



MILWAUEE PEDESTRIAN PLAN

Driver Yielding Rates at Uncontrolled Intersection Crosswalks
Prepared for the City of Milwaukee Pedestrian Master Plan

FINAL DRAFT | April 2019

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Acknowledgments

City of Milwaukee Department of Public Works

- Jeff Polenske, Commissioner
- Samir Amin, City Engineer
- Laura Daniels, Director of Operations
- Rollin Bertran, Engineer in Charge
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Funding Partners

- US DOT Federal Highway Administration
- Wisconsin Department of Transportation

Background

This paper was prepared in support of the Milwaukee Pedestrian Plan. It contains previously compiled information about driver yielding rates in the City of Milwaukee as well as new research conducted specifically for this Plan.

Information contained in this document is for planning purposes and should not be used for final design of any project. All results, recommendations, concept drawings, and commentary contained herein are based on limited data and information, and on existing conditions that are subject to change.

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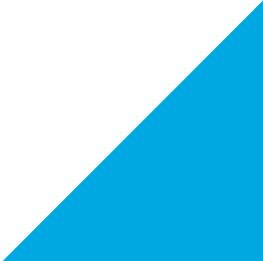
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Background

During fall 2016 and fall 2017, students from the University of Wisconsin-Milwaukee observed whether or not drivers yielded to pedestrians at 40 uncontrolled intersection crosswalks in the City of Milwaukee. Uncontrolled intersections are locations where the main street does not have a traffic signal or stop sign. However, state law requires drivers to yield the right-of-way to pedestrians who have entered a crosswalk even without a traffic signal or stop sign present.¹ Students recorded information about each intersection and observed pedestrian and driver behaviors. This report summarizes driver yielding rates at different locations. Ultimately, the results can help inform education, enforcement, and engineering treatments to increase driver yielding and improve pedestrian safety at uncontrolled crosswalks.

Study Locations

20 intersections were observed in fall 2016 and 20 intersections in fall 2017. All 20 intersections in 2016 were along two-lane arterial and collector streets. These 20 intersections were centrally located in the city (all within approximately three miles of Downtown Milwaukee). The initial focus was on central Milwaukee because it tends to have moderate to high levels of pedestrian activity due to its relatively high development density, streets through commercial areas, the central business district, and high-frequency bus lines. Relatively high pedestrian volumes helped provide a sufficient sample of pedestrian crossings to observe during the short field data collection period at each site. These constraints were relaxed in fall 2017 to increase geographic coverage and the variety of street characteristics at study sites. For example, the fall 2017 sites included streets with features like more than two lanes, medians, and curb extensions. Two multi-use trail crossing locations were also added. Table 1 summarizes the characteristics of all 40 study intersections.

Table 1. Milwaukee Driver Yielding Study Intersection Characteristics (continued on next two pages)

Study Intersection	Major street Annualized Average Daily Traffic (AADT)	Major street posted speed limit (miles per hour)	Major street number of lanes	Major street crossing distance (average crosswalk curb-to-curb distance) (feet)	Major street median or crossing island (1=Yes, 0=No)	Major street curb extension (1=Yes, 0=No)	Both major street crosswalks marked (1=Yes, 0=No)	Major street crosswalk sign (MUTCD Code)	Distance to on-street parking (average distance for mainline approaches) (feet)	Near-side bus stop at the intersection (1=Yes, 0=No)	Adjacent commercial land use (1=Yes, 0=No)	Intersection had 2+ reported crashes in 5-year period (1=Yes, 0=No) ¹
W Capitol Dr & N 25th St	44,000	30	4	91	1	0	1	S1-1	N/A	1	1	0
W Capitol Dr & N 54th St	32,600	30	6	90	1	0	1	None	N/A	1	1	0
W Lisbon Ave & N 52nd St	25,800	30	4	60	0	0	0	S1-1	N/A	1	1	0
W Oklahoma Ave & S 25th St	22,000	30	4	68	1	0	1	S1-1	50	1	0	1
S Layton Bl & W Mineral St	20,800	25	4	70	1	0	1	None	100	0	0	0
W Fond Du Lac Ave & N 36th St	20,100	30	4	122	1	0	1	None	75	0	1	0
W North Ave & N 36th St	19,200	30	2	51	0	0	1	None	20	0	1	0
W National Ave & S 25th St	17,900	30	4	62	1	0	1	None	50	1	0	1
W North Ave & N 1st St	16,400	30	2	52	0	0	1	None	200	1	0	0
E North Ave & N Palmer St	16,400	30	2	51	0	0	1	W11-2	100	0	0	1
S Cesar Chavez Dr & W Walker St	14,900	30	2	47	0	0	1	None	5	0	1	0
N 35th St & W Garfield Ave	14,500	30	2	56	0	0	1	None	500	1	1	1
W Lincoln Ave & S 15th Pl	14,200	30	2	55	0	0	0	None	20	0	1	1
E Hampton Ave & Oak Leaf Trail	13,800	30	2	64	1	0	N/A	W11-1	N/A	0	0	0
N 35th St & W Meinecke Ave	13,800	30	2	51	0	0	1	W11-2	400	0	1	0
E North Ave & N Cramer St	13,400	30	2	39	0	1	0	None	40	0	1	0

Study Intersection	Major street Annualized Average Daily Traffic (AADT)	Major street posted speed limit (miles per hour)	Major street number of lanes	Major street crossing distance (average crosswalk curb-to-curb distance) (feet)	Major street median or crossing island (1=Yes, 0=No)	Major street curb extension (1=Yes, 0=No)	Both major street crosswalks marked (1=Yes, 0=No)	Major street crosswalk sign (MUTCD Code)	Distance to on-street parking (average distance for mainline approaches) (feet)	Near-side bus stop at the intersection (1=Yes, 0=No)	Adjacent commercial land use (1=Yes, 0=No)	Intersection had 2+ reported crashes in 5-year period (1=Yes, 0=No) ¹
W North Ave & N 44th St	13,200	30	2	56	0	0	0	None	25	0	1	1
N King Dr & W Chambers St	13,200	30	4	60	1	0	1	None	100	1	1	0
W Lincoln Ave & S 17th St	13,000	30	2	51	0	0	0	None	25	0	0	0
W Atkinson Ave & N 11th St	12,000	30	2	76	0	0	1	None	55	0	1	0
N 27th St & W Hadley St	12,000	30	2	50	0	0	0	None	75	1	1	1
W North Ave & N 45th St	11,000	30	2	56	0	0	1	None	200	1	1	0
E Brady St & N Arlington Pl (east)	10,600	25	2	34	0	1	1	W11-2	25	1	1	0
E Brady St & N Franklin Pl	10,100	25	2	40	0	0	1	W11-2	18	0	1	1
N Holton St & E Meinecke Ave	10,100	30	2	42	0	1	1	W11-2	40	1	0	0
W Center St & N 5th St	10,000	30	2	54	0	0	0	None	80	1	1	1
W Becher St & S 7th St	9,600	30	2	49	0	0	0	W11-2	300	0	0	1
W Center St & N 9th St	9,100	30	2	59	0	0	0	W11-2	400	0	0	0
W Mitchell St & S 8th St	9,000	25	2	56	0	0	1	None	25	0	1	0
S Kinnickinnic Ave & E Homer St	9,000	30	2	60	0	0	1	S1-1	15	0	1	0
W Mitchell St & S 10th St	8,400	25	2	54	0	0	1	None	30	0	1	0
W Wells St & N 15th St	8,000	30	2	50	1	0	1	W11-2	20	0	0	0

Study Intersection	Major street Annualized Average Daily Traffic (AADT)	Major street posted speed limit (miles per hour)	Major street number of lanes	Major street crossing distance (average crosswalk curb-to-curb distance) (feet)	Major street median or crossing island (1=Yes, 0=No)	Major street curb extension (1=Yes, 0=No)	Both major street crosswalks marked (1=Yes, 0=No)	Major street crosswalk sign (MUTCD Code)	Distance to on-street parking (average distance for mainline approaches) (feet)	Near-side bus stop at the intersection (1=Yes, 0=No)	Adjacent commercial land use (1=Yes, 0=No)	Intersection had 2+ reported crashes in 5-year period (1=Yes, 0=No) ¹
N Downer Ave & E Park Pl	7,200	30	2	50	0	0	1	W11-2	30	1	1	1
N 20th St & W Meinecke Ave	6,800	30	2	50	0	0	1	None	120	0	0	0
W Becher St & S 15th St	6,600	30	2	46	0	0	0	None	200	0	0	0
W Mitchell St & S 12th St	6,300	25	2	51	0	0	1	None	30	0	1	1
W Canal St & Hank Aaron Trail	6,000	30	4	79	1	0	N/A	W11-15	N/A	0	0	0
N Downer Ave & E Linnwood Ave	5,100	30	2	58	0	0	0	None	200	1	0	0
N 20th St & W Melvina St	4,900	30	2	49	0	0	0	None	90	0	0	1
E State St & N Cass St	2,900	30	2	51	0	0	1	None	20	0	0	0

1.) Intersection experienced at least two reported pedestrian crashes during the five-year period, 2010-2014.

Overall, the 40 locations included:

- 6 main streets with traffic volumes higher than 20,000 AADT and 14 with traffic volumes lower than 10,000 AADT.
- 34 main streets with posted speed limits of 30 MPH and 6 with speed limits of 25 MPH.
- 31 main streets with two lanes (one lane in each direction) and 9 with four or more lanes.
- 9 main street crossings wider than 60 feet and 8 narrower than 50 feet.
- 10 main street crossings with medians or median crossing islands.
- 3 main street crossings with curb extensions.
- 26 main streets with both crosswalks (near side and far side) marked.
- 9 main street crossings with standard crosswalk warning signs (MUTCD W11-2 signs), 4 main street crossings with school crosswalk warning signs (MUTCD S1-1 signs), and 2 main street crossings with bicycle or trail crosswalk warning signs.
- 35 main streets with on-street parking, though some had parked vehicles closer to the crosswalk than others.
- 15 intersections with near-side bus stops and no intersections with far-side bus stops.
- 23 intersections with commercial land uses on at least one adjacent property.
- 13 intersections with two or more daytime pedestrian crashes reported during 2010-2014.

Observation Method

Student data collectors observed driver and pedestrian behaviors for two hours during weekday evening travel periods (Monday through Thursday, typically between 4 pm and 7 pm). Importantly, they observed unstaged pedestrian crossings—pedestrians and drivers of all types of motor vehicles interacting naturally in public—rather than having members of the research team stage pedestrian crossings when automobiles approached. Pedestrian crossings were only observed for the mainline street crosswalks (crossing the major street) and were only considered when pedestrians started within the crosswalk lines. Pedestrians were observed when crossing either from the driver’s left or right.²

The study focused on drivers who were traveling straight on the mainline street (not turning to or from cross streets). After a pedestrian arrived at the crossing, data collectors observed the first driver approaching with an opportunity to yield. Drivers were considered as having an opportunity to yield if they were further than a minimum distance upstream of the crosswalk when the pedestrian arrived at the curb.³ The method described by Van Houten et al. (2013) was used to calculate the minimum safe stopping distance.⁴ For example, based on a driver reaction time of 2.5 seconds, the posted speed limit in feet per second, and a conservative deceleration rate of 11.2 feet (3.41 m) per second, the safe stopping distance for vehicles traveling at 30 mph (48 km/h) on a flat grade is 196 feet (59.7 m).

The field data collection instructions for the driver yielding observations is provided in Appendix A.

Results

Overall, we observed 1,207 pedestrian crossings across the 40 study sites, and drivers had an opportunity to yield for 825 of these crossings. Drivers yielded 173 times out of these 825 opportunities (21 percent driver yielding rate). Note that this overall yielding rate gives greater weight to intersections with more driver yielding opportunities. Table 2 shows the driver yielding rates for all 40 study intersections, sorted from highest to lowest. The intersection-level comparisons below only consider the 32 locations with 10 or more driver yielding opportunities.

The highest observed rate of driver yielding was 61 percent at E Brady St & N Arlington Pl (east intersection). Of the 32 intersections with 10 or more driver yielding opportunities, 10 had no drivers yield during the two-hour observation period (0 percent driver yielding rate). The average of all 32 intersection-level yielding rates was 17 percent. This overall yielding rate gives equal weight to all intersections.

Geographic Distribution of Driver Yielding Rates

Figure 1 shows the geographic distribution of driver yielding rates across the 32 study intersections with 10 or more driver yielding opportunities. Overall, study locations on commercial corridors with only two travel lanes and buildings close to the street (e.g., Brady St, Downer Ave, Mitchell St, and parts of North Ave and Lincoln Ave) tended to have higher yielding rates than other locations. Broadly, there tended to be higher driver yielding rates closer to Milwaukee's downtown core and East Side neighborhoods, with most locations in these areas having yielding rates between 25 percent and 60 percent.

Figure 1. Driver Yielding Rates at 32 Milwaukee Study Intersections

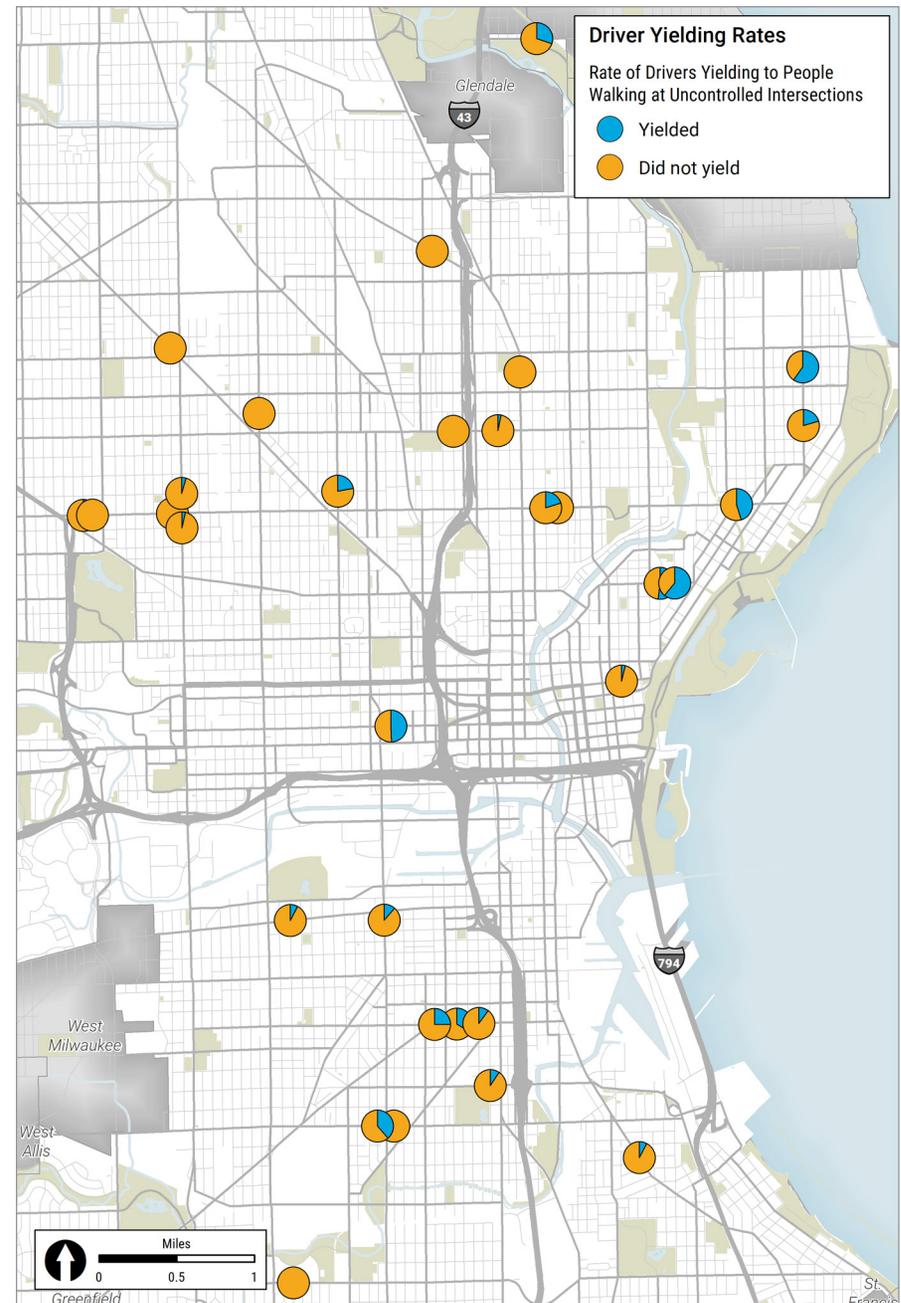


Table 2. Driver Yielding Rates at 40 Milwaukee Uncontrolled Intersections (continued on next page)

Study intersection	Field data collection date	Field data collection time period	Major street Annualized Average Daily Traffic (AADT)	Major street posted speed limit (miles per hour)	Major street number of lanes	Major street crossing distance (average crosswalk curb-to-curb distance) (feet)	Pedestrian crossings	Driver yielding opportunities	Number of drivers who yielded	Percent of drivers who yielded
E Brady St & N Arlington Pl (east)	10/5/2017	4:45-6:45 pm	10,600	25	2	34	82	56	34	61%
N Downer Ave & E Linnwood Ave	8/30/2016	5:00-7:00 pm	5,100	30	2	58	15	10	6	60%
E Brady St & N Franklin Pl	8/10/2016	5:00-7:00 pm	10,100	25	2	40	38	27	14	52%
W Wells St & N 15 th St	10/18/2017	4:20-6:20 pm	8,000	30	2	50	174	97	48	49%
E North Ave & N Cramer St	10/12/2017	4:20-6:20 pm	13,400	30	2	39	54	40	18	45%
W Lincoln Ave & S 17 th St	10/18/2016	5:00-7:00 pm	13,000	30	2	51	19	13	5	38%
W Mitchell St & S 10 th St	9/1/2016	5:00-7:00 pm	8,400	25	2	54	20	18	6	33%
E Hampton Ave & Oak Leaf Trail	10/12/2017	4:00-6:00 pm	13,800	30	2	64	14	10	3	30%
W North Ave & N 45 th St	9/6/2016	4:30-6:30 pm	11,000	30	2	56	30	27	8	30%
W Mitchell St & S 12 th St	8/24/2016	5:00-7:00 pm	6,300	25	2	51	18	16	4	25%
N 20 th St & W Meinecke Ave	10/25/2016	4:30-6:30 pm	6,800	30	2	50	23	18	4	22%
N Downer Ave & E Park Pl	8/11/2016	5:00-7:00 pm	7,200	30	2	50	58	29	6	21%
W North Ave & N 1 st St	11/1/2016	4:30-6:30 pm	16,400	30	2	52	14	10	2	20%
S Layton Bl & W Mineral St	9/11/2017	4:05-6:05 pm	20,800	25	4	70	8	6	1	17%
N Holton St & E Meinecke Ave	8/30/2017	5:00-7:00 pm	10,100	30	2	42	9	6	1	17%
S Cesar Chavez Dr & W Walker St	9/12/2017	5:00-7:00 pm	14,900	30	2	47	32	26	3	12%
W Mitchell St & S 8 th St	10/19/2016	4:30-6:30 pm	9,000	25	2	56	16	10	1	10%
W Becher St & S 7 th St	8/29/2016	5:00-7:00 pm	9,600	30	2	49	24	11	1	9%
W National Ave & S 25 th St	9/28/2017	4:25-6:25 pm	17,900	30	4	62	47	39	3	8%
S Kinnickinnic Ave & E Homer St	9/19/2017	4:00-6:00 pm	9,000	30	2	60	20	13	1	8%
N 35 th St & W Meinecke Ave	9/13/2016	4:45-6:45 pm	13,800	30	2	51	26	22	1	5%
N 35 th St & W Garfield Ave	8/24/2016	5:15-7:15 pm	14,500	30	2	56	31	28	1	4%

Study intersection	Field data collection date	Field data collection time period	Major street Annualized Average Daily Traffic (AADT)	Major street posted speed limit (miles per hour)	Major street number of lanes	Major street crossing distance (average crosswalk curb-to-curb distance) (feet)	Pedestrian crossings	Driver yielding opportunities	Number of drivers who yielded	Percent of drivers who yielded
E State St & N Cass St	9/13/2017	4:15-6:15 pm	2,900	30	2	51	108	26	1	4%
W Center St & N 5th St	8/16/2016	5:00-7:00 pm	10,000	30	2	54	32	29	1	3%
W Capitol Dr & N 25th St	10/25/2017	4:00-6:00 pm	44,000	30	4	91	7	7	0	0%
W Capitol Dr & N 54th St	8/31/2017	4:30-6:30 pm	32,600	30	6	90	5	4	0	0%
W Oklahoma Ave & S 25th St	10/3/2017	4:00-6:00 pm	22,000	30	4	68	18	15	0	0%
W Fond Du Lac Ave & N 36th St	9/25/2017	4:45-6:45 pm	20,100	30	4	122	13	12	0	0%
W North Ave & N 36th St	9/27/2017	4:05-6:05 pm	19,200	30	2	51	24	15	0	0%
E North Ave & N Palmer St	8/15/2016	5:00-7:00 pm	16,400	30	2	51	17	17	0	0%
W Lincoln Ave & S 15th St Pl	8/25/2016	5:00-7:00 pm	14,200	30	2	55	38	34	0	0%
W North Ave & N 44th St	8/18/2016	5:15-7:15 pm	13,200	30	2	56	17	16	0	0%
N King Dr & W Chambers St	8/23/2017	4:55-6:55 pm	13,200	30	4	60	24	17	0	0%
W Atkinson Ave & N 11th St	9/5/2017	4:10-6:10 pm	12,000	30	2	76	47	42	0	0%
N 27th St & W Hadley St	9/14/2017	4:35-6:35 pm	12,000	30	2	50	43	28	0	0%
W Center St & N 9th St	8/31/2016	4:30-6:30 pm	9,100	30	2	59	16	16	0	0%
W Becher St & S 15th St	10/11/2016	4:30-6:30 pm	6,600	30	2	46	15	7	0	0%
W Canal St & Hank Aaron Trail	8/24/2017	4:35-6:35 pm	6,000	30	4	79	5	2	0	0%
N 20th St & W Melvina St	8/17/2016	5:00-7:00 pm	4,900	30	2	49	6	6	0	0%
W Lisbon Ave & N 52nd St	10/25/2017	4:15-6:15 pm	25,800	30	4	60	0	0	0	N/A
Totals							1207	825	173	21%

Average of intersection-level yielding rates from the 32 sites with 10 or more driver yielding opportunities 17%

Roadway Crossing Characteristics

The 32 intersections with 10 or more driver yielding opportunities were analyzed to explore specific street design attributes associated with driver yielding behavior. These were single-variable comparisons, so they did not control for interactions between multiple factors. Still, they provide important insights. In general, streets with higher traffic volumes (Figure 2), longer crossing distances (Figure 3), more lanes (Figure 4), and higher posted speed limits (Figure 5) have lower driver yielding rates. There were only two intersections with curb extensions, but they had much higher driver yielding rates (average of 53 percent) than intersections without curb extensions (average of 15 percent). Crosswalk signs are also associated with higher driver yielding rates.

Figure 3. Main Street Crossing Distance & Intersection Yielding Rates

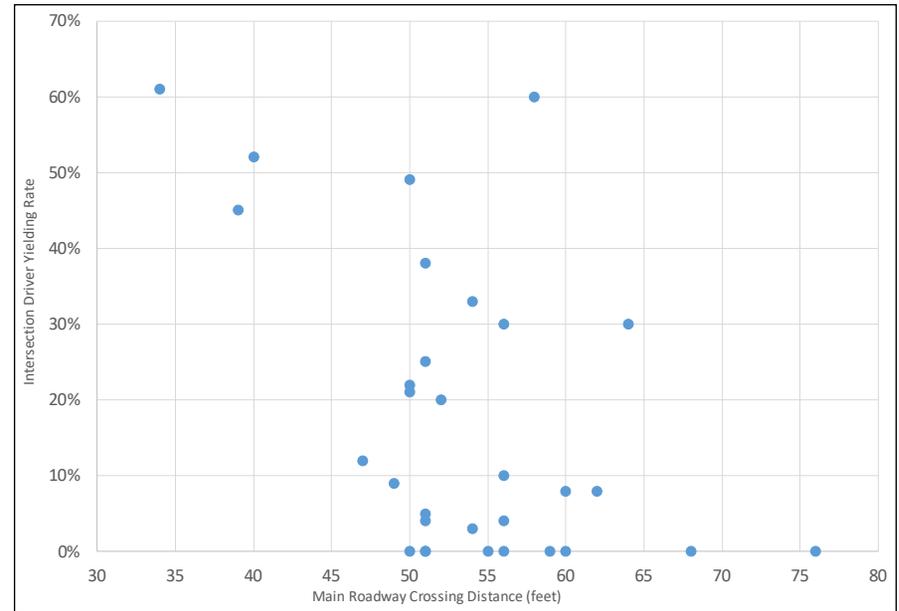


Figure 2. Main Street AADT & Intersection Yielding Rates

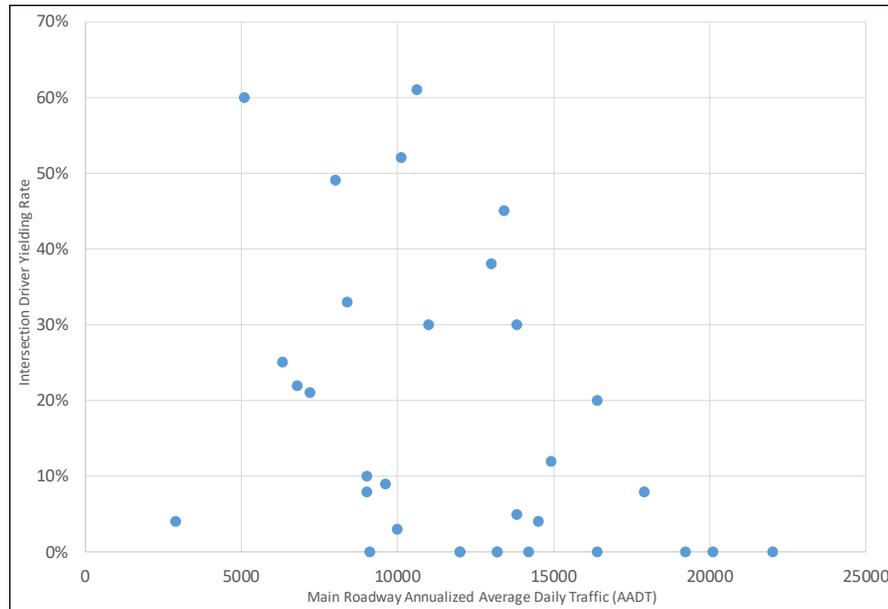
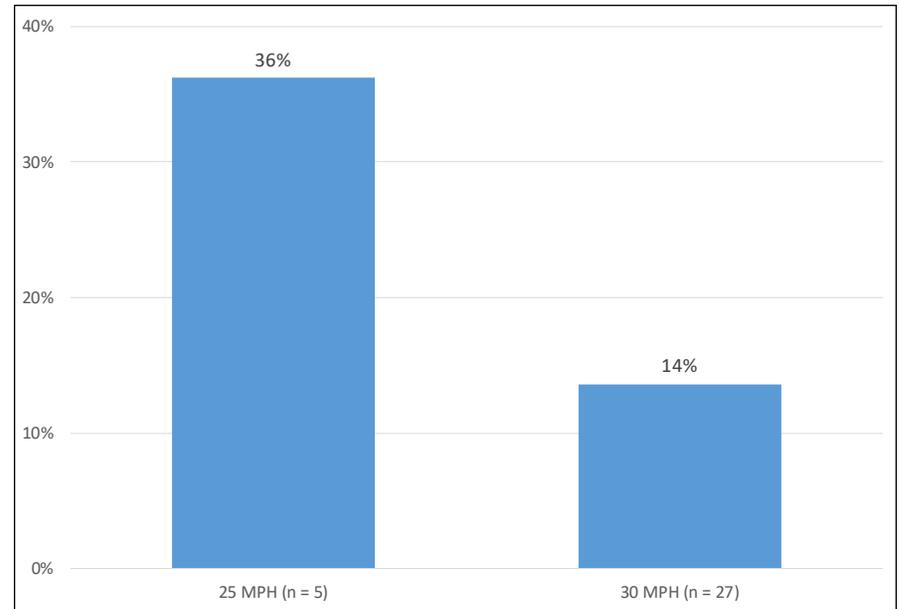


Figure 4. Main Street Posted Speed Limit & Average Intersection Yielding Rate



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Importantly, streets with lower driver yielding rates were associated with more daytime pedestrian crashes (Figure 6).⁵ This result suggests that increasing driver yielding may improve pedestrian safety.

This single-variable analysis did not find notable differences in driver yielding between intersections with versus without medians and intersections with one versus two marked crosswalks. However, these treatments could still show a positive relationship with driver yielding within a larger sample of intersections or in particular urban contexts. In addition, these features are likely to have other benefits for pedestrian comfort and safety. For example, the Federal Highway Administration (FHWA) has identified median islands as a Safe Transportation for Every Pedestrian (STEP) proven safety countermeasure for uncontrolled crossing locations.⁶ Other STEP countermeasures (e.g., reduce travel lanes, improve nighttime lighting) should also be considered for uncontrolled crossings like those used in this study.

The 364 driver yielding opportunities observed at 20 intersections in fall 2016 were analyzed individually as a part of a Wisconsin Department of Transportation study to identify which street crossing features, pedestrian and bicyclist demographic characteristics, and pedestrian behaviors were related to higher probabilities of drivers yielding to pedestrians.^{7,8} The study used binary logistic regression to control for multiple factors simultaneously. Statistically-significant street crossing features from that study are consistent with those identified above: drivers were more likely to yield at locations with lower traffic volumes, lower posted speed limits, and shorter crossing distances.

Figure 5. Main Street Number of Lanes & Average Intersection Yielding Rate

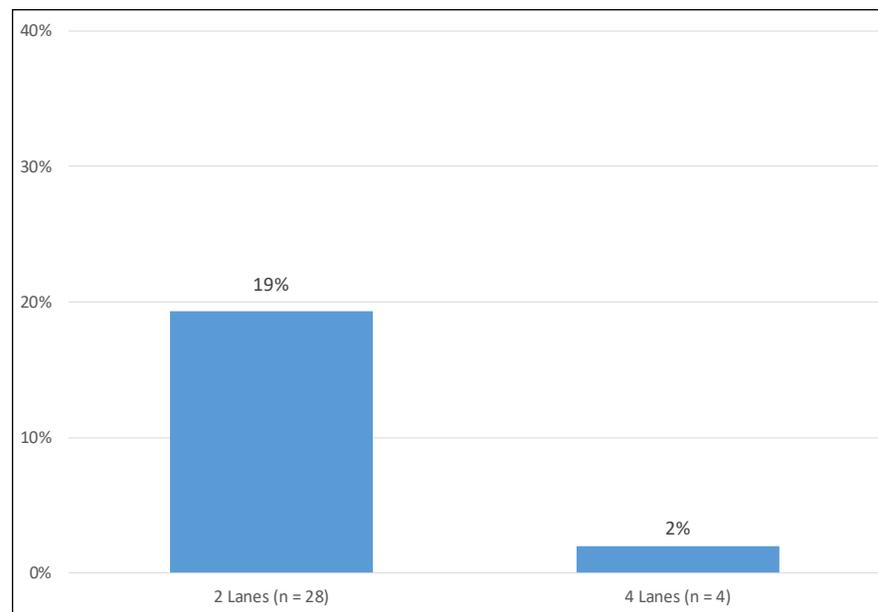
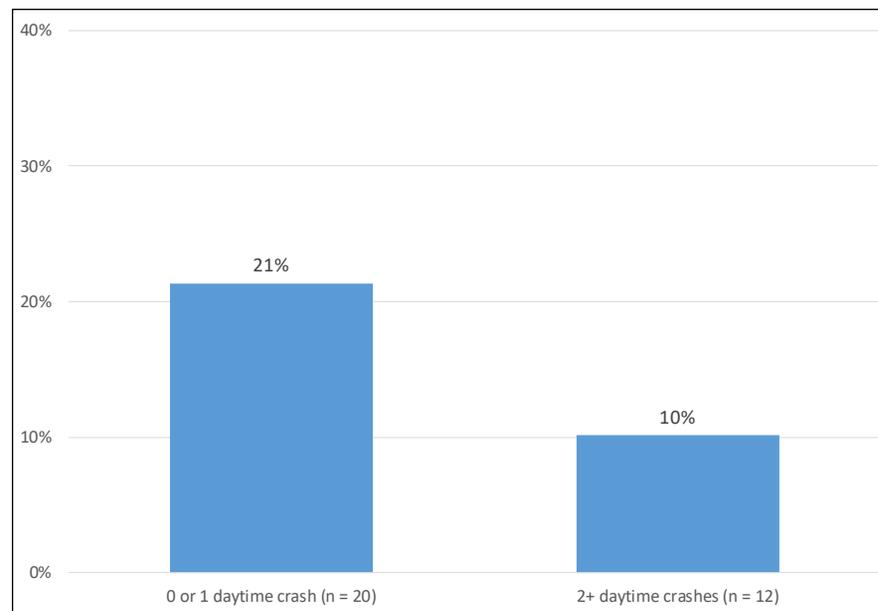


Figure 6. Daytime Pedestrian Crashes & Average Intersection Yielding Rate



Demographic and Behavior Characteristics

The fall 2016 Wisconsin Department of Transportation study on pedestrian yielding in various locations throughout the state also showed that pedestrian behavior was an important factor in if drivers yield to them. Drivers at the 20 Milwaukee intersections were more likely to yield to pedestrians who stood in the street and indicated their intent to cross more assertively.⁹ In addition, detailed video observations at one crosswalk in Milwaukee (E Kenwood Blvd & N Farwell St) and one crosswalk in Madison (W Dayton St & N Charter St) showed that 71 percent (48 of 68) of drivers yielded to pedestrians exhibiting high assertiveness, 30 percent (25 of 82) yielded to pedestrians exhibiting moderate assertiveness, and 3 percent (1 of 29) yielded to pedestrians exhibiting low assertiveness.¹⁰ These findings suggest that strategies to increase driver yielding should address pedestrian assertiveness along with street crossing design. Driver behaviors may influence social norms for pedestrian crossing behavior,¹¹ so strategies to change pedestrian behavior should recognize the broader context of driver and pedestrian interactions within the community.

Conclusion

Observed rates of motorists yielding to pedestrians at uncontrolled intersections in the City of Milwaukee are low, despite a state statute requiring them to do so. This study showed that the more lanes a street has and the higher the posted speed limit, the less likely motorists are to yield to pedestrians at uncontrolled intersections. Actions to reduce traffic speeds and the number of travel lanes, where feasible, may improve motorist yielding and, subsequently, pedestrian safety. The FHWA is promoting the following pedestrian safety countermeasures to address these issues:

- **Road diets** can reduce vehicle speeds and the number of lanes pedestrians cross, and they can create space to add new pedestrian facilities.
- **Pedestrian hybrid beacons (PHBs)** provide stop control in areas without the high pedestrian traffic volumes that typically warrant signal installation.
- **Pedestrian refuge islands** give pedestrians a safe place to stop at the midpoint of the street before crossing the remaining distance. This is particularly helpful for older pedestrians or others with limited mobility.
- **Raised crosswalks** can reduce vehicle speeds.
- **Crosswalk visibility enhancements**, such as crosswalk lighting and enhanced signing and marking, help drivers detect pedestrians—particularly at night.

Other countermeasures that reduce vehicle speeds may also improve motorist yielding and pedestrian safety.

Appendix A.

Driver Yielding Field Data Collection Instructions

The following instructions were used by field data collectors to observe driver yielding behavior at uncontrolled intersection crosswalks in Milwaukee in fall 2016 and fall 2017. The instructions were originally developed in summer 2016 by Robert Schneider and Aida Sanatizadeh of the University of Wisconsin-Milwaukee for the Wisconsin Department of Transportation study titled, "Evaluation of Driver Yielding to Pedestrians at Uncontrolled Crosswalks." The instructions were modified slightly in summer 2017 to prepare for City of Milwaukee Pedestrian Plan data collection in fall 2017. Note that this approach builds from methods used in Gainesville, FL¹², Portland, OR¹³ and other driver yielding field observations.

Field Data Collection

The following sections provide instructions for collecting field data at uncontrolled crossings in Milwaukee. Data collection should be done at either the near-side or far-side crosswalk and for drivers approaching as the pedestrian enters the crosswalk from either side. Data collection should typically be done for at least two hours. Three sheets should be filled out at each study location. Sheet 1 is for recording characteristics of the intersection. Sheet 2 is for recording pedestrian behaviors and demographic characteristics. Sheet 3 is for recording driver yielding behavior and demographic characteristics.

Sheet 1: Intersection Characteristics

- **Time:** List the time of day when data collection starts and ends. All observations should be made during daylight hours.
- **Traffic volume:** Record the annualized average daily traffic volume (AADT) for the main street.

- **Two-way street:** Record whether or not the street is one-way or two-way. This particular study considers only two way streets.
- **Marked crosswalk:** Record whether the crosswalks across the main street are marked or unmarked. A marked crosswalk is designated by visible lines (either paint, epoxy, or thermoplastic).
- **Crosswalk crossing distance (feet):** Record the crossing distance for each crosswalk. This is defined as the shortest distance from the curb on one side of the street to the curb on the other side of the street within the crosswalk.
- **Crosswalk sign at the intersection (Type):** Record all types of crosswalk signs at the intersection. These signs may include the standard crosswalk sign (yellow diamond warning sign at crosswalk), in-street "State Law: yield to pedestrians" signs on the street centerline, or pedestrian crosswalk overhead signs.
- **Crosswalk sign in advance of the intersection (Y/N):** Record whether or not there is an advance warning sign for the crosswalk. This type of sign may simply be a yellow warning sign with a pedestrian figure or may say "Pedestrian Crosswalk Ahead."
- **Number of travel lanes being crossed:** Record the number of travel lanes being crossed at the study crosswalk. Travel lanes include all general purpose travel lanes as well as left- and right-turn lanes. Bicycle lanes should not be treated as travel lanes. Parking lanes should not be treated as travel lanes (unless there is a peak hour parking restriction and there is moving traffic in the parking lane at the time of study).
- **On-street parking (Y/N):** Record if there is on-street parking on the

same side of the street vehicles are traveling as they approach the crosswalk. Record if there is restricted on or off street parking at certain times of day.

- **Average distance from the crosswalks to on-street parking:** Estimate the average distance from the outside line of the crosswalk to the first car that has parked on-street nearby the intersection. This should be an average of four distances.
- **Nearside bus stop near the intersection (Y/N):** Record any nearside bus stop at the intersection. The sign might be on the curb where pedestrians wait to cross.
- **Farside bus stop near the intersection (Y/N):** Record any farside bus stop at the intersection.
- **Right-turn lane at the intersection (Y/N):** Record whether or not the main street has a designated right-turn lane at the intersection.
- **Right-turn area in the direction of the traffic at the intersection (Y/N):** Record whether or not there is a separate area to the right of the travel lane that is commonly used by right-turning cars to move out of the traffic stream prior to turning right.
- **Left-turn lane in the intersection of traffic at the intersection (Y/N):** Record whether or not the main street has a left-turn lane at the intersection.
- **Curb extension (Y/N):** Record whether or not there are any curb extensions (bump outs) where pedestrians will be entering the crosswalks.
- **Median at the crosswalk (Y/N):** Record whether or not there is a median refuge that can be used by pedestrians at either crosswalk.
- **Speed limit (miles per hour):** All case studies should have similar speed limits. Use a speed gun to record vehicle speed or record the speed limit signs of the streets where cars approach the intersection.
- **School zone or specific land use:** Record the presence of any

school, business or specific land use near (within one block of) the intersection.

Sheet 2: Pedestrian Behavior and Demographic Characteristics

Each row in this form represents a pedestrian crossing in a single direction in a single crosswalk. The first pedestrian to arrive at the crosswalk in any group should be observed. No additional pedestrians should be recorded until all members of that group complete crossing. The information that should be recorded includes:

- **Pedestrian direction:** Record the direction that the pedestrian is crossing the street (e.g., northbound/southbound). This direction should be perpendicular to the driver's direction of travel (e.g., eastbound/westbound).
- **Crosswalk location:** Record the location of the crosswalk in which the pedestrian is crossing (e.g., east or west; north or south). Do not record pedestrians who start crossing outside of the crosswalk. Record pedestrians if they go outside of the crosswalk lines near the end of their crossing.
- **Time:** Record the time that the pedestrian enters the crosswalk to the closest ten seconds (e.g., 4:32:10 pm). Note that the time stamp allows the pedestrian characteristics to be matched with the driver characteristics.
- **Yielding opportunity (Y/N):** Record whether or not there is a car approaching with an opportunity to yield to the pedestrian. If there is, record Yes. If there is not, record No. In both cases, record all other relevant data fields. An approaching driver is defined as having an opportunity to yield to the pedestrian at the crosswalk if he or she is a minimum distance away from the crosswalk when the pedestrian arrives at the curb. This definition is slightly different than state law, which requires drivers to yield the right of way to a pedestrian once

he or she has put at least one foot in the crosswalk. The method described by Van Houten et al. (2013) is used to calculate safe stopping distance. Based on a driver reaction time of 2.5 seconds, the posted speed limit in feet per second, and a conservative deceleration rate of 11.2 feet per second, the safe stopping distance for vehicles traveling at 30 mph on a flat grade is 196 feet.

- **Sex (Female/Male):** Estimate the sex of the pedestrian.
- **Race (Black/White/Latino/Asian/Other):** Estimate the race of the pedestrian.
- **Age:** Estimate the general age category of the pedestrian to the closest five years or decade (<20, 20s, 30s, 40s, 50s, 60s, 70s, 80s, 90s).
- **Physical disability (wheelchair/walker/other):** Record the type of assistive device being used if the pedestrian has a visible physical disability.
- **Waiting location (On the Curb/In the Street/None):** Record whether the pedestrian waits to cross on the curb or in the street (has at least one foot in the crosswalk). If the pedestrian crosses without stopping, mark “none.”
- **Assertive stance (Y/N):** Pedestrian assertiveness should be recorded as “Yes” when one or more of three characteristics is observed: 1) the pedestrian actively leans toward the opposite side of the street when in the crosswalk, 2) the pedestrian directs his or her eyes toward approaching drivers for more than 3 seconds, or 3) the pedestrian points his or her arms or fingers toward the crosswalk.
- **Group size (number of pedestrians waiting to cross at the same time):** Record the group size. This is defined as the total number of pedestrians waiting to cross at one time. Babies being carried by their parents count as separate individuals. Even if members of the group cross at different times, the group size is based on the number of people waiting together initially. If additional pedestrians arrive after

the initial pedestrian or group sets foot into the crosswalk, make a note of this on the data collection sheet.

- **Waiting time to cross (less than 10 sec/more than 10 sec):** Record whether the pedestrian needed to wait less than 10 seconds or more than 10 seconds before they were able to cross the street. This may depend on whether or not drivers yield as well as traffic volumes.
- **Number of cars that drove through crosswalk without yielding (Total):** Record the total number of vehicles that passed through the crosswalk without yielding before the pedestrian crossed.
- **Driver yielded (Y/N):** Record whether or not the first driver with an opportunity to yield actually yielded to the pedestrian when he or she crossed. It is possible that the pedestrian simply crossed when there was a gap in traffic. In that case, mark N/A.

Sheet 3: Driver Yielding Behavior and Demographic Characteristics

The purpose of this sheet is to document the characteristics of drivers who either yield or do not yield when a pedestrian is at the crosswalk. Each row represents one driver with an opportunity to yield. A driver observation should be made for the first car that approaches the crosswalk with sufficient distance to yield after a pedestrian arrives at the crosswalk. Each driver should be recorded on a single row of the spreadsheet. The information that should be recorded by an observer includes:

- **Driver direction:** Record the driver's direction of travel (e.g., eastbound/westbound). This direction should be perpendicular to the direction that the pedestrian is crossing the street (e.g., northbound/southbound).
- **Time:** Record the time that the driver passes the point on the street where he or she has sufficient distance to stop for a pedestrian in the crosswalk (whether a pedestrian is present or not) to the closest ten seconds (e.g., 4:32:10 pm). Note that the time stamp allows the driver characteristics to be matched with the pedestrian characteristics.
- **Yielded to the pedestrian (Y/N):** If a driver has the opportunity to yield but the driver does not yield, then the observer should record this item as No. If a driver stops to yield or slows visibly to allow the pedestrian sufficient time to cross the street, this item should be recorded as Yes. See yielding definition in the Sheet 2 description for more details about safe stopping distance.
- **Number of pedestrians at curb or crosswalk waiting to cross:** Record the number of pedestrians waiting together (regardless of whether they appear to know each other or not). Babies being carried by their parents count as separate individuals. Drivers might not yield for one pedestrian waiting to cross, but they may be compelled to yield for a group of people waiting to cross.
- **Sex (Female/ Male):** Estimate the sex of the driver. There may be differences in driver yielding between male and female drivers.
- **Race (Black/White/Latino/Asian/other):** Estimate the race of the driver. There may be differences in driver yielding by race, ethnicity, or culture.
- **Age:** Estimate the general age category of the driver to the closest five years or decade (<20, 20s, 30s, 40s, 50s, 60s, 70s, 80s, 90s).
- **Where the driver yielded:** Record the appropriate yielding distance category (in crosswalk/within 1.5m/1.5-6m/>6m/did not stop (slowed/rolled)). If the driver did not yield, do not record a measurement in this field.
- **Car in front (Y/N):** If the automobile being observed is following another automobile within 4 car lengths, record this characteristic as Yes.
- **Car behind (Y/N):** If the automobile being observed is being followed by another automobile within 4 car lengths, record this characteristic as Yes.

Endnotes

- 1 Relevant Wisconsin State Statutes from <https://docs.legis.wisconsin.gov/statutes/statutes/346/IV/23>, 2017:
Wisconsin State Statute 346.24. Crossing at uncontrolled intersection or crosswalk.
 - (1) At an intersection or crosswalk where traffic is not controlled by traffic control signals or by a traffic officer, the operator of a vehicle shall yield the right-of-way to a pedestrian, or to a person riding a bicycle or electric personal assistive mobility device in a manner which is consistent with the safe use of the crosswalk by pedestrians, who is crossing the highway within a marked or unmarked crosswalk.
 - (2) No pedestrian, bicyclist, or rider of an electric personal assistive mobility device shall suddenly leave a curb or other place of safety and walk, run, or ride into the path of a vehicle which is so close that it is difficult for the operator of the vehicle to yield.
 - (3) Whenever any vehicle is stopped at an intersection or crosswalk to permit a pedestrian, bicyclist, or rider of an electric personal assistive mobility device to cross the roadway, the operator of any other vehicle approaching from the rear shall not overtake and pass the stopped vehicle.

Wisconsin State Statute 340.01(75).
“Yield the right-of-way to a pedestrian” means the operator of a vehicle is required to reduce speed, or stop if necessary, to avoid endangering, colliding with or interfering in any way with pedestrian travel.
- 2 Pedestrians crossings were observed from either direction because Wisconsin state law requires drivers to yield to pedestrians entering the crosswalk from either side of the street.
- 3 State law requires drivers to yield the right of way when a pedestrian puts at least one foot in the crosswalk, but this method also recorded driver yielding behavior to pedestrians who stood on the curb to wait to cross. In fall 2016, the overall driver yielding rate to pedestrians who put their foot in the crosswalk was 18 percent, while the yielding rate to all pedestrians was 16 percent, so there was little difference between these methods. See Section 5.3 of the Wisconsin Department of Transportation study titled, Evaluation of Driver Yielding to Pedestrians at Uncontrolled Crosswalks, for an explanation of why pedestrians were observed when they arrived at the curb.
- 4 Van Houten, R., L. Malenfant, R.D. Blomberg, B.E. Huitema, and S. Casella. High-Visibility Enforcement on Driver Compliance with Pedestrian Right-of-Way Laws, National Highway Traffic Safety Administration, DOT HS 811 786, Available online, <http://www.nhtsa.gov/staticfiles/nti/pdf/811786.pdf>, August 2013.
- 5 While these each of the differences highlighted in this section were notable, they were not determined to be statistically significant due to the small sample of intersections used in this study.
- 6 Federal Highway Administration. Cost-effective countermeasures with known safety benefits can help reduce pedestrian fatalities at uncontrolled crossing locations and un-signalized intersections, Safe Transportation for Every Pedestrian (STEP), Every Day Counts: An Innovation Partnership with States, EDC-4, FHWA-16-CAI-020, Available online, https://www.fhwa.dot.gov/innovation/everydaycounts/edc_4/factsheet/safe_transportation.pdf, 2017.
- 7 Schneider, R.J., X. Qin, M.R.R. Shaon, A. Sanatizadeh, Z. He, P. Wkyhuis, B. Block, K. Santiago, and A. Bill. Evaluation of Driver Yielding to Pedestrians at Uncontrolled Crosswalks, Prepared by the University of Wisconsin-Milwaukee and University of Wisconsin-Madison Traffic Operations and Safety (TOPS) Laboratory for the Wisconsin Department of Transportation, December 2017.
- 8 Schneider, R.J., A. Sanatizadeh, M.R. Shaon, Z. He, and X. Qin. “Exploratory Analysis of Driver Yielding at Low-Speed, Uncontrolled Crosswalks in Milwaukee, Wisconsin,” Transportation Research Record: Journal of the Transportation Research Board, DOI: 10.1177/0361198118782251, 2018.
- 9 This part of the Wisconsin Department of Transportation study recorded pedestrians as “acting assertively” if they exhibited any one of the following characteristics: 1) the pedestrian actively leaned toward the opposite side of the street when in the crosswalk, 2) the pedestrian directed his or her eyes toward approaching drivers for more than 3 seconds, or 3) the pedestrian pointed his or her arms or fingers toward the crosswalk.
- 10 This part of the Wisconsin Department of Transportation study defined three levels of assertiveness. High assertiveness is a pedestrian crossing without stopping. Moderate assertiveness is a pedestrian stopping but making a body gesture or hand gesture to indicate a desire to cross the street, standing in the street and observing (looking at) the traffic, or standing on curb (<50 cm from the edge) and observing the traffic. Low assertiveness is standing in the street or on the curb but being inattentive (not looking at the traffic) and standing further than 50 cm from the edge of the curb.
- 11 Schneider, R.J. and R.L. Sanders. “Pedestrian Safety Practitioners’ Perspectives of Driver Yielding Behavior across North America,” Transportation Research Record: Journal of the Transportation Research Board, Volume 2519, pp. 39-50, 2015.
- 12 Van Houten, R., L. Malenfant, R.D. Blomberg, B.E. Huitema, and S. Casella. High-Visibility Enforcement on Driver Compliance with Pedestrian Right-of-Way Laws, National Highway Traffic Safety Administration, DOT HS 811 786, Available online, <http://www.nhtsa.gov/staticfiles/nti/pdf/811786.pdf>, August 2013.
- 13 Goddard, T., K.B. Khan, and A. Adkins. “Racial Bias in Driver Yielding Behavior at Crosswalks,” Transportation Research Part F, Volume 33, pp. 1-6, 2015.

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