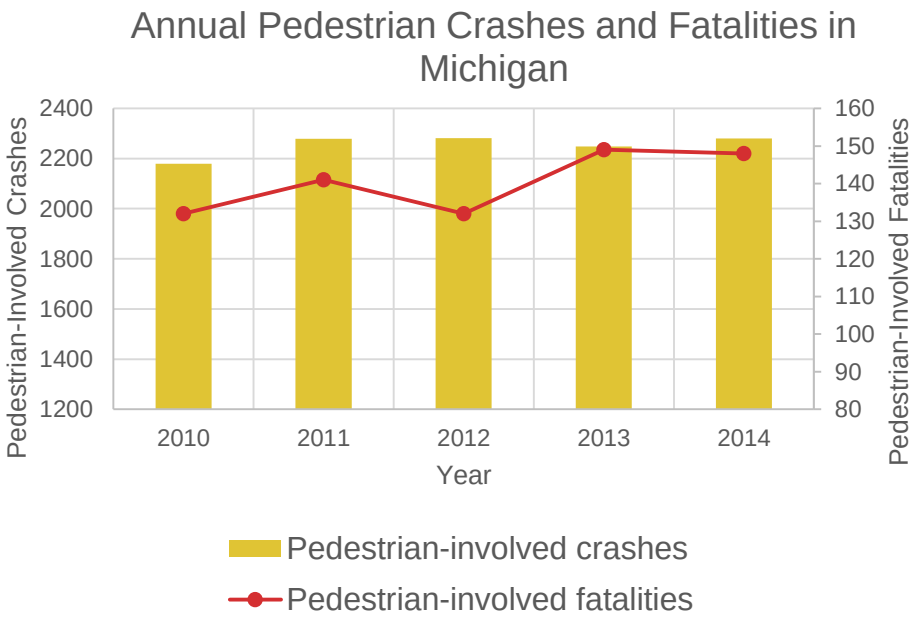
Overview

- Introduction
- Study Methods
  - Field Evaluation
  - Statistical Analysis
- Results
- Conclusions

Background: Crash Facts

- Pedestrian Crash Facts
  - ~4,800 pedestrian fatalities in US annually (steady)
  - ~2,275 pedestrian crashes in Michigan annually (steady)
  - 130 – 150 pedestrian fatalities annually (increasing)



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Pedestrian Crashes and Fatalities by Location Type

Type of Location	Crash Statistics, 2011 - 2015		
	Number of Crashes	Number of Fatalities	Fatalities as Percent of All Crashes
Non Intersection – No Signal	4,998	484	9.7%
Non Intersection – Signal	540	32	5.9%
Intersection – No Control	1,237	71	5.7%
Intersection – Stop or Yield	872	13	1.5%
Intersection – Signal	2,291	66	2.9%
TOTAL	9,938	666	6.7%

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Research Objectives

- Field studies were performed at low-speed midblock crossings across Michigan to determine factors that influence pedestrian safety. This included analysis of:
  - Driver yielding compliance to crossing pedestrians
  - Vehicle/ped conflicts
  - Ped and bike traffic crashes

Methods: Site Selection

- Low speed (25-mph) sites were selected in Detroit, East Lansing and Kalamazoo near university campuses
  - Three of the five counties with the greatest pedestrian crash rates (normalized by population) in Michigan

County	Pedestrian Crashes (2010-2014)	County population (2013)	Pedestrian Crashes per 10,000 Capita	Ranking
Wayne	3531	1,775,273	19.9	1
Ingham	430	282,234	15.2	2
Kent	884	621,700	14.2	3
Washtenaw	500	354,240	14.1	4
Kalamazoo	345	256,725	13.4	5

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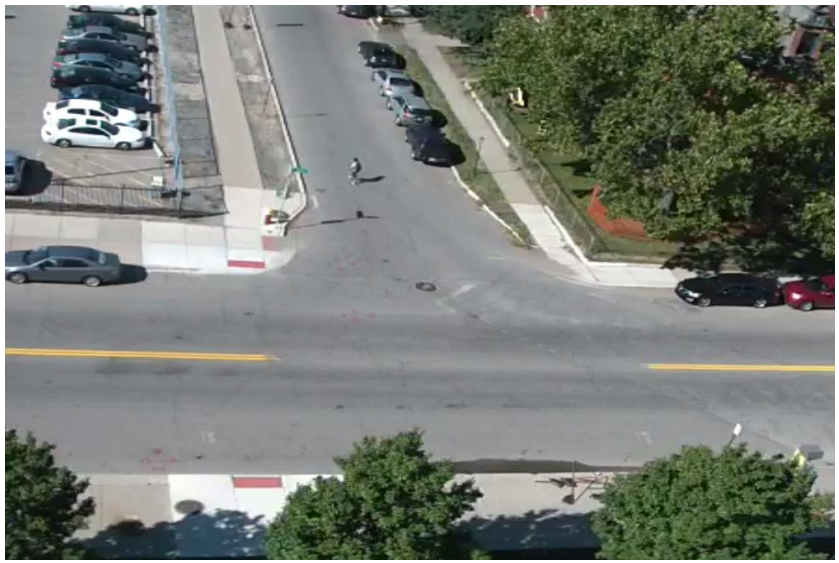
Methods: Site Selection

- 40 midblock locations
- Sites were selected to provide a broad range of:
  - Vehicle and pedestrian volumes
  - Geometric characteristics
  - Crossing facility types
  - Traffic control devices



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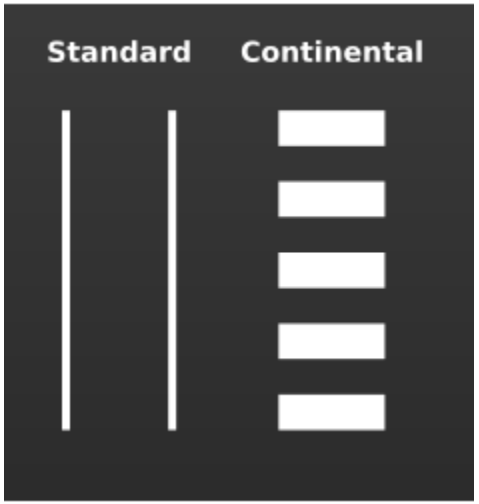
Methods: Site Characteristics



Pedestrian Hybrid Beacon

RRFB

In-Street R1-6 Sign

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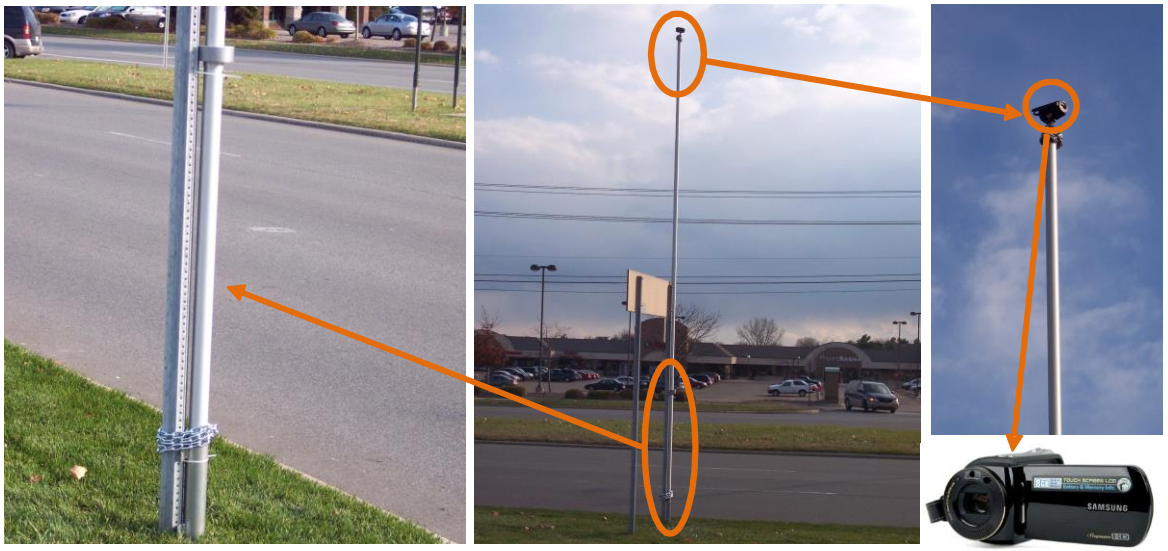
Methods: Site Characteristics

Factor	Level or Unit	Mean	Std. Dev.
Hourly vehicle volume	veh/hr	554.72	376.67
Hourly pedestrian volume	pedestrians/hr	85.95	101.36
Hourly bicycle volume	bicycles/hr	9.16	7.93
Hourly vehicle volume	<500 vehicles	0.53	0.50
	500-1000 vehicles	0.43	0.50
	>1000 vehicles	0.04	0.20
Hourly pedestrian volume	<50 pedestrians	0.53	0.50
	≥50 pedestrians	0.47	0.50
Hourly bicycle volume	<5 bicycles	0.38	0.49
	5-15 bicycles	0.34	0.47
	>15 bicycles	0.28	0.45
Position of vehicle in lane	Near lane	0.69	0.46
	Center or far lanes	0.31	0.46
Position of vehicle in queue	Unqueued vehicle	0.66	0.47
	Queue leader	0.21	0.41
	Queued vehicle	0.13	0.34
Driver action	yield	0.62	0.49
	did not yield	0.38	0.49

Factor	Level or Unit	Mean	Std. Dev.
Crosswalk length	ft	48.89	22.78
Through lanes	number of	3.02	1.20
Crosswalk treatment	Unmarked	0.20	0.40
	Standard	0.07	0.25
	Continental	0.58	0.49
	In-street R1-6 sign	0.08	0.27
	PHB	0.04	0.20
	RRFB	0.03	0.16
Crosswalk length	<50 ft	0.48	0.50
	50-69 ft	0.36	0.48
	≥70 ft	0.16	0.37
Number of thru lanes	2 lanes	0.54	0.50
	3-4 lanes	0.33	0.47
	≥5 lanes	0.13	0.34
Roadway cross-section	Two-lane	0.54	0.50
	Undivided multilane	0.08	0.27
	Divided multilane	0.39	0.49
Bike lanes	Present	0.44	0.50
	Not present	0.56	0.50

Methods: Video Recording of Pedestrian/Vehicle Behavior

- Elevated HD cameras used to record volume and behavioral data
- In most cases, video recorded on weekdays (9 AM to 4 PM)



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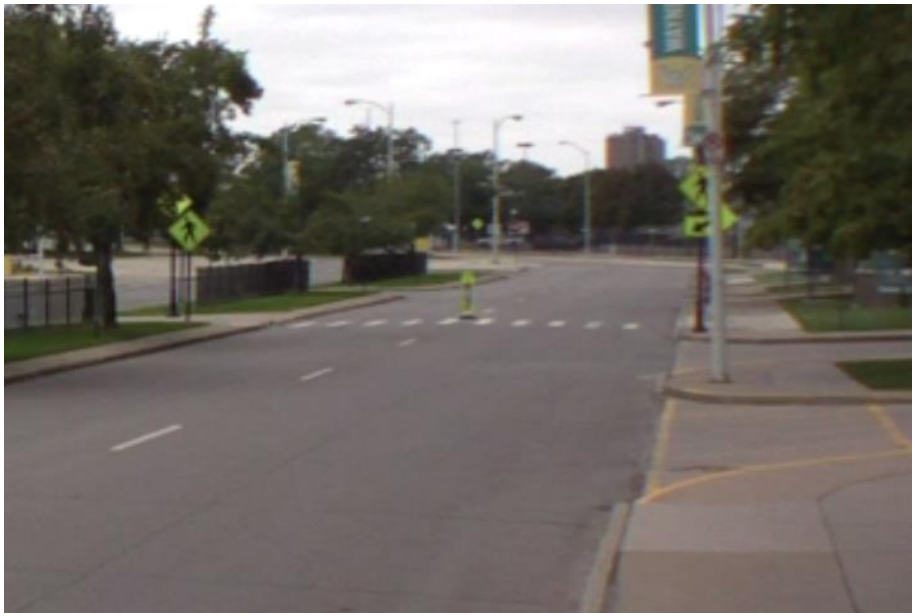
Methods: Video Review/Assessment

- Video data reduced by trained technicians
- Volume counts (vehicles, peds) every 15 min
- Assessed yielding compliance during staged pedestrian crossing events



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Methods: Staged Pedestrian Crossings

- Pedestrian indicated intention to cross by standing at the curb or roadway edge with one foot in crosswalk while facing oncoming traffic
- Pedestrian continued crossing when motorist in the nearest lane had begun to yield
- Maintained eye contact with motorist at all times
- Procedure was repeated from opposite direction at same crosswalk

Methods: Logistic Regression

- Driver yielding compliance is a binary (yes/no) outcome, well-suited for logistic regression:

$$\ln\left[\frac{p_i}{1-p_i}\right] = \beta' X_i,$$

  - Where:
  - p_i is the probability of a driver yielding to pedestrian *i*,
  - β' is a vector of estimable parameters,
  - X_i is a vector of predictor variables (e.g., crosswalk treatment, pedestrian/vehicular volumes, etc.)

Results: Driver Yielding Compliance Logistic Regression Model

- Type of crosswalk treatment had strongest association with yielding compliance
- Crossing width was also positively correlated with compliance
- Ped volumes had positive correlation, while vehicle volume had negative correlation

Variable	Level or Unit	β	Std. Error	Odds Ratio
Constant Term	N/A	-1.566	0.483	N/A
Crosswalk Treatment*	Unmarked	baseline		
	Standard	1.316	0.386	3.73
	Continental	1.790	0.240	5.99
	In-Street R1-6 Sign	3.864	0.515	47.68
	PHB	4.156	1.045	63.80
Crossing Width	ft	0.021	0.009	1.02
Cross-Section	Undivided	baseline		
	Divided	-0.608	0.156	0.55
Vehicle Volume	veh/hr	-0.001	0.000	0.99
Pedestrian Volume	<50 ped/hr	baseline		
	≥50 ped/hr	0.545	0.165	1.72
Vehicle Lane Position	Near (curb) lane	baseline		
	Other lane	1.213	0.174	3.36
Vehicle Position Queue	Unqueued vehicle	baseline		
	Queue leader	0.673	0.177	1.96
	Queued vehicle	-0.421	0.239	0.66

N = 1,245; Nagelkerke R2 = 0.348

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Results: Driver Yielding Compliance by Lane and Roadway Cross-Section

Cross-Section	Near Lane	Outer Lanes	Overall
2-Lane	56%	74%	61%
Multilane Undivided	88%	95%	91%
Multilane Divided	47%	78%	57%

- Yielding compliance was greater for lanes other than the near (curb) lane regardless of roadway cross-section
- 2-lane and multilane divided roadways showed poorer yielding compliance than multilane undivided roadways

Results: Driver Yielding Compliance by Lane and Crosswalk Treatment

Crosswalk Treatment	Near Lane	Far Lanes	Overall
Unmarked	20%	44%	29%
Standard	35%	96%	50%
Continental	61%	83%	66%
R 1-6 (Single)	93%	97%	95%
PHB (Hawk)	96%	100%	98%
RRFB	100%	100%	100%

- Yielding compliance improves substantially when crosswalk markings are used
- Additional improvements are observed with RRFBs, PHBs, or in-street R1-6 signs
  - Results insensitive to lane
  - Compliance rates show improvements compared to prior Michigan studies

Conclusions

- Driver yielding improved with the visibility of the crosswalk treatment
- Continental provided better response than standard crosswalk
- High-visibility treatments were significantly more effective at eliciting drivers to yield
- R1-6 signs performed comparably to hybrid beacon and RRFB

Thanks!!!
Comments or Questions?

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