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The Impact of Pedestrian Crossing Flags on Driver Yielding Behavior in Las Vegas, NV

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Abstract: Walking is the most affordable, accessible, and environmentally friendly method of transportation. However, the risk of pedestrian injury or death from motor vehicle crashes is significant, particularly in sprawling metropolitan areas. The purpose of this study was to examine the effect of pedestrian crossing flags (PCFs) on driver yielding behaviors. Participants crossed a marked, midblock crosswalk on a multilane road in Las Vegas, Nevada, with and without PCFs, to determine if there were differences in driver yielding behaviors (n = 160 crossings). Trained observers recorded (1) the number of vehicles that passed in the nearest lane without yielding while the pedestrian waited at the curb and (2) the number of vehicles that passed through the crosswalk while the pedestrian was in the same half of the roadway. ANOVA revealed that drivers were significantly less likely to pass through the crosswalk with the pedestrian in the roadway when they were carrying a PCF (M = 0.20; M = 0.06); drivers were more likely to yield to the pedestrian waiting to enter the roadway when they were carrying a PCF (M = 1.38; M = 0.95). Pedestrian crossing flags are a low-tech, low-cost intervention that may improve pedestrian safety at marked mid-block crosswalks. Future research should examine driver fade-out effects and more advanced pedestrian safety alternatives.

Keywords: crosswalk safety; pedestrian safety; community design; public health; physical activity; pedestrian crash; active transport; active living; sprawl

1. Introduction

While active transportation is experiencing a renaissance in the United States (USA), only 3–4% of commuters currently report walking or biking to work [1]. Travelers often cite safety as a primary reason not to bike or walk, and research supports their hesitance [2]. In 2017, the National Center for Health Statistics reported 5977 traffic related pedestrian deaths in the USA, the equivalent of one pedestrian killed by injuries sustained in a motor vehicle collision every hour and a half [3].

Three out of four Americans drive to work [4], while only one in five meets the Centers for Disease Control and Prevention's minimum guidelines for physical activity [5]. Walking and bicycling for transportation can decrease American's dependency on motor vehicles and increase physical activity levels; however, the built environment and driver and pedestrian behaviors must support these practices. Driver yielding behaviors are influenced by a variety of factors [6]. Drivers are more likely to yield to groups of pedestrians than to individuals [7,8]. Age also affects yielding, with Sun et al. finding older drivers more likely to yield than younger drivers [7]. Personality and upbringing may be additional factors in yielding likelihood, based on an individual desire to be courteous and/or polite [6].

Distraction is a primary cause of vehicle- and pedestrian-related crashes [9,10]. In 2012, it was estimated that one of every five distraction-related motor vehicle crashes involved the use of a hand-held device [9]. Most drivers do not recognize the extent to which distractions, particularly using a hand-held device, decrease their attentiveness when controlling their vehicle and monitoring their surroundings [10]. A possible solution to decreasing distraction may be recruiting technology that increases the focus on walking and/or driving [11–15]. Wearable technology and apps that track physical activity often encourage users to take a certain number of steps or achieve a target heart rate [11–13]. This goal-setting may encourage pedestrians to focus on walking at a brisk pace that would be hard to achieve while looking at a device. Apps have been designed to track distracted driving [14] or completely disable devices in moving vehicles [15]. When used mindfully, technology may decrease distraction-related motor vehicle crashes.

Interventions aimed at increasing pedestrian safety have had somewhat mixed results. For example, one study aimed to decrease cell phone distractions amongst pedestrians by stenciling safety messages on curbs. While distracted walking decreased initially, the change was not sustained at a four-month follow-up [16]. A study in Gainesville, Florida used a high-visibility enforcement intervention to increase driver yielding (i.e., increased driver citations, advanced yielding markings and signs, media education campaign, etc.), and found that the initially significant increase in yielding was sustained at a four-year follow-up [17]. A meta-analysis of behavioral interventions targeted at child pedestrians concluded that interventions improved children's pedestrian safety [18].

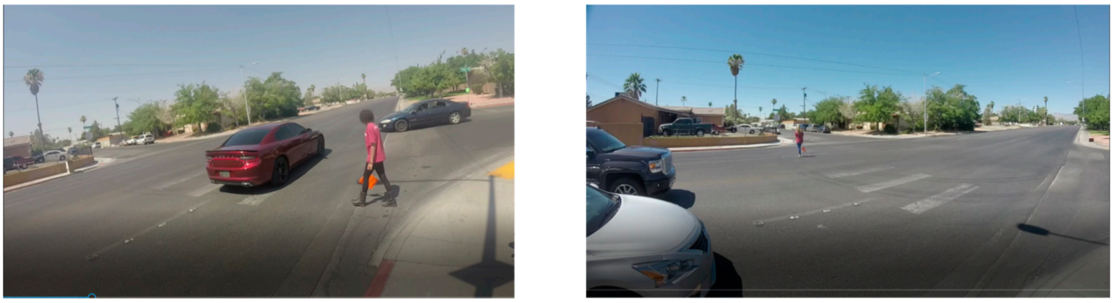
Increasing pedestrian visibility is one effective engineering modification classification for reducing pedestrian crashes [19]. One method for increasing pedestrian visibility is the use of pedestrian crossing flags (PCFs), or brightly colored, typically plastic, reusable flags that are carried by the pedestrian as they cross the roadway. A PCF system usually involves installing buckets to hold flags on both sides of a crosswalk. Pedestrians then pick up a flag before entering the roadway and carry it from one side of the road to the other, depositing the flag in the bucket after their crossing is complete. While some cities around the world are utilizing PCFs, little research has been done on their impact on driver yielding behavior. A 2007 study examined the use of PCFs at six sites and reported an average 65% driver compliance rate. PCFs may improve driver yielding behavior and enhance pedestrian safety at marked crosswalks [20]. The purpose of this study was to examine the effect of PCFs on driver yielding behaviors in marked crosswalks in Las Vegas, Nevada.

2. Materials and Methods

Two zebra-striped midblock crosswalks with similar street design and neighborhood income demographics were selected for inclusion in this study. Streets consisted of two travel lanes in each direction with a center turn lane and a posted 35 mph speed limit. Trained observers viewed and analyzed crossings by study participants when they were the only pedestrians attempting to use the crosswalk. Two female participants wearing similar attire (a T-shirt and shorts or pants) volunteered to act as pedestrians using the crosswalks. Data collection took place on weekend mornings during July 2017 between 10 a.m. and 12 p.m.

When approaching vehicles reached a predetermined landmark (i.e., a specific street tree) located about 200 yards from the crosswalk, participants indicated their intent to cross the street by standing at the curb facing oncoming vehicles. They entered the roadway only when they were confident that drivers planned to yield because of decelerating, making eye contact, and/or physically signaling to the pedestrian. During the PCF crossing attempts, participants held bright orange safety flags (12″ × 12″, on a 2-foot pole) vertically at waist height. Trained observers recorded (1) whether or not the pedestrian was carrying a PCF, (2) the number of vehicles that passed in the nearest lane before yielding while the pedestrian waited at the curb ready to enter the roadway, and (3) the number of vehicles that continued in the closest adjacent lane on the same half of the roadway once the pedestrian entered the crosswalk.

Each of the mid-block crosswalks was crossed 60 times without a PCF and 80 times with a PCF, resulting in a total of 120 roadway crossings without a PCF and 160 with a PCF. Results were analyzed using a two-way analysis of variance (ANOVA) to examine the effects PCFs had on (1) the number of vehicles that passed in the nearest lane without yielding while the pedestrian waited at the curb ready to enter the roadway and (2) the number of vehicles that passed through the crosswalk while the pedestrian was in the same half of the roadway. See Figure 1 for example photos of the mid-block crosswalk test sites. Analysis was conducted with IBM SPSS Statistics 25 (IBM Corp., Armonk, NY, USA).



(**A**) (**B**)

Figure 1. (**A**) Example of vehicle failing to yield while the pedestrian is in the roadway. (**B**) Example of vehicles yielding to the pedestrian crossing the roadway at a midblock crosswalk in Las Vegas, NV.

3. Results

3.1. Number of Vehicles that Passed in the Nearest Lane without Yielding while the Pedestrian Waited at the Curb Ready to Enter the Roadway

Results of the two-way ANOVA revealed that drivers were significantly more likely to yield if the pedestrian waiting to enter the roadway was carrying a PCF (M = 1.38, SE = 0.13; M = 0.95, SE = 0.11). The interaction effect between crosswalk location and PCF was not statistically significant, with a small effect size. See Table 1 for the full model results. Violations of assumptions were tested. The model resulted in heterogeneity of variances (Levene's Test: F = 4.047; $p = 0.008$), but given that the sample sizes are nearly equal ($n = 276$; df = 3), the effect on error is minimal. Regarding the normality condition of the dependent variable, given the size of the sample ($n = 280$), it is possible to conclude that it approximates well to a normal distribution following the conditions imposed by the central limit theorem. See Figure 2 for the normality graph.

Table 1. Analysis of variance (ANOVA) results examining the number of vehicles that passed in the nearest lane without yielding while the pedestrian waited at the curb.

	df	Mean Square	F	*p*-Value	Partial Eta Squared
Corrected model	3	4.600	2.200	0.088	0.023
Intercept	1	373.333	178.566	<0.001	0.393
PCF	1	12.876	6.159	0.014	0.022
Street location	1	0.011	0.005	0.943	0.000
PCF * street interaction	1	0.868	0.415	0.520	0.002
Error	276	2.091			
Total	280				

* PCF = pedestrian crossing flag; df = degrees of freedom; *R*-squared = 0.023 (adjusted *R*-squared = 0.013).

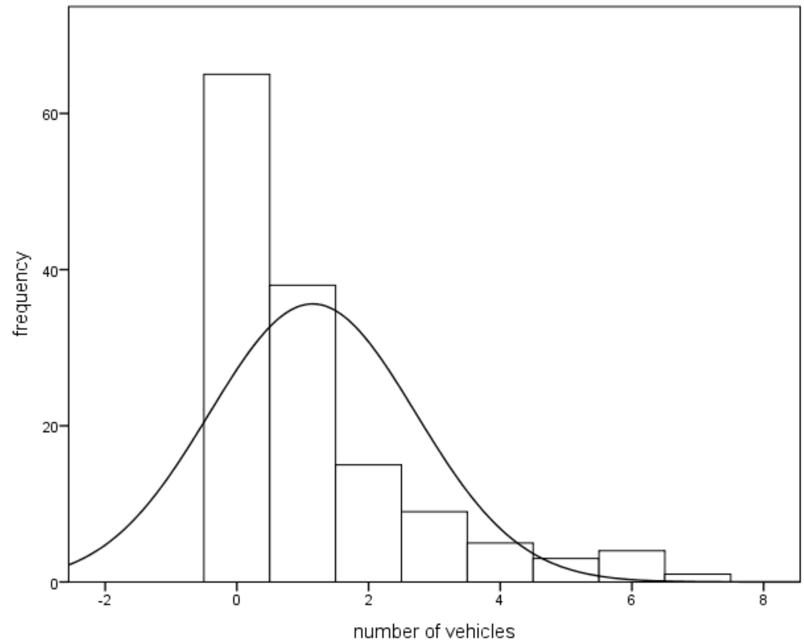


Figure 2. Histogram of number of vehicles that passed in the nearest lane without yielding while the pedestrian waited at the curb.

3.2. Number of Vehicles that Passed through the Crosswalk while the Pedestrian Was in the Same Half of the Roadway

Results of the two-way ANOVA revealed that drivers were significantly more likely to stop if the pedestrian in the roadway was carrying a PCF (M = 0.20, SE = 0.04; M = 0.06, SE = 0.03). The interaction effect between crosswalk and flag status was not significant, with a small effect size. See Table 2 for the full model results. Violations of assumptions were tested. The model resulted in heterogeneity of variances (Levene's Test: F = 18.192; $p < 0.001$), but given that sample sizes are nearly equal ($n = 276$; df = 3), the effect on error is minimal. Regarding the normality condition of the dependent variable, given the size of the sample ($n = 280$), it is possible to point out that it approximates well to a normal distribution following the conditions imposed by the central limit theorem. See Figure 3 for the normality graph.

Table 2. Analysis of variance (ANOVA) results examining the number of vehicles that passed through the crosswalk while the pedestrian was in the roadway.

	df	Mean Square	F	*p*-Value	Partial Eta Squared
Corrected Model	3	0.674	4.128	0.007	0.043
Intercept	1	4.503	27.563	<0.001	0.091
PCF	1	1.417	8.674	0.004	0.030
Street location	1	0.003	0.016	0.898	0.000
PCF * street interaction	1	0.603	3.689	0.056	0.013
Error	276	0.163			
Total	280				

* PCF = pedestrian crossing flag; df = degrees of freedom; *R*-squared = 0.043 (adjusted *R*-squared = 0.033).

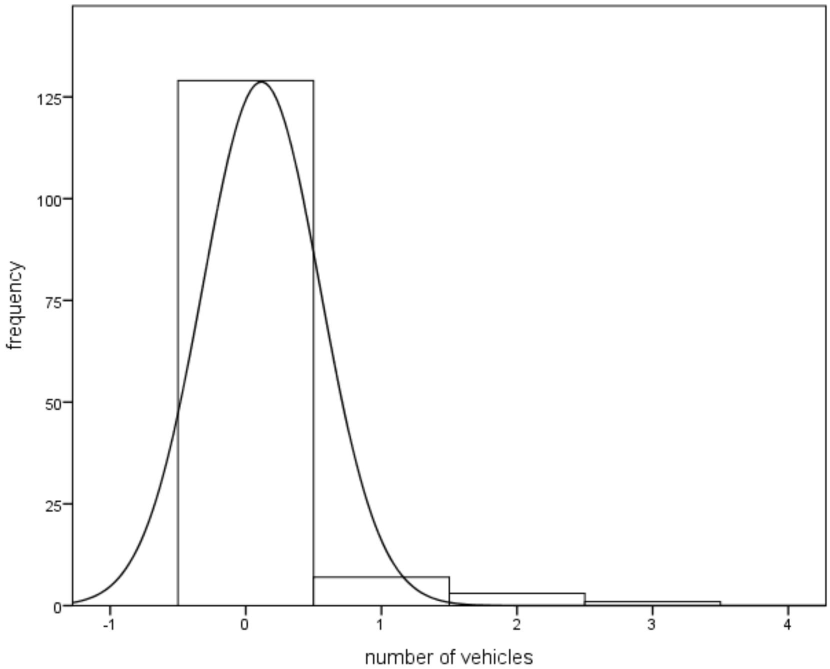


Figure 3. Histogram of number of vehicles that passed through the crosswalk while the pedestrian was in the same half of the roadway.

4. Discussion

This study examined the association between the use of PCF and driver yielding behavior for pedestrians at two mid-block crosswalks in Las Vegas, NV. The study results revealed an association between the use of PCFs and driver yielding. Specifically, motor vehicle drivers were more likely to yield both for pedestrians indicating that they intended to cross the roadway and for those already in the roadway when carrying a PCF. Our results have implications for public health, as the frequency of pedestrian crashes remains high and these constitute a disproportionate burden of all motor vehicle crashes [21].

Given the cross-sectional nature of the study, we are unable to ascertain the reasons why drivers were more likely to yield to pedestrians holding a PCF. However, the use of a PCF is likely to enhance the visibility of the pedestrian, thus increasing the likelihood of driver yielding [19]. In places where PCFs are provided by the city or town governments, installation costs are minimal (approximately $150 per crosswalk for 20 PCFs and two buckets) [22]. However, some cities have discontinued the use of PCFs due to theft [23,24], which indicates that the costs may be greater if there is a continual need to replace the PCFs.

The study setting has unique nuances that lend support to pedestrian safety interventions. In 2019, Dangerous by Design ranked Las Vegas the 24th most dangerous large metropolitan area for pedestrians on their list of the top 100 [25]. Urban sprawl, high-speed arterial roads, and a rapidly growing population make the Las Vegas valley a distinctive and often perilous environment for pedestrians [26,27]. Nevada state law may be an additional precarious factor, as it is unclear when yielding to pedestrians is mandated [6]. Nevada Revised Statutes [28] state: "When official traffic-control devices are not in place or not in operation, the driver of a vehicle shall yield the right-of-way, slowing down or stopping if need be to yield to a pedestrian crossing the highway within a crosswalk when the pedestrian is upon the half of the highway upon which the vehicle is traveling, or when the pedestrian is approaching so closely from the opposite half of the highway as to be in danger." This indicates that yielding is only necessary once a pedestrian has already entered a crosswalk. Conversely, the Revised Statutes also state that drivers must "Exercise proper caution upon observing a pedestrian: (1) On or near a highway, street or road; ... (3) In or near ... a marked or unmarked crosswalk [29].” It is unclear when drivers are legally required to yield, which has the potential to lead to confusion as to who has the right of way and could further endanger pedestrians.

Further research is needed to identify solutions to increase driver yielding that do not have a fade-out effect, especially on unsignalized mid-block crossings. While interventions that increase pedestrian visibility and decrease distracted walking and driving are still necessary, technological advancements are one burgeoning crash mitigation method. For example, automatic emergency braking (AEB) systems have the ability to detect pedestrians and decelerate the vehicle to avoid or minimize pedestrian injury. Unfortunately, such technology is not yet widespread and is typically available only in high-end cars, though there has been research examining phone app-based detection systems that have the ability to alert drivers without automatic speed deceleration [30]. While widespread use of such technologies would certainly enhance pedestrian safety, it is important to note that pedestrian detection is much more efficient at lower travel speeds, with most tests being conducted at speeds of around 20 mph. Continued efforts to implement and improve AEB systems are warranted. Young and Salmon [31] call for a systems approach to road safety: a combination of multiple efforts aimed at various interactive components simultaneously is likely to have the greatest impact.

This study is not without limitations. Driver behavior was only observed on two mid-block crosswalks in Las Vegas, NV, thus limiting generalizability to other locations. Recreating this study in other geographical areas would assist with determining the efficacy of PCFs. All pedestrians in this study were female, so an examination of gender differences is also necessary. The cross-sectional nature of this study makes it impossible to determine how driver behavior may change over time as they become more accustomed to seeing the PCFs, i.e. the fade-out effect.

5. Conclusions

This study found that drivers yielded more for pedestrians when they were carrying PCFs at two mid-block crosswalks in Las Vegas, NV. While walking for transportation and/or recreation is affordable and sustainable, it is not without risk. Changes in the built environment, policy, individual behaviors, and technological advancements are essential to increasing road safety in America. Pedestrian crossing flags may be one affordable and simple way to improve pedestrian safety at mid-block crosswalks.

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