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**The Effects of High Visibility Enforcement on  
Driver Compliance to Pedestrian Stop Right-of-Way  
Laws in Ann Arbor, MI**

**FINAL REPORT**

**Ron Van Houten, Jun Oh, and De'Lon Dixon**



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<b>16. Abstract</b> The purpose of this study was to replicate the findings of Van Houten et. al. (2013) demonstrating that a multifaceted program could increase the percentage of motorist's yielding to pedestrians in crosswalks on a community basis in Gainesville, FL, and that these changes actually improved further over a four year follow-up period (Van Houten et. al. (2017). The current study replicated the original findings in a similar sized city in a different region of the US (Ann Arbor, MI). Stopping for pedestrians in Ann Arbor increased from a mean of 28.5% to 65.2% at the treatment sites, which also received police enforcement, and from 34.2% to 53% at the generalization sites that did not receive police enforcement. These changes were very similar to those observed in the city of Gainesville Florida. The finding indicated that the use of the feedback signs showing the percentage of motorists stopping for pedestrians each week along with the record level of compliance with the ordinance was a key element contributing to the success of the package. Follow-up data should be collected after 4 years to determine whether further improvements in driver compliance occur.			
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**The Effects of High Visibility Enforcement on Driver Compliance to  
Pedestrian Stop Right-of-Way Ordinance in Ann Arbor, MI**

By

Principal Investigator  
Ron Van Houten, Ph.D.  
Professor, Psychology  
Western Michigan University  
Kalamazoo, MI, 49008  
Ron.vanhouten@wmich.edu  
Tel: (269) 929-2609

Co Principal Investigator  
Jun-Seok Oh, Ph.D., P.E. PTOE  
Professor, Department of Civil and Construction Engineering  
Western Michigan University  
Kalamazoo, MI, 49008-5316  
jun.oh@wmich.edu  
Tel: (269) 276-3216

Graduate Research Assistant  
De'Lon Dixon  
Psychology Department  
Western Michigan University  
Kalamazoo, MI, 49008  
delon.j.dixon@wmich.edu

# 1 INTRODUCTION

This is the final report of *The Effects of High Visibility Enforcement on Driver Compliance to Pedestrian Stop Right-of-Way Law in Ann Arbor, MI*. The study was conducted by the Western Michigan University Transportation Research Center(WMU), and the Department of Psychology. The two objectives of the study were:

- 1) To replicate the effects of the NHTSA study conducted in Gainesville, FL to increase drivers yielding right-of-way to pedestrians on a city-wide basis to produce a large and sustained change in the driving culture to favor yielding to pedestrians.
- 2) To determine whether increases in yielding behavior produced by the program generalize to untreated locations.

## 1.1 Background

According to the National Highway Traffic Safety Association (NHTSA) in 2015 there were 5,376 pedestrian fatalities in the United States, and an additional 70,000 injuries. There has been an increasing trend in pedestrian deaths since 2009 with 4,109 fatalities, as well as an increase in the proportion of pedestrian fatalities out of all traffic related fatalities from 12% to 15% (United States Government Accounting Office. Report to Congressional Request, 2015). NHTSA also reports that over one quarter of those fatalities involved a failure to yield right-of-way to the pedestrian. In large cities, pedestrians account for 40 to 50% of traffic fatalities.

Past research (e.g., Hunter, Stutts, Pein, and Cox, 1996) has indicated that a lack of driver compliance is associated with pedestrian motor vehicle crashes. One way of increasing driver compliance is to utilize high visibility enforcement of pedestrian right-of-way laws. Research conducted in the U.S. indicates that the use of increased enforcement coupled with increased publicity about the enforcement program has been associated with substantial increases in compliance with occupant protection laws as well as a reduction in alcohol related crashes (Levy, Shea, & Asch, 1988; Levy, Asch, & Shea, 1990; Lacey, Jones, & Smith, 1999; Milano, McInturff, & Nichols, 2004). An underlying assumption of general deterrence theory is that sustained enforcement in conjunction with media attention will increase the public's perception of the risk of being stopped by the police thereby increasing compliance with traffic laws (Waller, Li, Stewart, & Ma, 1984). Thus, raising the perceived probability of apprehension which is an essential element of an effective pedestrian enforcement program. Another variable that can facilitate a culture change in driver behavior is community feedback. This element was also present in the Gainesville study and yielding tended to improve at many sites when this element was added to enforcement.

## 1.2 General Deterrence

An underlying assumption of general deterrence theory is that sustained high visibility enforcement in conjunction with media attention will increase the public's perception of the risk of being stopped by the police thereby increasing compliance with traffic laws (Waller, Li, Stewart, & Ma, 1984). Raising the perceived probability of apprehension is an essential element of an effective pedestrian enforcement program. In 1985, Van Houten and Malenfant developed a multifaceted high visibility countermeasure described as a pedestrian decoy operation to increase the efficacy of pedestrian right-of-way enforcement operations (Malenfant, Van Houten,

Hall, & Cahoon, 1985; Van Houten, Malenfant, & Rolider, 1985). Typically, decoy operations involve the use of police in plainclothes who step into the roadway at marked or unmarked crosswalks following a carefully defined protocol, which provides ample opportunity for drivers to stop for pedestrians. Spotters are used to identify those drivers who do not yield right-of-way to the pedestrian decoy. This program also included the following elements to further increase the visibility of the program: the use of feedback flyers that inform violators about the law and the number of pedestrian crashes in their community; the use of highway feedback signs that provide weekly information on the percentage of motorists yielding to pedestrians along with the record; and outreach materials distributed to members of the community that describe the law, ask for cooperation in making the program a success and provide a warning of impending enforcement operations. Subsequent iterations of this program included signs at enforcement sites that inform motorists that vehicles pulled over are being stopped for failing to stop for pedestrians; no passing lines from the dilemma zone to the crosswalk so police did not have to place cones prior to each enforcement operation; and the installation of signs reminding pedestrians of the law and drivers of the fine for failing to yield to pedestrians to increase public awareness at the start of enforcement.

Malenfant and Van Houten (1989) replicated their earlier work in three small Canadian cities with populations between 40,000 and 95,000 and reported marked increases in yielding and a marked reductions of crashes in each city. These data demonstrated that this type of program can be successful in increasing motorist compliance, and was associated with a reduction in pedestrian crashes. However, it was not clear whether this program would be effective in larger cities.

To determine the effectiveness of increased enforcement on motorist compliance, Van Houten and Malenfant (2004) implemented a limited single wave pedestrian enforcement program alone without an accompanying publicity campaign in Miami Beach, Florida and found it could produce a modest increase in yielding levels.

Britt, Bergman, and Moffet (1995) also reported on the effect of decoy pedestrian right-of-way enforcement operations carried out in Seattle. These were carried out over a period of several years. The authors concluded “In light of the often contradictory results, expectations of traffic enforcement to improve pedestrian safety should remain modest.” However, they also recommended continued research to determine ways to optimize the effects of pedestrian right-of-way enforcement. It should be noted that Britt et. al. did not utilize extensive publicity or public posting of the percentage of drivers yielding each week along with the record on highway signs.

Van Houten, Malenfant, Huitema, and Blomberg (2013) evaluated a program that coupled police enforcement with inexpensive engineering upgrades (e.g., in-street STATE LAW YIELD TO PEDESTRIAN signs), education through earned media, the deployment of large road signs that provided feedback on the percentage of drivers yielding the right-of-way to pedestrians during the preceding week along with the record at treated sites in Gainesville, Florida. The introduction of the high visibility enforcement over the course of a year during the original study led to a marked increase in yielding to pedestrians at the six enforcement crosswalk sites from a baseline level of 32% to a high of 62% for research assistant (staged) crossings and from 54% to 83% for naturally occurring (unstaged) crossings by the general public. At the six generalization crosswalk sites which did not receive any enforcement, yielding to pedestrians increased from

37% to 59% for staged crossings and from 50% to 73% for the unstaged naturalistic crossings. The original study ended in February of 2011.

While this study produced an immediate behavioral change with steady improvement in Gainesville drivers, the study ended before researchers could measure the persistence of any of the program's effects. In particular, the extent to which the GPD continued to enforce the yield-to-pedestrian laws, the post-study yielding rate to pedestrians, changes in pedestrian crash rates, and long-term changes in the safety culture of drivers in Gainesville were unknown.

A four-year follow-up study evaluated the extent to which increases in the percentage of drivers yielding to pedestrians in Gainesville, Florida observed in the original study persisted over time (Van Houten, Malenfant, Blomberg, Huitema, & Hochmuth, 2017). The results indicated the increase in yielding seen in the original study not only persisted but increased further during the follow-up period. Moreover, both the enforcement and generalization sites showed this continued improvement. This, together with the significant citywide drop in pedestrian crashes after the end of the intervention, supports a conclusion of program effectiveness and suggests the possibility of a substantial spread of affect from the original study's enforcement and education program.

In order to consider the reasons for the observed improvement in yielding behavior four years after the program, one must first consider the possible reasons for the program's initial success in addition to the increased enforcement itself. Possible reasons include: The original intervention used community feedback signs that may have produced both a social norming effect as well as implying continued surveillance of motorist behavior that created a general deterrent effect. The levels of yielding achieved by the end of the intervention period may have produced a tipping point effect resulting in a further improvement in behavior even after the end of the enforcement period. Once the majority of motorists were yielding to pedestrians, seeing other motorists consistently yielding to pedestrians served as a strong model for a new social norm. Yielding to pedestrians is a very visible behavior that other drivers can easily see and copy.

Two possible extraneous explanations for an apparent continued effect of the intervention can be largely discounted—continued countermeasure activity and measurement unreliability. No documented evidence existed of continued high levels of enforcement or publicity once the original program ended. In fact, the Gainesville Police personnel, who would have carried out further enforcement, adamantly report that no special enforcement of yield to pedestrian laws took place after the end of the program.

The results of the follow-up study taken together with the findings of the original study lead to the following observations: Yielding behavior began to improve at the enforcement sites when enforcement started and continued largely unabated into the follow-up period. This suggests either a notable and continuing increase in general deterrence, a fundamental change in driver behavior and courtesy, or both. The coincident timing of the increase in yielding behavior and the onset of the program suggests an association between the two. While pedestrian education has increased in Florida, Gainesville is somewhat isolated from surrounding communities and the fatality rate per population still ranks Florida number two in the country. Thus, it is unlikely the increased motorist yielding is a direct result of statewide efforts. Previous research (Malenfant, Wells, Van Houten, & Williams, 1996; Wells, Malenfant, Williams, & Van Houten, 2000) suggests that the feedback signs promoted driver awareness and

contributed to the positive results. The available data do not support a determination of the relative contributions of the enforcement, earned media, and feedback signs to the success of the overall program. The existence of higher levels of yielding to natural pedestrian crossings than to staged crossings cannot be fully explained but is consistent with the findings of the original Gainesville study and previous research by Van Houten, Ellis, and Marmolejo (2008). One possible reason for this effect is that naturally occurring pedestrians may cross more assertively than staged, decoy pedestrians who follow a safety protocol for a staged crossing. For example, in a staged crossing the pedestrian only steps into the crosswalk with one foot while naturalistic pedestrians often take several steps into the crosswalk thereby challenging a driver to stop.

One limitation of this study was that it took place in a single city that was not adjacent to other urban areas in one region of the country. The study therefore can shed little light on the amount of effort needed to convince other cities, particularly cities that are not geographically isolated from other urban areas. Second, it was implemented in a southern city where enforcement waves could be implanted in a continuous effort without being suspended during winter months. The purpose of the present study was to replicate the results of the Gainesville study in a city of similar size boarding a much larger urban area in a northern region of the United States with a hiatus over the winter months.

## **SITE SELECTION**

This project was designed to be a collaborative effort between the research team and the City of Ann Arbor, MI. The concept was to apply the joint experience and training of researchers and local practitioners to mount five two-week enforcement waves along with a variety of interventions to increase the visibility of enforcement operations. These interventions aimed to support enforcement by raising public awareness of their intensity and scope. Ann Arbor is near the Detroit metropolitan area and has a winter period where pedestrian enforcement would be difficult to implement.

## **2 IDENTIFICATION OF TREATMENT AND GENERALIZATION SITES**

### **2.1 Crosswalk Site Selection**

The City of Ann Arbor provided the research team with a database of all marked crosswalks at locations without traffic signal or stop sign control. The research team then visited the crosswalks located near pedestrian trip generators such bus stops or parks. The research team used the following criteria to select crosswalk locations:

- a) The presence of hospitals with parking located across the street.
- b) Transit stop locations that require crossing to reach neighborhoods that are served by the transit entity or transfer points.
- c) The presence of civic facilities such as arenas, city hall, or libraries.
- d) Locations near civic parks.



- e) Locations near schools with playgrounds, or high school crosswalk locations that are not served by crossing guards.
- f) Locations with shops on both sides of the street.
- g) Infrequent gaps to allow safe crossing. If gaps are so frequent that pedestrians frequently arrive at a gap, the need for enforcement will not be evident.

In addition to the above criteria, the following requirements were needed for the deployment of safe pedestrian right-of-way enforcement operations:

- a) Flaggers should be clearly visible to violators. This is critical if the officer is to safely pull over violators.
- b) Storage capacity should be adequate to pull over at least four violators.
- c) It should be easy for drivers to safely pull over and re-enter the roadway when stopped by police.
- d) If it is a multilane road, the officers should be able to safely stop both travel lanes. It is unwise to conduct enforcement on roads with more than two travel lanes in each direction.
- e) It should be possible for the officers to talk with the driver while the vehicle is stopped without danger from passing vehicles.
- f) Flaggers should be able to see the violation and determine whether the driver was beyond the dilemma zone (see below) when the pedestrian entered the crosswalk.

The research team selected 12 sites that met the above criteria. The team randomly assigned 6 of these sites to receive HVE and 6 crosswalks to serve as untreated sites to determine whether the effects of HVE pedestrian right-of-way enforcement generalized to untreated sites. Figure 1 shows the uncontrolled crosswalks in the City of Ann Arbor with blue circles around crosswalk sites that received HVE pedestrian right-of-way enforcement and red circles around crosswalk sites that did not receive HVE pedestrian right-of-way enforcement.

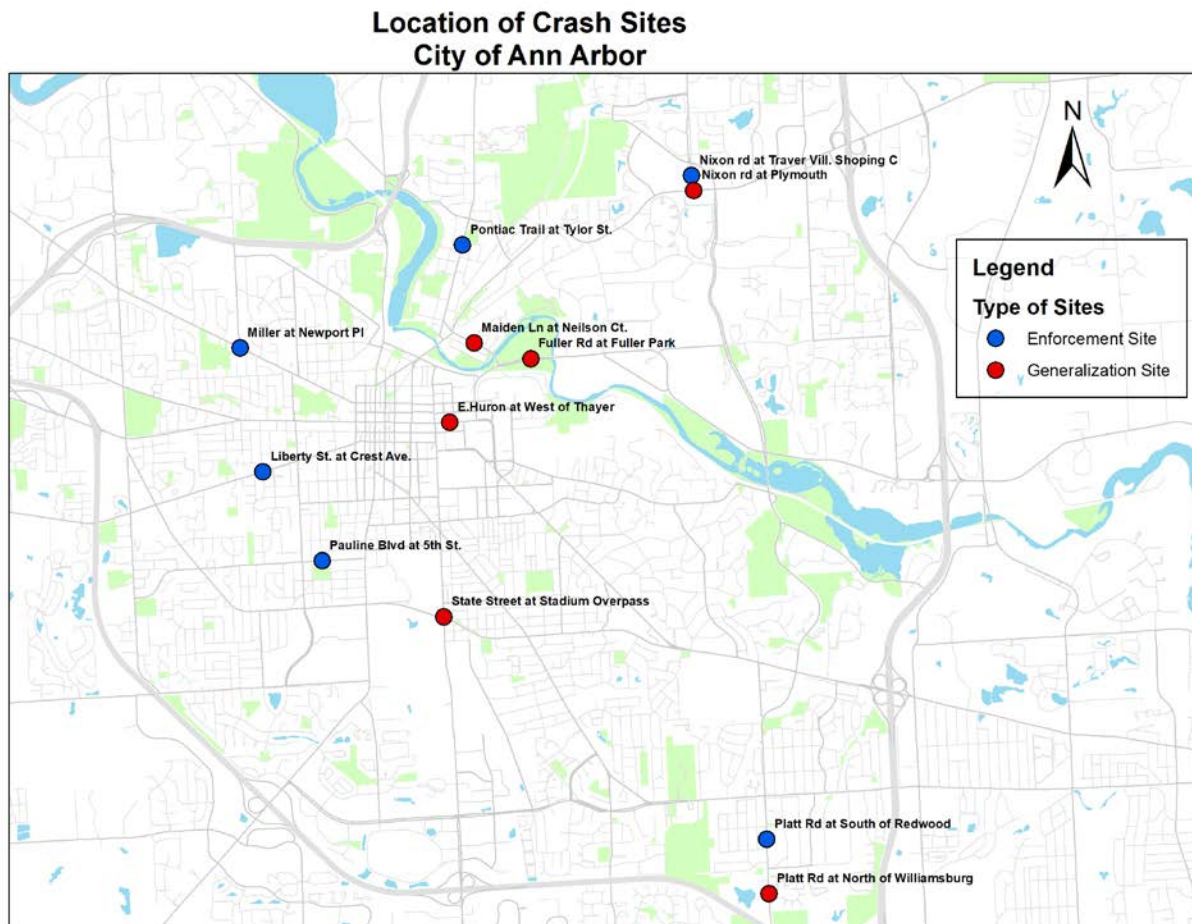
Enforcement sites were:

- Nixon Rd. at Traver Village Shopping Center. Midblock Crossing connecting two shopping areas.
- Platt Rd. at south of Redwood Ave. Neighborhood crossing at a bus stop.
- Liberty St. at Crest Ave. School crosswalk near a Middle School.
- Pauline Blvd. at 5<sup>th</sup> Street Crossing for Allmendinger Park.
- Pontiac Trail at Taylor St. Crossing at northside playground.
- Miller Ave. at Newport Pl. School crossing.

Generalization sites were:

- Fuller Rd. midblock crossing at Fuller Park and bus stops.

- E. Huron St. west of Thayer. Midblock crosswalk
- Nixon at Bus Stop at Plymouth
- Platt Rd. North of Williamsburg Rd. Midblock crossing at bus stop locations and near a Middle School.
- Maiden Ln. at Neilson Ct. Crossing near a medical center.
- State St. at Stadium overpass. Midblock crossing on main road on University of Michigan campus.



**Figure 1.** This figure shows a map of marked crosswalks at uncontrolled locations in Ann Arbor that were evaluated in this study. A blue circle marked enforcement sites and a red circle marked generalization sites.

## 2.2 Pre-Baseline Site Preparation

Prior to beginning baseline data collection, the crosswalk markings for all treatment and untreated sites were refreshed if required (either repainted or new thermoplastic markings installed).

## 2.3 Data collection procedures

Data to evaluate changes in motorist stopping behavior were collected using a standard recording sheet at crosswalks with an uncontrolled approach. Data collectors were trained to use

an operational definition of stopping behavior that increased the objectivity of data collection. This method included the definition of the dilemma zone. Drivers needed to be behind the dilemma zone when the pedestrian entered the crosswalk in order to be scored. This procedure ensured that motorists traveling at the speed limit had adequate time to stop for a pedestrian.

### **2.31 Defining the Dilemma Zone**

A walking wheel was used to measure the distance from the nearest crosswalk edge to the dilemma zones prior to the crosswalks. A cone or a solid no pass line was used to mark each dilemma zone. The research team employed the formula used by traffic engineers to determine whether a driver could have safely stopped at a traffic signal to determine whether the driver could have stopped for a pedestrian standing with one foot in the crosswalk. Calculating the distance beyond which a motorist can safely stop for a pedestrian is the same as calculating the distance in advance of a traffic signal that a motorist driving the speed limit can stop if the traffic signal changes to yellow. Traffic engineers use the signal-timing formula (Institute of Transportation Engineers, 1985), which takes into account driver reaction time, safe deceleration rate, the posted speed, and the grade of the road to calculate this interval for the amber indication. This formula:

$$y = t + \frac{v}{2a + 2Gg}$$

was used to determine the distance to the dilemma zone boundary by multiplying the time by the speed limit in feet per second. Motorists who had passed the landmark (cone) when a pedestrian entered the crosswalk were scored as stopping for pedestrians but not as failing to stop, because they passed the point at which there was sufficient time to easily give right-of-way to pedestrians. Motorists who had not yet crossed the dilemma zone boundary when the pedestrian entered the crosswalk were scored as stopping or not stopping because they had sufficient distance to safely stop given the speed limit.

### **2.3.2 Scoring Driver Giving Right-of-Way to Pedestrians**

Once a pedestrian indicated an intention to cross the street (by standing at the curb between the crosswalk lines facing the roadway or oncoming traffic with one foot in the roadway between the crosswalk lines and the other foot on the curb), the behavior of drivers who had not yet crossed the dilemma zone boundary was scored as not stopping for pedestrians if they failed to stop.

When the pedestrian first started to cross, only drivers in the first half of the roadway were scored for stopping. Once the pedestrian approached within a half lane of the center of the road, the stopping behaviors of motorists in the remaining lane(s) were scored. This procedure was followed because it conformed to the obligation of motorists specified in most motor vehicle statutes. The observers used a clipboard and data sheets to record their observations of the research assistants who served as decoy pedestrians.

Observers scored motorist-stopping behavior for both staged crossings and any naturally occurring, or unstaged, crossings that took place during each data collection period. These data were disaggregated for analysis purposes. Data were recorded in sets of 20 staged crossings

when vehicles were present that could stop or fail to give right-of-way during each observation session.

### **2.3.3 Data Collectors Training**

Dr. Van Houten and his graduate students trained observers until they could attain an inter-observer agreement of 90% or more for two consecutive data sheets. The third author served as the coordinator for data collection and supervised observers and conducted regular reliability checks. The coordinator checked reliability for each observer for one full sheet on a weekly basis. The graduate student reported directly to the principal investigator (PI), summarized and graphed data to determine the percentage to be posted on the feedback signs. Dr. Van Houten received reports on the enforcement operations including the number of stops, warnings, and citations.

### **2.3.4 Data Collection Schedule**

A data sheet consisted of twenty staged crossings, and as many unstaged crossings as occurred during that period of time. Researchers collected between two and three data sheets each week at each site (depending on weather) for the duration of the study at six enforcement sites and six untreated generalization sites. All data were collected during daylight hours in the morning and afternoon at times that coincided with times scheduled for enforcement. Data were not collected when the pavement was wet, or at enforcement sites when enforcement was being carried out. Data were collected from April 20<sup>th</sup> of 2017 to December 7<sup>th</sup> 2017 and resumed on June 4<sup>th</sup> of 2018 and ended on July 18<sup>th</sup> of 2018.

### **2.3.5 Inter-observer agreement (IOA)**

IOA is a method of determining whether the observers are measuring the conditions reliably. IOA was calculated for 36% of the sheets collected. Each event that was scored the same by both observers was counted as an agreement and each event that was scored differently by each observer was scored as a disagreement. IOA was calculated by dividing the number of agreements during each session by the number of agreements during that session plus the number of disagreements for that session. The result of this calculation was then multiplied by 100% to obtain a percentage. During sessions in which agreement data were collected, the two observers stood several meters apart at a location with an unobstructed view of the crosswalk. When more than one pedestrian was crossing at a particular crosswalk, the primary observer identified the pedestrian for whom stopping behavior was to be scored. An agreement on stopping was scored only if both observers scored all vehicles the same for each pedestrian. An agreement on the occurrence of conflicts was scored if both observers scored an event as a conflict, and an agreement for a pedestrian being trapped at the centerline was scored if both observers scored the pedestrian as trapped.

The percentage of IOA for stopping behavior for staged crossings averaged 96% with a range of 80% to 100%. The percentage of IOA for unstaged, or natural, crossings averaged 87% with a range of 75% to 100%. The lower IOA for natural crossing pedestrians was related to the low number of naturally crossing pedestrians during some sessions and the observer missing some of these crossings which were scored as a disagreement. Because instances of conflicts and trapped pedestrians were relatively rare, they were not reliably captured by observers with IOA.

### **2.3.6 Independent variable integrity**

Verification of enforcement was obtained from records of citations and warnings issued.

### **2.3.7 Crash Data**

Crash data were not yet available for recent 2017 and 2108. Therefore, and analysis of crashes will need to wait until data are available for an adequate post-treatment period.

### **2.3.8 Statistical Analysis**

A regression analysis was applied to these data comparing baseline stopping with stopping during the last treatment phase. A t test was then preformed.

## **3 HIGH VISIBILITY PEDESTRIAN RIGHT-OF-WAY ENFORCEMENT**

The total program implemented in Ann Arbor consisted of pedestrian right-of-way enforcement accompanied by the development and deployment of a variety of countermeasures to increase the visibility of the enforcement program. This section discusses the countermeasures, their framework, and their implementation. The next section addresses the evaluation design and results.

### **3.2 Enforcement Elements**

Each enforcement wave consisted of two weeks of enforcement plus educational and engineering components. Educational and engineering interventions are described separately in subsequent sections. During the enforcement wave, each of the six enforcement sites received between two and three enforcement operations, for a total of sixteen per wave. The schedule of enforcement operations and concomitant education and engineering interventions is presented in Table 1.

Because Ann Arbor had not conducted previous high visibility pedestrian right-of-way enforcement operations, the first two-week enforcement wave during the last two weeks of June of 2017 involved warnings, unless the violation was very flagrant. During this period, police gave 1,411 warnings. Examples of flagrant violations were driving very close to the pedestrian and swerving to avoid hitting the pedestrian or if the pedestrian had to step back to avoid a non-stopping vehicle. Warnings were issued during the first phase to generate driver and public support for the program goals and to maximize the number of traffic stops observed by other drivers. The remaining four two-week enforcement operations all involved issuing citations to drivers that violated the pedestrian right-of-way statutes. During the second enforcement wave during the middle two weeks of August 2107, police officers wrote 316 citations for failure to stop for pedestrians and 56 warnings. During the third wave the first half of October of 2017, they wrote 227 citations and 64 warnings. During the fourth wave in November of 2017, officers wrote 163 citations and 51 warnings. During the final wave in June of 2018, 138 citations and 76 warnings were issued. A total of 1,658 warnings and 844 citations were given during this experiment for a total of 2,502 traffic stops.

#### **3.2.2 Preparation for the deployment of the enforcement elements**

The team also briefed civic leaders during early meetings because support of government leaders is essential for the long-term success of police enforcement of pedestrian right-of-way programs for two reasons. First, civic leaders shape funding priorities and their support is essential if the program is to continue. Second, an engaged leadership helps avoid miscommunication should residents reach out to make complaints.

Prior to the first wave of enforcement, the local team conducted outreach to the public. Informing the public prior to the start of the program helps ensure people are aware of why police are enforcing pedestrian right-of-way and that the police will begin enforcement soon. Warning and enforcement flyers clearly identified the issue to drivers and informed them their help was needed in solving it. More detail on this program component is included under the section on public education.

### **3.2.3 Officer Training**

Officers were shown a series of PowerPoint slides comparing the pedestrian injury and fatality statistics in Ann Arbor. This was followed by a lesson on State pedestrian right-of-way laws at uncontrolled crosswalks. Officers were also given a card that showed the distance to the dilemma zone for roads based on the speed limit. This segment also included: the definition of a crosswalk; the requirements for motorists and pedestrians at marked uncontrolled crosswalks; and the definition of an unmarked crosswalk. The next series of slides explained the importance of employing a HVE approach to pedestrian right-of-way enforcement and reviewed enforcement, education, and engineering components of a HVE pedestrian right-of-way operation.

Next, officers and the research team walked through how to conduct a safe and effective enforcement operation in the field. Considerable emphasis was placed on using the standard crossing protocol because it helps ensure citations will be upheld in court and, most importantly, ensures the safety of officers serving as decoy pedestrians. Much of this work involved conducting actual pedestrian right-of-way enforcement operations in the field. Operations were conducted at three sites that sampled very different crosswalk characteristics to ensure that officers were prepared to conduct operations at all of the selected enforcement sites.

### **3.2.4 The Use of Decoy Pedestrians**

Police officers in plain clothes crossed as decoy pedestrians. This feature of the program provided three important advantages:

- Officers could maximize the number of stops during an operation. If police had to wait for pedestrians to cross, there would have been down time because pedestrians sometimes arrive when there are no vehicles present, and because there are not as many pedestrians as vehicles at most locations.
- Officers crossed in accordance with the crosswalk statutes to ensure that citations, when they are given, stand up in court.

- Officers did not cross if the vehicle was inside the dilemma zone. This ensured that they could stop all vehicles that did failed to give right-of-way to pedestrians.

### 3.2.5 The Use of Warning Flyers

Warning flyers reminded drivers of Ann Arbor's crosswalk ordinance, informed them not to pass vehicles stopped at crosswalks, check to see if a crosswalk is clear before turning and asked drivers for their cooperation. The use of warnings offers several advantages over citations when people violate a law: it serves as an initial education phase; it allows a larger number of violators to be stopped because warnings take less time to issue than citations; and, it allows officers to use a short standardized script that points out how serious the problem is, tells the person they are only getting a warning this time, and asks them to help make their community a safer place by sharing the information they have received with friends and neighbors. It also permits the officer to ask the driver to serve as a model by stopping the next time he/she sees a pedestrian in a crosswalk.

### 3.2.5 The Use of Large Sandwich Board Signs at the Flagging Areas

Sandwich board signs were set up at the flagging areas downstream from enforcement sites at the flagging site where violators were pulled over. Because pedestrian enforcement had not been conducted as frequently as seatbelt or speed limit enforcement, these signs ensured that motorists passing that pedestrian right-of-way enforcement was being conducted. This component increased driver awareness and the visibility of the enforcement operations. A picture of a sandwich board sign is shown in Figure 2.



**Figure 2. Picture of a sign used at a flagging area.**

### **3.3 Education Elements**

Educational elements are critical to the success of HVE programs. These divide into proactive and concurrent components. Proactive components focus on preparing people for the program and enlisting their cooperation before enforcement is initiated. Concurrent elements are implemented alongside enforcement to enhance its efficacy.

#### **3.3.1 School Flyers**

School flyers were proactive and had two components. One flyer provided information on pedestrian safety for children and drivers. The second flyer was a notice that warned parents that enforcement was about to begin and asked them to be good community models by stopping for pedestrians. This component went home along with the safety flyer to the parents of all elementary and middle school students in Ann Arbor.

#### **3.3.2 Earned and Paid Media**

Because the City of Ann Arbor was located at the periphery of the much larger Detroit metro media market it was difficult to attract much earned media attention. Because the program attracted nearly no earned media, the City of Ann Arbor decided to buy ad time promoting Ann Arbor's crosswalk ordinance during the final enforcement phase. They invested \$20,000 to produce digital graphics and a 30-second ad. They also spent \$55,000, in total, on television advertising, which included network (ABC, CBS, NBC and FOX), cable (HGTV, Bravo, DIY, ENT, Food Network, ESPN2,) and Comcast online. They also produced 18" x 24" posters for local organizations and businesses. Almost all media coverage occurred during the final phase of the study between the first week of May and the middle of June, 2018.

#### **3.3.3 Feedback Sign**

Feedback signs were erected along busy roads within the city. These signs displayed the percentage of drivers stopping for pedestrians each week along with the highest level of stopping for a week attained to date (Record). The data presented on the signs was based on the data collected by the research assistants, and was changed every Monday based on the average percentage of drivers stopping the previous week. These signs were smaller than the ones used in Gainesville but more signs were installed. Signs were each four feet wide and two and a half feet high. A total of eight signs were installed. Signs were installed and activated the week of September 25, 2017. The numbers were removed during the winter and early spring when data were not collected. Posted feedback resumed when data collection started again at the beginning of June, 2018. Figure 3 shows two of the eight signs.





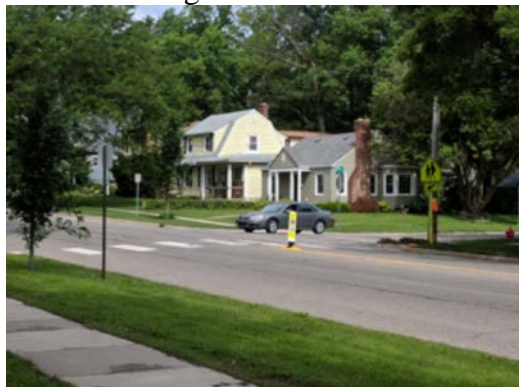
**Figure 3. Photos of two of the eight Feedback Sign.**

### 3.4 Engineering Element

The engineering elements included the use in-street signs warning drivers that it was a local law to stop for pedestrians at crosswalks. An in-street sign on the median island or centerline was added to all treatment sites during this condition except the site at the midblock site at Nixon at Travers village. One generalization site, the midblock crosswalk on Huron had several had in-street signs throughout the study including the baseline period. In street signs were added to three of the generalization sites including and several of the generalization sites during the final phase of the experiment.

#### **In-Street LOCAL LAW STOP FOR PEDESTRIAN Signs**

These signs were placed in the center of the road or in the median next to crosswalks. They reminded motorists that they were required by local ordinance to stop for pedestrians in crosswalks. Figure 5 shows a site with the in-street signs installed.



**Figure 5. An image of the in-street sign at Pauline and 5<sup>th</sup>.**

## 4 COORDINATION OF TREATMENT ELEMENTS

There are several reasons why sequencing is crucial when implementing a HVE program. First, sequencing is necessary to maintain the interest of the paper and electronic media. Novel elements were paired with each enforcement wave to make the story newsworthy. Second, pairing elements can help develop synergistic effects where the sum of the parts produces a larger effect than the component parts. The diagram presented in Figure 5 shows the timing of each of the scheduled events over the program year.

YEAR	2017						2018				
HVE Element	MONTH										
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	May	Jun	Jul
Warnings											
Citations											
Parent Outreach											
Feedback Signs											
Earned Media											
Paid Media											
In-Street Signs											

**Figure 5. Diagram showing when each treatment was introduced.**

## 4 DESIGN AND RESULTS

The evaluation included measurements of stopping for pedestrians for treatment and generalization sites. Stopping for pedestrians at the generalization sites which did not receive treatment indicated the change in community behavior.

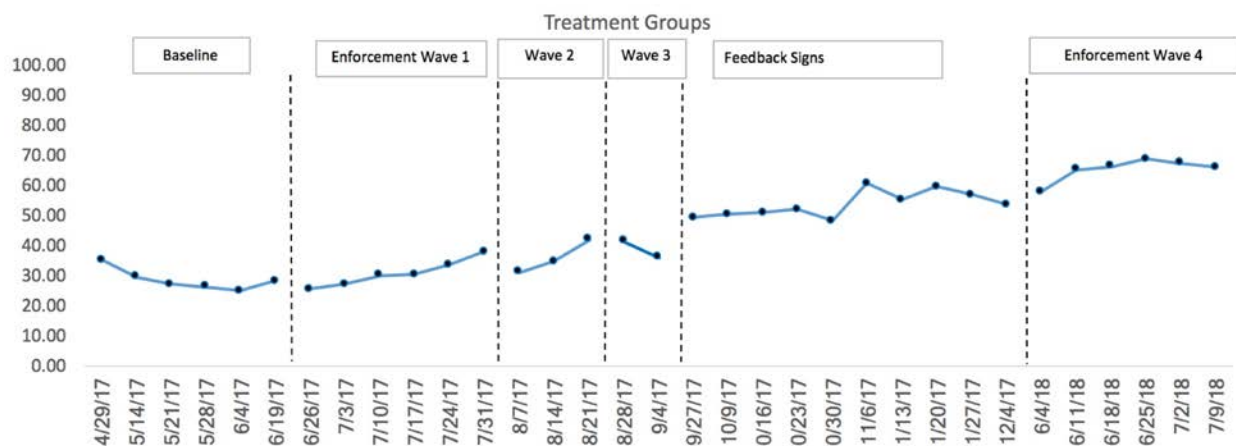
### 4.1 Stopping Results

Stopping results for enforcement and generalization sites were examined for staged and naturally occurring pedestrians.

#### 4.1.1 Stopping Results at Enforcement Sites

The average percent of drivers stopping for staged crossings during baseline and following each successive enforcement wave averaged across all enforcement sites are presented in Figure 6. It is clear that stopping increased following the initiation of the high visibility pedestrian right-of-way enforcement program at enforcement sites and stopping showed an

increasing pattern over the duration of the program.



**Figure 6. The Mean Percent of drivers stopping for pedestrians at enforcement sites during each condition of the experiment.**

The individual site data are shown in tabular form in Table 1a for staged crossings for the enforcement sites. Stopping for staged crossings averaged 28.5% during baseline and 62.2% by the end of the study. Two of the sites (Nixon at Travers Village, Pontiac Trail at Taylor) showed little or no increase until posted feedback was introduced. The remaining sites showed a more gradual increase over the course of the study. Data for natural crossing at the enforcement sites are shown in Table 1b. Stopping for natural crossing improved in four of the six sites prior to the introduction of posted feedback, stopping for natural crossings improved at the remaining sites (Pauline Blvd. at Fifth and Miller Ave. at Newport Pl.) when the feedback signs were introduced.

**Table 1a. The percentage of drivers stopping for pedestrians for staged crossings at each enforcement site during each condition of the experiment.**

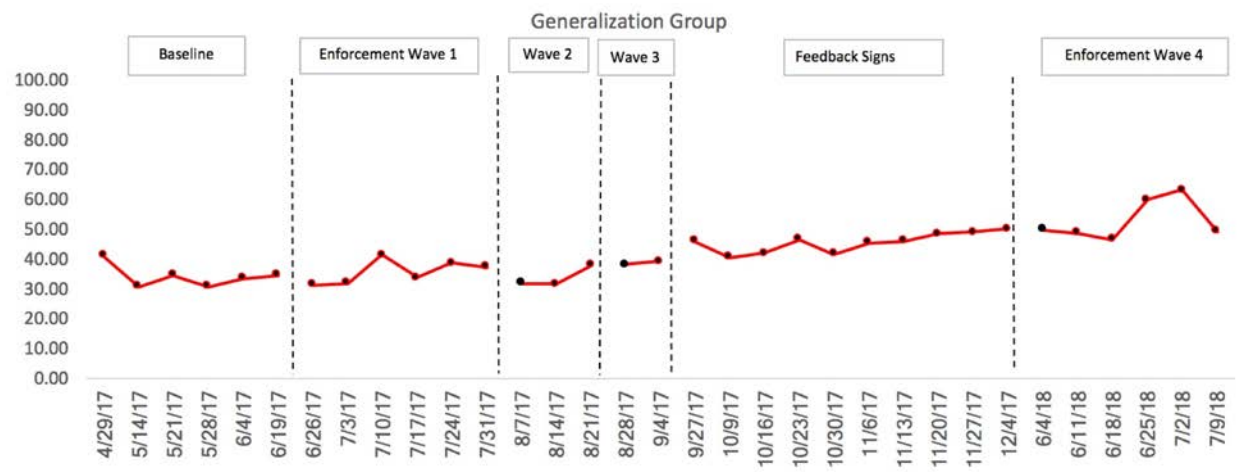
	Site	Baseline	Enforcement	Enforcement & Ticketing 1	Enforcement & Ticketing 2	Enforcement 3 & Feedback Signs	Enforcement 4 & Feedback Signs
Staged	Nixon Rd. at Traver Village	30	26	28	25	60	56
	Platt Rd. South of Redwood Ave.	25	41	48	43	51	66
	Liberty St. at Crest Ave.	30	34	30	39	44	51
	Pauline Blvd at 5 <sup>th</sup>	27	18	32	40	43	75
	Pontiac Trail at Taylor St.	12	14	20	21	66	66
	Miller Ave. at Newport Pl.	47	51	57	64	78	77
	<b>MEAN</b>	<b>28.5</b>	<b>30.7</b>	<b>35.8</b>	<b>38.7</b>	<b>57.0</b>	<b>65.2</b>

**Table 1b. The percentage of drivers stopping for pedestrians for natural or unstaged crossings at each enforcement site during each condition of the experiment.**

	Site	Baseline	Enforcement	Enforcement & Ticketing 1	Enforcement & Ticketing 2	Enforcement 3 & Feedback Signs	Enforcement 4 & Feedback Signs
Staged	Nixon Rd. at Traver Village	10	27	85	NA	55	100
	Platt Rd. South of Redwood Ave.	0	NA	0	NA	55	59
	Liberty St. at Crest Ave.	30	15	NA	NA	58	70
	Pauline Blvd at 5 <sup>th</sup>	40	33	NA	16	100	69
	Pontiac Trail at Taylor St.	0	58	100	NA	85	100
	Miller Ave. at Newport Pl.	63	50	NA	36	78	NA
	<b>MEAN</b>	<b>23.8</b>	<b>36.6</b>	<b>61.7</b>	<b>26.0</b>	<b>71.8</b>	<b>79.6</b>

#### 4.1.2 Yielding Results at Generalization Sites

The average percent of drivers stopping for pedestrians for staged crossings during baseline and following each successive enforcement wave averaged across all generalization sites are presented in Figure 7. It is clear that stopping also increased at the generalization sites following the initiation of the high visibility pedestrian right-of-way enforcement program at the enforcement sites and stopping also showed an increasing pattern over the duration of the program at these sites.



**Figure 7. Mean percent of drivers yielding to pedestrians at the generalization sites during each condition of the experiment.**

Data for staged crossings are shown in tabular form for the generalization sites in Table 2a. Stopping at these sites averaged 34.2% during baseline and 53.0% percent at the end of the study. Two of these sites showed a marked increase in stopping when the feedback signs were added (Fuller Rd at Fuller Park, and Nixon at Plymouth), two showed steady improvement, (E. Huron and Platt Rd at Williamsburg) and two showed little or no improvement over the course of the study (Maiden Ln. at Neilson Ct., and State St.). One of these sites showed only a 4% improvement while the other showed a 14% improvement. This was similar to the results of the Gainesville study where one generalization site only showed a 9% improvement and the other a 17% improvement. It is noteworthy that both of the poor performing Gainesville sites showed significant improvement during follow-up measure obtained four years after the end of the program. Data for natural crossing at the generalization sites is shown in Table 2b. Data for natural crossing at the generalization sites are shown in Table 2b. Yielding for natural crossing improved in five of the six sites while one site with a high level of yielding during baseline (E. Huron St. at Thayer) remained high throughout the study.

**Table 2a. The percentage of drivers stopping for pedestrians for staged crossing at each generalization site during each condition of the experiment**

	Site	Baseline	Enforcement	Enforcement & Ticketing 1	Enforcement & Ticketing 2	Enforcement 3 & Feedback Signs	Enforcement 4 & Feedback Signs
Staged	Fuller Rd at Fuller Park	33	20	23	28	54	59
	E. Huron Street west of Thayer	73	83	73	84	81	90
	Nixon at Bus Stop at Plymouth	47	44	38	37	60	69
	Platt Rd. N of Williamsburg Rd.	31	44	43	46	44	61
	Maiden Lane at Neilson Court	11	12	19	26	24	25
	State Street at Stadium Overpasst	10	9	6	10	10	14
	<b>MEAN</b>	<b>34.2</b>	<b>35.3</b>	<b>33.7</b>	<b>38.5</b>	<b>45.5</b>	<b>53.0</b>

**Table 2b. The percentage of drivers stopping for pedestrians for to natural or unstaged crossings at each generalization site during each condition of the experiment.**

	Site	Baseline	Enforcement	Enforcement & Ticketing 1	Enforcement & Ticketing 2	Enforcement 3 & Feedback Signs	Enforcement 4 & Feedback Signs
Staged	Fuller Rd at Fuller Park	50	68	55	0	80	76
	E. Huron Street west of Thayer	92	93	100	85	97	100
	Nixon at Bus Stop at Plymouth	44	50	90	22	82	90
	Platt Rd. N of Williamsburg Rd.	25	NA	66	NA	49	83
	Maiden Lane at Neilson Court	8	50	NA	27	NA	NA
	State Street at Stadium Overpasst	0	33	0	NA	35	35
	<b>MEAN</b>	<b>36.5</b>	<b>58.8</b>	<b>62.2</b>	<b>33.5</b>	<b>68.6</b>	<b>76.8</b>

## 4.2 Statistical Analysis of Stopping Results

The research design provided multiple sources of data that were subjected to formal statistical evaluation. These analyses were carried out to determine: (1) whether the evidence supports the conclusion that there are overall effects of the interventions at the enforced sites, and if so, the size of these effects; (2) whether the interventions generalized to other sites, and if so, the magnitude of the generalization. The results of the regression analysis are shown in Table 3a. The results of the t test are shown in Table 3b. The results indicate that the changes are highly significant. The regression analysis shows the changes were not the results of the passage of time.

**Table 3a. Results of the regression analysis.**

	LC	P-Value	Sc	P-Value	Baseline Level	Level at end of study	End Level Minus Baseline
Treatment Groups	38.08	0.0001	2.853	0.02	28.39	65.07	36.68
Generalization Group	17.56	0.027	2.43	0.23	34.04	52.82	18.78

**Table 3b. Results of the t-tests.**

T-test Results Baseline Vs. Enforcement Wave 4		
	T-Value	P-Value
Treatment Groups	-12.13	0.0001
Generalization Group	-5.24	0.003

### 4.3 Crash Results

Crash data are not yet available to cover the period after the crashes. These data will be of particular interest once they become available. Crash data for the period five years before the program are available and after data after the program should be available in 2020.

## 5. DISCUSSION

This study was designed to evaluate whether the effect of a high visibility pedestrian enforcement operation on driver yielding right-of-way to pedestrians documented in Gainesville, Florida could be replicated in another city in a different part of the country that had a winter hiatus from enforcement. A second purpose was to determine whether similar effects could be obtained in a city at the periphery of their media market. In order to establish a perception of a high level of enforcement, it was essential that the program attract broad attention within the community. This was achieved by implementing frequent prompts or reminders to drivers through a number of measures that help ensure broad media coverage, by sending reminders to parents and other community stakeholders, providing community feedback, paid media, and signs at crosswalks that remind drivers of the legal obligation to stop and yield right-of-way at crosswalks.

It is important to recognize that there are two distinct mechanisms for increasing the visibility of enforcement operations. First, the operation itself is highly visible if many vehicles are stopped and the nature of the enforcement operation is conveyed to drivers that pass the location where the operation is being carried out. Therefore, it is important that operations are carried out on busy streets where police make numerous stops and set up signs that communicate to passing drivers why vehicles are being stopped. Second, one can increase the perception of enforcement by widely publicizing that police will be enforcing pedestrian right-of-way at crosswalks. One critical element is the use of feedback signs. Several of the treatment and generalization sites only showed improvement when these signs were implemented, and the improvement was sudden and marked. At other sites it is likely the signs facilitated the steady improvement in stopping for pedestrians.

This study produced three interesting results.

1. As in Gainesville, the enforcement led to a slow and steady increase in the percentage of drivers giving right-of-way to pedestrians over the course of the year.
2. The program produced a marked increase in stopping behavior. This effect was particularly apparent at some sites when highway feedback signs were added.
3. The effects of the program generalized to crosswalks that were not targeted for pedestrian right-of-way enforcement.

The slow but steady increase in stopping behavior over the course of the study provides added evidence that the high visibility elements that were introduced in a stepwise manner contributed to the overall success of the program. If drivers only responded to actual enforcement operations it would be more likely that the effects would be confined to sites that received enforcement.

Stopping for pedestrians increased from a mean of 28.5% to 65.2% at the treatment sites, which also received police enforcement, and from 34.2% to 53% at the generalization sites that did not receive police enforcement. These changes were very similar to those observed in the city of Gainesville Florida. The finding indicated that the use of the feedback signs showing the percentage of motorists stopping for pedestrians each week along with the record was a key element of the packages success.

The study also demonstrated that the high visibility enforcement method employed in Gainesville could be effective in a city that was not geographically isolated from other urban area because the City of Ann Arbor is near the large Detroit metropolitan area. The Ann Arbor replication also demonstrates that the program could work in another region of the country where it has to be suspended during winter months.

It is also interesting that drivers gave right-of-way at somewhat higher levels to naturally-occurring pedestrian crossings than to staged crossings during all but the baseline condition. These data replicate a finding by Van Houten, Ellis, and Marmolejo (2008) who found that yielding to an engineering treatment was higher for natural occurring pedestrians than for staged crossings. One possible reason for this effect is that naturally occurring pedestrians may cross more assertively than pedestrians following a safety protocol for staged crossing. For example, in staged crossing the pedestrian only steps into the crosswalk with one foot while natural occurring pedestrians often take several steps into the crosswalk. While drivers are legally required to stop for pedestrians that enter the crosswalk either way, pedestrians that take several steps are likely more visible and may be perceived as more determined to cross the street.

## **5.2 Future Research**

Additional research should determine whether the number or duration of enforcement waves needs to be increased in larger cities in order to produce similar changes in stopping behavior. The population of Ann Arbor (120,782) and the population of Gainesville (131,591) were very similar. It is also the case that both sites had a large University with the city limits. It is critical to determine whether this approach would work in cities between 300,000 and a million in size. One very interesting finding was the role the highway feedback signs played on driver program awareness. These signs may be an effective way to promote both enforcement and community support for safer driving behavior. Other research has shown that community feedback signs can also increase seatbelt use (Malenfant, Wells, Van Houten, & Williams, 1996; Wells, Malenfant, Williams, & Van Houten, 2000) and reduce speeding behavior (Van Houten & Nau, 1983; Van Houten, et al., 1985; Van Houten, Roider, Nau, Friedmann, Becker, Chalodovsky, & Scherer, 1985; Scherer, Friedman, Rolider, & Van Houten, 1985). It also appears that single in-street sign may be more effective when introduced during an enforcement wave. Research should further explore whether in street signs work better when accompanied by police enforcement of pedestrian right-of-way. Follow-up data should also be collected after 4 years to determine whether further improvements will occur in Ann Arbor, as was the case in Gainesville.

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