The Effect of High-Visibility Enforcement on Driver Compliance With Pedestrian Right-of-Way Laws

4-Year Follow-Up

U.S. Department of Transportation
National Highway Traffic Safety Administration

NHTSA

Disclaimer

Suggested APA Citation:

Van Houten, R., Malenfant, L., Blomberg, R. D., & Huitema, B. E. (2017, January). *The effect of high-visibility enforcement on driver compliance with pedestrian right-of-way laws: 4-year follow-up* (Report No. DOT HS 812 364). Washington, DC: National Highway Traffic Safety Administration.

Technical Report Documentation Page

1. Report No. DOT HS 812 364	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subject The Effect of High-Visibility Enforcement on Driver Compliance With Pedestrian Right-of-Way Laws: Four-Year Follow-Up		5. Report Date January 2017 6. Performing Organization Code
7. Authors Ron Van Houten, Louis Malenfant, Richard D. Blomberg,[a] & Bradley E. Huitema		8. Performing Organization Report No.
9. Performing Organization Name and Address Western Michigan University Psychology Department 3700 Wood Hall Kalamazoo, MI 49008		10. Work Unit No. (TRAIS) 11. Contract or Grant No. DTNH22-11-D-00228/0001
12. Sponsoring Agency Name and Address National Highway Traffic Safety Administration 1200 New Jersey Avenue SE. Washington, DC 20590		13. Type of Report and Period Covered Final Report 09/16/14 – 09/16/15 14. Sponsoring Agency Code
15. Supplementary Notes [a]Richard D. Blomberg is with Dunlap and Associates, Inc. Kristie Johnson, Ph.D., was the NHTSA Task Order Manager.		

16. Abstract

This is a follow-up to a previous study titled *High-Visibility Enforcement on Driver Compliance With Pedestrian Right-of-Way Laws* to determine the extent observed increases in driver yielding in the previous study persisted nearly 4 years after the high-visibility enforcement intervention program ended. The study involved no new enforcement or publicity. Observers collected data on staged and naturally occurring crossings at the same six sites used in the previous study and at the same six spillover effect sites where no enforcement had taken place. The same observation procedures were used as in the original study. Results showed yielding behavior continued on an upward trend with both the enforcement and generalization sites exhibiting significantly higher rates of driver yielding during the follow-up than at the end of the intervention almost 4 years earlier. Yielding rates averaged 76.5% at the enforcement sites and 77.0% at the generalization sites. Thus, above and beyond the significant increase documented by the original study from before to immediately after the intervention, this study showed an additional significant increase in yielding from the end of the intervention to the follow-up. The results suggest a notable and continuing increase in general deterrence, a fundamental change in driver behavior and courtesy to pedestrians crossing the road, or both. However, a caveat of the increased yielding results is that it is unknown if similar changes took place in surrounding localities that may suggest additional factors affecting change other than the HVE program.

17. Key Words culture change; persistence of program results; pedestrian decoy operations; pedestrian right-of-way enforcement; high-visibility enforcement; HVE; crosswalk safety; warning program; multifaceted pedestrian right-of-way enforcement; community feedback; yielding.	18. Distribution Statement This report is free of charge from the NHTSA Web site at www.nhtsa.dot.gov

19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 29	22. Price

Form DOT F 1700.7 (8-72)

ACKNOWLEDGMENTS

This project was conducted by the Western Michigan University Department of Psychology under contract with the National Highway Traffic Safety Administration. The authors are grateful for the dedication and insights provided by Gainesville Police Department personnel, especially Lieutenant Joseph H. Raulerson, the head of the traffic division.

Executive Summary

This follow-up study on *High-visibility Enforcement on Driver Compliance With Pedestrian Right-of-Way Laws* demonstrates the extent to which the observed increases in driver yielding obtained in a previous study (Van Houten, Malenfant, Blomberg, Huitema, & Casella, 2013) persisted approximately 4 years after the program ended.

Background

On average, a traffic crash results in a pedestrian death every 2 hours and a pedestrian injury every 8 minutes (National Center for Statistics and Analysis, 2015). Research indicates that a lack of driver compliance with laws requiring a driver to yield to pedestrians at crosswalks causes many of the pedestrian motor vehicle crashes at intersections (Hunter, Stutts, Pein, & Chante, 1996). High-visibility enforcement (HVE) represents one possible way to increase general deterrence among drivers and thereby improve their compliance with yield-to-pedestrian laws. The previous study developed and evaluated a yield-to-pedestrian HVE program in Gainesville, Florida in 2010. This program included high-visibility enforcement, community feedback signs, and low cost education and engineering interventions that were closely coordinated with the enforcement component. Research staff observed pedestrian staged and natural crossings at select locations before, during, and after the HVE program. Staged crossings involved crossings made by research assistants who followed a stringent crossing protocol. Natural crossings involved members of the community or visitors using the crosswalks. The results showed a significant increase in drivers yielding both to staged and naturally occurring pedestrian crossings. The present study assessed the extent to which the yielding behavior increase observed in the earlier study persisted. No additional enforcement operations occurred during the intervening period between the end of the HVE program and the present study.

Method and Results

Yielding behavior. This follow-up study included the collection of observational data on driver yielding behavior, acquisition and analysis of crash data, and informal discussions with Gainesville Police Department (GPD) personnel. It involved no new enforcement or publicity efforts beyond those normally undertaken by GPD. Observers collected data at the 12 crossing sites used in the original study. Six of these sites had enforcement during the original intervention and 6 sites (called generalization sites in this report) had no enforcement. Observations took place for three weeks in the late fall of 2014 and again for three weeks in the early spring of 2015.

The observations showed a continued increase in yielding behavior above that observed at the end of the original intervention. At the enforcement sites, the overall observed follow-up yielding rate to staged crossings was 76.5%, which was a statistically significant 8.3 percentage points above the value predicted from the experience in the first study and 10.5 percentage points (66%) above the last measured phase during the intervention period. Similar results were seen at the generalization sites with a 77.0% rate of overall observed follow-up yielding that were significantly (20.4 percentage points) above the predicted value and 18.5 percentage points (58.5%) above the final intervention phase measure.

Table ES 1
Mean Percentage of Drivers Yielding to Pedestrians at Enforcement and Generalization Sites by Phase of the Project

	Percentage of Drivers Yielding	
Phase	**Enforcement Sites**	**Generalization Sites**
Baseline	31.5	36.7
HVE 1 - Warnings, Flyers, Parent Outreach, University of Florida Outreach, & Earned Media	44.7	46.3
HVE 2 - Ticketing, Earned Media, Paid Radio Ads, & Feedback Signs	52.5	51.1
HVE 3 - Ticketing, Earned Media, & Feedback Signs	56.7	52.5
HVE 4 - Ticketing, Feedback Signs, & In-Street Signs	66.0	58.5
Follow-Up 2014	77.5	79.1
Follow-Up 2015	75.7	74.7

Crash data. From 2006 to 2010, when the HVE program was conducted, there were on average 101.2 pedestrian crashes per year (*SD*=8.0, *SE*=3.6) in Gainesville. From 2012 to 2014, after the program ended, the average number of pedestrian crashes per year dropped to 83.0 (*SD*=7.0, *SE*=4.0), which represents a statistically significant decrease, $t(6)=3.232$, $p=.02$, Mann-Whitney U-test, 0.001, $p=.03$.

Discussion

The present results indicate that the increase in yielding percentages seen in the original study not only persisted but also increased further as measured during the follow-up period. Moreover, both the enforcement and generalization sites showed this continued improvement. While it is unknown if similar yielding increases took place in surrounding localities that may suggest additional factors affecting change other than the HVE program, there were also changes in the number of pedestrian crashes in Gainesville. The yielding increases, together with the significant drop in pedestrian crashes after the end of the intervention, supports a conclusion of long-term program effectiveness and suggests the possibility of a substantial change in driving culture in relation to pedestrians.

The results of this study taken together with the findings of the original study lead to the conclusion that a large change in yielding occurred that may have been facilitated by driver perception of crosswalk enforcement and/or the need to yield to pedestrians at crosswalks. 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. In addition, 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. Once the majority of motorists were yielding to pedestrians, seeing other motorists consistently yielding to pedestrians may have 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. Overall, fear of a citation, the desire to be a good citizen, and social norming may all have played a role.

Table of Contents

List of Tables

List of Figures

Introduction

This report contains the results of a follow-up study on *High-Visibility Enforcement on Driver Compliance With Pedestrian Right-of-Way Laws.* The objective of this study was to determine the extent to which the observed increases in driver yielding obtained in a previous study by Van Houten, Malenfant, Blomberg, Huitema, & Casella (2013)[1] persisted over a follow-up period of approximately 4 years after the program ended.

Background

On average, a traffic crash results in a pedestrian death every 2 hours and a pedestrian injury every 8 minutes. In some cities, pedestrians account for as much as 50% of all traffic fatalities (NCSA, 2015). Over 20% of all fatal pedestrian crashes occur at intersection locations (NCSA, 2015). Research indicates that a lack of driver compliance with laws requiring a driver to yield to pedestrians at crosswalks causes many of the pedestrian motor vehicle crashes at intersections (Hunter, Stutts, Pein, & Chante, 1996). High-visibility enforcement (HVE) represents one possible way to increase general deterrence among drivers and thereby improve their compliance with yield-to-pedestrian laws.

The original study developed and evaluated strategies to increase driver yielding to pedestrians on a citywide basis using high-visibility pedestrian right-of-way enforcement over an extended period. After a site recruitment process, Gainesville, Florida, became the test site. Researchers selected 12 marked crosswalks at locations without a traffic signal or stop sign near pedestrian trip generators such as bus stops or parks. Researchers assigned six of these crosswalk sites to receive enforcement. The other six did not receive enforcement and served as comparison sites and as a test for spillover/generalization effects. Prior to beginning baseline data collection in January 2010, the city refurbished the crosswalk markings at all treatment and control sites to achieve homogeneous engineering treatments at all 12 sites.

The program evaluation for the original study consisted of weekly measurements of driver yielding behavior when approaching both research assistant pedestrians in staged crossings and actual pedestrians crossing at enforced and generalization sites. Staged crossing adhered to the following procedure. 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 yielding to pedestrians if they failed to yield. (The dilemma zone boundary is the point at which a decision has to be made to proceed through or stop for a traffic signal.) When the pedestrian first started to cross, only drivers in the first half of the roadway were scored for yielding. Once the pedestrian approached within a half lane of the center of the road, the yielding behaviors of motorists in the remaining lanes were scored. This procedure was followed because it conformed to the obligation of motorists specified in most motor vehicle statutes. Observers collected baseline data before the GPD conducted high-visibility crosswalk enforcement operations using decoy pedestrian crossings.

[1] The remainder of this report refers to the study by Van Houten et al. (2013) as the "earlier study" or the "original study" without repeated citations.

High-visibility enforcement included use of decoy pedestrian crossings, sandwich board signs set up at the flagging areas (area where drivers were pulled over for infractions and warnings/citations are issued) downstream from enforcement sites, and educational flyer distribution describing the seriousness of the problem and relevant laws/responsibilities. These sandwich board signs communicated to drivers traveling along the road that drivers were being stopped for failing to yield right-of-way to pedestrians. Because Gainesville had not conducted previous pedestrian right-of-way enforcement, the first 2-week enforcement wave involved giving warnings unless the violation was very flagrant. 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-yielding vehicle. During this period, police gave 1,177 warnings. 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. Gainesville police estimated that 5 to 7 times more warnings can be given than citations issued over a given time period as is reflected in the number of warning issued during this period versus the number of citations issued during the remaining periods. The remaining three 2-week enforcement operations all involved issuing citations to drivers that violated the pedestrian right-of-way statutes. During the second enforcement wave, police wrote 182 citations for failure to yield right-of-way to pedestrians. During the third wave, they wrote 153 citations and during the fourth wave, they wrote 66 citations. It should be noted that there were fewer violators during the last enforcement wave, resulting in fewer citations.

The program coupled the GPD enforcement with inexpensive engineering upgrades (e.g., advance yield markings, in-street STATE LAW YIELD TO PEDESTRIAN signs), education through earned media, and the deployment of road signs that provided feedback on the percentage of drivers yielding the right-of-way to pedestrians during the preceding week.

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 66% 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, 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 2011.

While the earlier 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 changes in the safety culture of drivers in Gainesville were unknown. The focus of the present effort was therefore to assess whether the results observed in the earlier study persisted and therefore possibly led to an enduring positive change in driver behavior and a long term safety benefit.

Method

This follow-up study included informal discussions with GPD personnel, the collection of citation data and observational data on driver yielding behavior, acquisition and analysis of crash data. It involved no new enforcement, publicity, or engineering efforts beyond those normally undertaken by GPD.

Discussions With Gainesville Police Department

Researchers held discussions with members of the GPD traffic division to determine what, if any, special activities related to yielding to pedestrians they had conducted since the end of the original study. These unstructured discussions helped place the results in context and aided the interpretation of the data.

Citations

Researchers obtained Gainesville citywide citation counts for the offenses of failure-to-yield to a pedestrian and for overtaking a yielding vehicle covering 2010 to 2014. These served as the best available measure of relevant enforcement activity by year. The department did not conduct failure to yield to pedestrian operations preceding the original study.

Observations

All observational data collection of driver yielding behavior followed the same protocols as in the earlier study. This report presents only a summary of the observation methods. For a more detailed description, the reader should refer to the final report from the original study. All observations were conducted within Gainesville.

The collection process used four observers, three of whom returned from the original study and therefore only required refresher training. The first step involved training the observers until they could attain an inter-observer agreement of 90% or more for two consecutive data sheets. **A data sheet consisted of 20 staged crossings and as many natural (non-staged) crossings as occurred naturally during the time it took to collect the staged events.**

Observers collected three data sheets each week at each of the 12 sites used in the original study (six originally used for enforcement and six as generalization sites) for 3 weeks in the late fall of 2014 and again for 3 weeks in the early spring of 2015. These measurements took place approximately 4 years after the end of the original study. Observers collected all data during daylight hours in the morning and afternoon on weekdays. Data collection did not take place if the pavement was wet. A local coordinator for data collection supervised observers and conducted regular reliability checks.

The 12 crosswalk locations used for observations included (see Figure 1):

Enforcement sites:

- SE 15th Street at 11th Avenue Lincoln Middle School,
- 782 SW 2nd Avenue at Shands Hospital,
- University of Florida crosswalk on Gale Lemerand Drive,
- NE 16th Street at Saint Patrick's Middle School,
- NW 13th Avenue midblock multilane crosswalk at Gainesville High School, and
- 300 SW 2nd Avenue at 1st Presbyterian Church.

Generalization sites:

- University of Florida crosswalk on Museum Road,
- NE 16th Avenue at NE 12th Street near Metcalfe Elementary School,
- NW 6th Street at the police station,
- NW 41st Street at a shopping center,
- SE 2nd Avenue at Sweetwater Park, and
- SW 2nd Avenue at the courthouse.

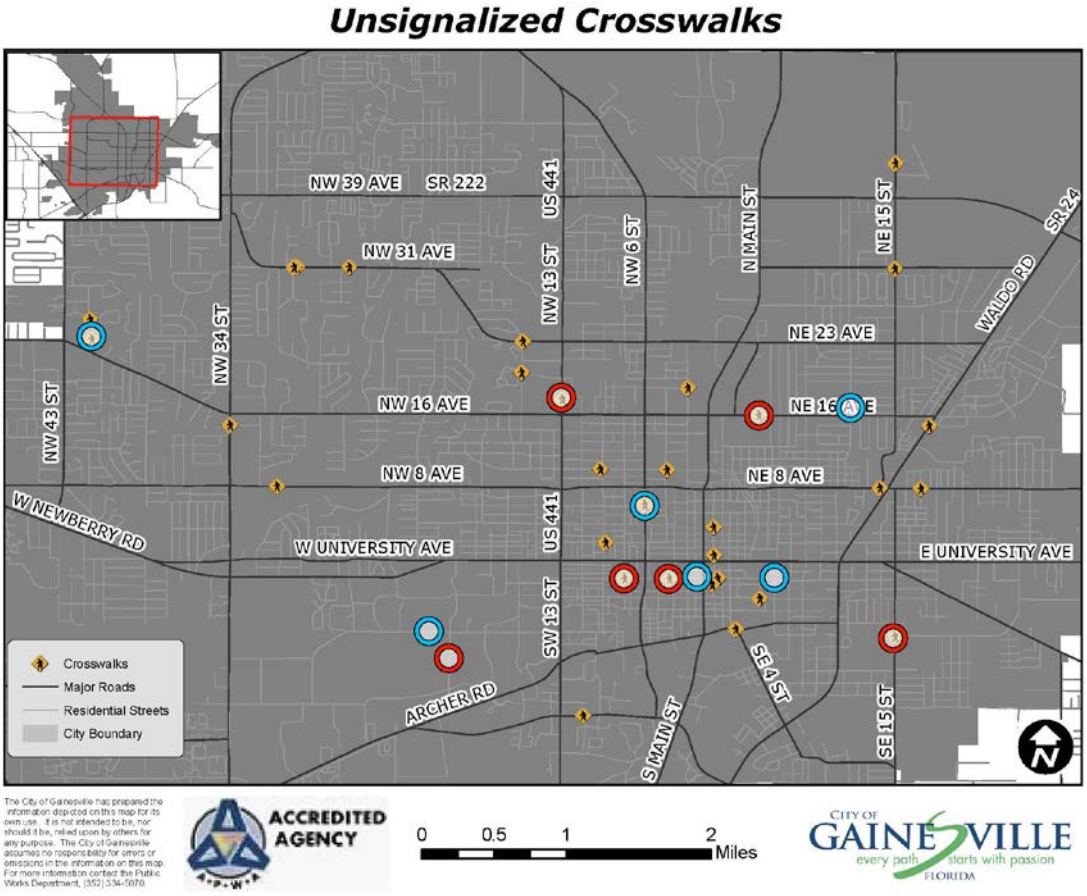

Figure 1. **Map of Gainesville Showing 6 Enforcement (Red) and 6 Generalization (Blue) Sites**

Crashes

The interval between the application of the enforcement and the end of the earlier study was relatively brief and therefore precluded any detailed examination of possible effects of the intervention on crashes. The passage of approximately 4 years between the original and present study provided an opportunity to examine crash trends and check for an association of crash outcomes with the timing of the increased enforcement. GPD provided pedestrian crash data covering 2006 to 2014.

Results

The results from this follow-up study encompass discussions with GPD, citations, observations of yielding, and crashes. The sections that follow present data covering the time period from the baseline of the original study through the completion of the data collection in the present follow-up effort. The reader should keep in mind that a break in measurements of almost 4 years took place after the end of the intervention phase of the original study.

Discussions With Gainesville Police Department

Gainesville had not made any engineering changes to any of the crosswalks studied in the original research. Some of the in-street signs had been damaged and had not been replaced. All of the markings at all of the sites were in good condition.

Citations

Figure 2 shows the number of citations issued for 2010 through 2014, inclusive. The figure indicates the effect of the original program by the large number of citations for failure to yield in 2010. The level of enforcement then generally dropped after the conclusion of the high-visibility enforcement program, but GPD did issue an increased number of citations in 2013. Discussions with GPD indicated that they issued most of these citations at a crosswalk near one of the high schools, a multi-lane site with a high traffic volume that had been resistant to previous intervention efforts.

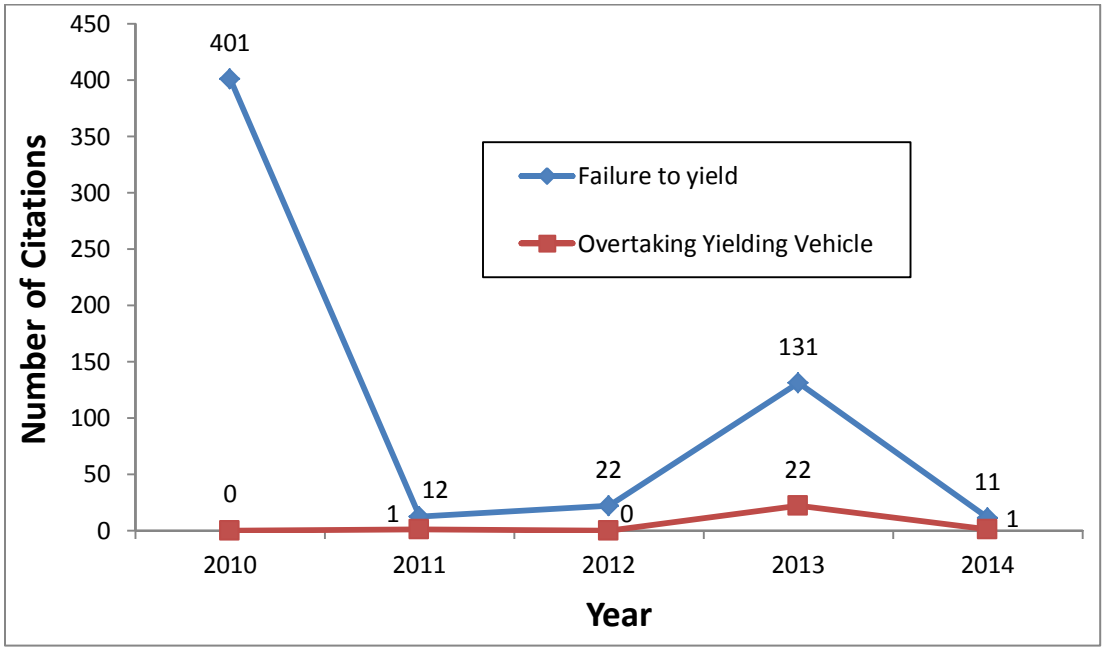

Figure 2. **Pedestrian Citations by Year**

Observations

Observations at the enforcement and generalization sites produced yielding data for staged and naturally occurring pedestrian crossings. The following sections first discuss the observed patterns of results and present statistical analyses separately for the enforcement and generalization sites, and finally compare the observations from the two types of sites. As with the citation data discussed above, the observation results cover the original study period as well as the new data collected for this follow-up. The observations are grouped into baseline, HVE, and follow-up periods. The baseline and HVE periods both occurred during the original study. The HVE period was divided into four phases that reflect the types of activities occurring:

- HVE 1 = Warnings, Flyers, Parent Outreach, University of Florida Outreach, and Earned Media,
- HVE 2 = Ticketing, Earned Media, and Feedback Signs,
- HVE 3 = Ticketing, Earned Media, Paid Radio Ads, & Feedback Signs, and
- HVE 4 = Ticketing, Feedback Signs, and In-Street Signs.

The follow-up observations were conducted approximately 3 years and 9 months (2014) and 4 years (2015) after the end of the original study program.

Yielding results at enforcement sites. Figure 3 shows the percentages of drivers yielding for staged crossings (averaged across all six enforcement sites) during baseline, the original study's intervention periods, and the two follow-up measures. The data show the increase in yielding observed during the original study persisted and may have increased during the two follow-up measurement periods.

Table 1 presents data for staged and unstaged crossings at each of the six enforcement sites for each study period. Table 1 collapses the various weekly measures in each phase shown in Figure 3 into a single compliance percentage for the period. An examination of Table 1 shows similar patterns of increased yielding for staged and unstaged crossings. Average yielding rates for staged crossings at the enforcement sites were 77.5% and 75.7% for the first and second follow-up measures, respectively. This represented a notable increase from the average of 66.0% yielding observed during the final measure of the original study. Yielding for unstaged crossing at these sites were similar to yielding for staged crossings. An entry of "No Data" in Table 1 and Table 2 indicates that no staged or natural pedestrian crossings occurred during the data collection periods. Note that unstaged crossing data is based on a much smaller sample size. During the follow-up period, unstaged crossing at the enforcement sites were consistent but based on very small numbers of pedestrians. During the follow-up period, the total number of pedestrians observed making staged crossings at the enforcement sites was 2,160 while the total number measured making natural crossings was only 378. At the control sites 2,160 pedestrians were observed with staged crossing but only 233 were observed making natural crossings. Although the data on natural crossings is based on a smaller number of pedestrians and includes one site where no pedestrians were observed, the results are consistent with the results for staged crossings.

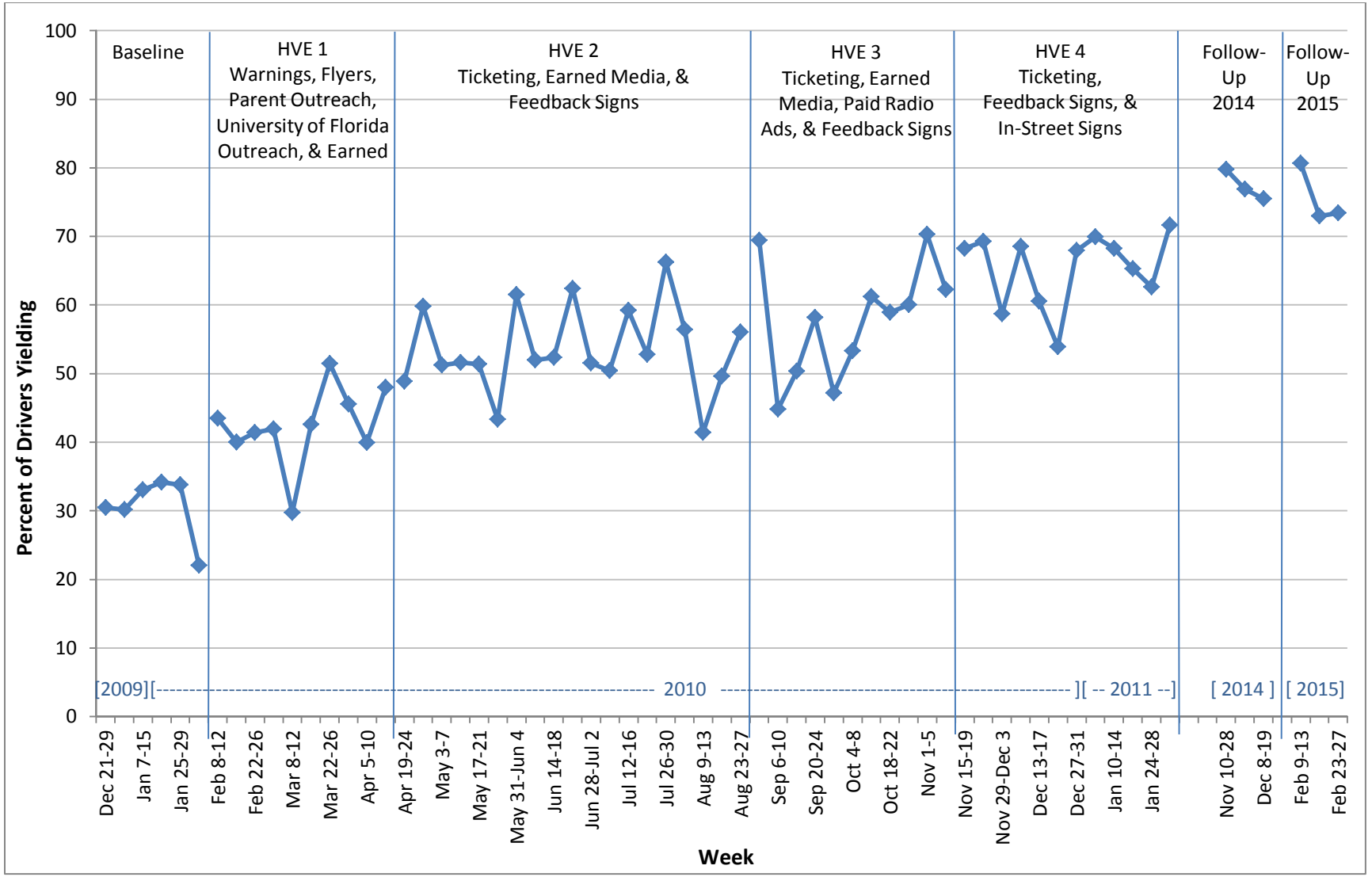

Figure 3. **Average Percentage of Drivers Yielding to Staged Crossings Across All 6 Enforcement Sites in Gainesville.**

Table 1
Percentage of Drivers Yielding by Type of Crossing and Time Period at Enforcement Sites*

	Site	Baseline	HVE 1	HVE 2	HVE 3	HVE 4	Follow-up 2014	Follow-up 2015
Staged	SE 15th St. at SE 11th	27.8	34.2	60.3	63.3	85.9	58.5	61.0
	782 SW 2nd Ave., AGH	30.9	49.0	64.9	63.4	66.2	92.5	88.1
	Gale Lemerand	86.2	85.6	82.3	85.9	86.4	94.6	93.34
	NE 16th St. at St. Pats	24.3	34.6	43.3	58.1	65.7	65.6	79.2
	NW13th St. at GHS	3.0	13.8	19.0	24.9	34.6	59.4	44.4
	300 SW 2nd Ave.	16.8	50.8	45.5	44.3	57.4	94.3	88.2
	Total Percent Yielding	**31.5**	**44.7**	**52.5**	**56.7**	**66.0**	**77.5**	**75.7**
Unstaged	SE 15th St. at SE 11th	29.2	59.5	83.3	56.3	91.7	No data	100
	782 SW 2nd Ave., AGH	56.5	55.0	83.3	80.0	80.6	100	90.5
	Gale Lemerand	86.3	71.9	85.4	84.6	89.0	88.2	87.0
	NE 16th St. at St. Pats	No Data	No Data	100.0	50.0	100.0	100	100
	NW13th St. at GHS	9.4	29.6	55.8	52.1	58.5	49.3	64.6
	300 SW 2nd Ave	No Data	No Data	50.0	No Data	No Data	94.4	87.2

* No Data for unstaged crossings means there were no natural pedestrian crossings when data was collected. HVE 1-4 descriptions are provided under the previous header Observations.
Total percentage of drivers yielding at unstaged crossing is not included because of the small and unequal number of pedestrians observed at each site during each period.

Yielding Results at Generalization Sites. Figure 4 shows the percentages of drivers yielding for staged crossings (averaged across all six generalization sites) during baseline, the original study intervention periods, and the two follow-up measures. As with the enforcement sites, the yielding percentage remained high even after the hiatus and may even have increased from the level at the end of the original study.

Table 2 presents the aggregate data for staged and unstaged crossings at the generalization crosswalks by time period and shows a pattern of higher yielding similar to that seen at the enforcement crosswalks. Yielding for staged crossings at generalization sites averaged 79.1% and 74.7% during the two follow-up measures, respectively. Yielding for unstaged crossings at these sites tended to be higher for the two follow-up measures, respectively. Both staged and unstaged crossings exhibited an increase in yielding from the closing values at the end of the original study.

Table 2
Percentage of Drivers Yielding by Type of Crossing and Time Period at Generalization Sites*

	Site	Baseline	HVE 1	HVE 2	HVE 3	HVE 4	Follow-up 2014	Follow-up 2015
Staged	Museum Road, Hume Hall	82.9	74.6	83.0	84.8	84.5	87.5	93.0
	NE 16th Ave. at NE 12th St.	13.6	39.2	30.3	32.8	47.1	52.5	57.4
	NW 6th Street at GPD	7.2	11.8	13.1	13.0	16.7	75.3	54.2
	NW 41st St at 2251 block	41.2	56.0	49.7	46.7	58.9	85.8	81.0
	SE 2nd Ave. Sweetwater Park	37.3	49.0	70.0	72.7	79.0	90.1	78.2
	NW 2nd Street at Courthouse	37.9	47.5	60.7	65.2	64.5	83.2	84.3
	Total Percent Yielding	**36.7**	**46.3**	**51.1**	**52.5**	**58.5**	**79.1**	**74.7**
Unstaged	Museum Road, Hume Hall	91.1	77.0	80.6	79.0	86.0	87.9	91.2
	NE 16th Ave. at NE 12th St.	0.0	0.0	50.0	No Data	100.0	100	83.3
	NW 6th Street at GPD	1.1	36.0	49.1	33.3	35.4	77.8	50
	NW 41st St at 2251 block	100.0	100.0	77.8	No Data	No Data	83.3	100
	SE 2nd Ave. Sweetwater Park	55.5	54.9	66.7	75.0	55.6	No Data	100
	NW 2nd Street at Courthouse	50.0	95.0	62.0	83.3	87.5	82.1	82.8

* No Data for unstaged crossings means there were no natural pedestrian crossings when data was collected. HVE 1-4 descriptions are provided under the previous header Observations.
Total percentage of drivers yielding at unstaged crossing is not included because of the small and unequal number of pedestrians observed at each site during each period.

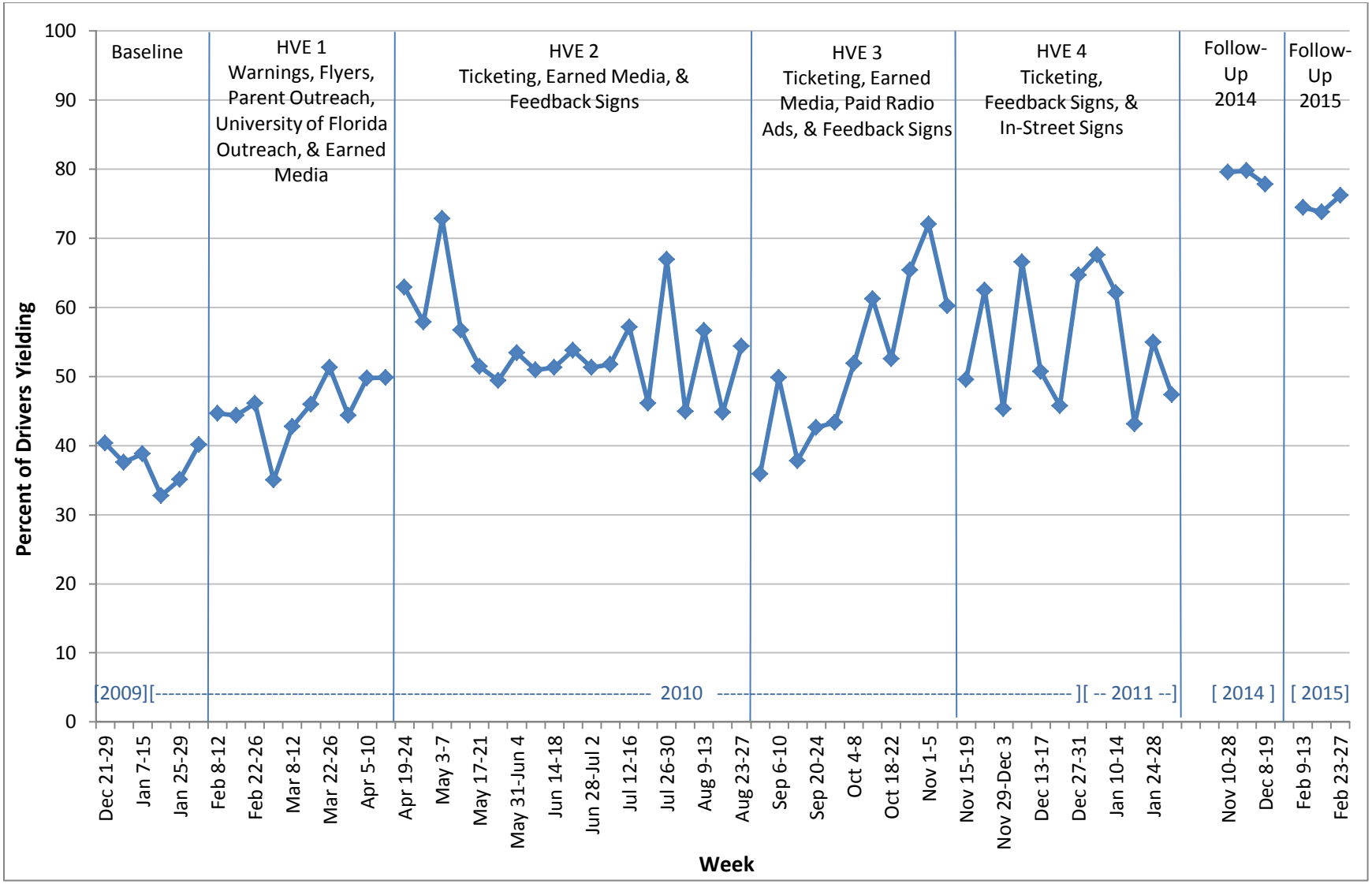

Figure 4. **Average Percentage of Drivers Yielding to Staged Crossings Across All 6 Generalization Sites in Gainesville.**

Statistical Analysis of Yielding Results

The objective of the statistical analysis was to determine if increases in yielding behavior documented in the original study persisted into the follow-up phase of the investigation. Analyses assessed persistence with respect to two prior time period points:

1. The baseline period of the original study, before any increased enforcement occurred, to determine if any residual effect remained. This assesses whether the program produced a net positive effect well after it concluded, and therefore likely produced a long-term gain – increased yielding to pedestrians by motorists. The comparison is baseline versus follow-up.

2. The end of the intervention phase, to determine if any further improvement or backsliding occurred. Using the end of intervention as a reference focuses more on persistence and post-intervention changes to examine the existence and nature of continuing change that could have resulted from the intervention. The comparison is the end of the intervention verses follow-up.

The comparison to the baseline is the most liberal. Statistically significant increases in yielding behavior from this analysis would only support a conclusion that some residual effect of the countermeasure likely remained. The second analysis examines the extent to which any observed effect in the follow-up measures changed from the level observed at the end of the intervention period. Since the original study showed a significant increase in yielding in the intervention period, a finding of no significant decrement or a significant increase at follow-up would support a conclusion of a sustained or heightened effect of the program even after withdrawal of the high-visibility enforcement.

Researchers applied interrupted time-series regression models of the general type described in Huitema (2011) to data sets that consisted of: (1) the weekly observational time series data obtained for the original study covering the baseline and intervention periods; and (2) the follow-up weekly time series data collected approximately 4 years later as part of this study. Overall, the data for each site included approximately 60 weeks of observation (ranging from 45 to 64 weeks) covering the original and this follow-up study combined. The analyses included only the data from the staged crossings since some sites had no unstaged crossing data. Moreover, the staged crossings involved standardized pedestrian behavior that removed one possibly large source of extraneous variation from the analyses. For example, all staged crossing involved only placing one foot off the curb and looking at approaching drivers. Natural pedestrians sometimes would often step further into the roadway. It is possible that the more assertive behavior of natural pedestrians increases the percentage of drivers yielding right-of-way to pedestrians.

The focus of the interrupted time-series analyses reported here is on the changes that occurred in driver yielding behavior between the baseline and follow-up and the end of the intervention phase and the follow-up level. The time-series specifically focused on level change types of differences. Since several different models can estimate level change, researchers had to

identify the most appropriate model for the time-series associated with each site and the composite data across all enforcement or generalization sites. The exact form of the level change analysis applied to the specific time-series from each site depended on the properties of the data collected at that site. It was possible to model some of the series using relatively simple level change models that could be estimated using conventional parametric intervention procedures. The series for most sites, however, required more complex models to accommodate trend components and/or autoregressive errors. The criteria used in model identification and diagnosis included lack-of-fit tests for the identification of functional form, tests for error dependency (Huitema & McKean, 2000, 2007; Durbin & Watson, 1950, 1951), and model comparison tests (e.g., Huitema, 2011). The method of estimating the final parameters depended on the properties of the model identified and included ordinary least squares, maximum likelihood, and the double-bootstrap method described in McKnight, McKean, and Huitema (2000).

Enforcement Sites. Figure 5 repeats the weekly yielding data from all six enforcement sites by study phase—baseline, intervention, and follow-up—previously shown in Figure 3. This analysis accounts for an interruption after the intervention phase. Figure 5 clearly suggests that driver yielding did not decrease and actually appears to increase during the follow-up phase. In order to confirm the validity of this impression, researchers conducted a formal statistical analysis of these data using the time-series approach discussed above.

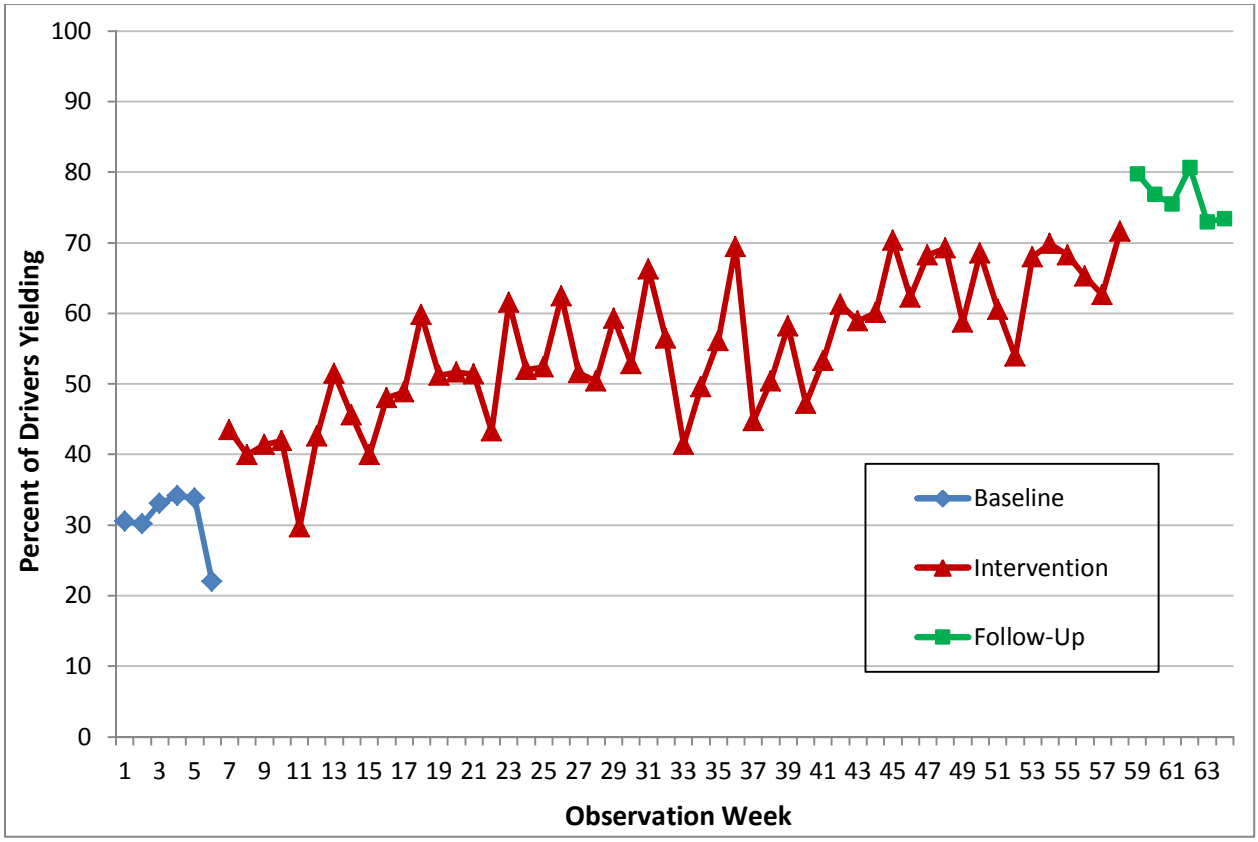

Figure 5. **Weekly Driver Yielding Percentage by Condition for Enforcement Sites**

Table 3 presents the results of this analysis. The overall follow-up level change value of 8.3 percentage points shown in the second column of Table 3 is the difference between projected and actual values for the follow-up period. That is, it represents the difference between the yielding percentage actually observed during follow-up (76.5) and the yielding percentage that a time-series intervention model projected would occur after the intervention phase should the same rate of increase continue (68.2). Hence, the level change calculates to 8.3 percentage points (76.5 – 68.2) as presented in Table 3. It also exceeds the statistical criterion for claiming that the follow-up level actually exceeded the yielding percentage seen at the end of the intervention period. The original study had shown that the intervention level was statistically higher than baseline. Hence, the follow-up level also significantly exceeded the baseline.

Table 3
Statistical Results for Pooled Enforcement Sites: Staged Crossings

Actual Observed Yielding Percentage in Follow-up Phase	Percentage Point Level Change from Intervention Phase	95% Confidence Interval on Level Change	*p-value* on Level Change
76.5	8.3	(2.2, 14.4)	.009

Researchers repeated the analysis described above separately for staged crossings at each of the six enforcement sites. The yielding levels all exceeded the baseline percentages. Four of the six sites had follow-up levels that were significantly greater than the prediction for the follow-up (i.e., mimicked the aggregate pattern). One site (NE 16th St. at St. Patrick's) showed an increase in the follow-up period, but it did not reach statistical significance. The remaining site (SE 15th St. at SE 11th Ave.) showed a significant decline from its intervention to follow-up levels but still exhibited a yielding level more than double its baseline value. While there is no definitive reason for the decrease in yielding at this site, it may be associated with the in-street pedestrian sign being damaged and subsequently not replaced.

The results for the individual enforcement sites and their aggregate establish that the intervention effects seen in the original study persisted with most increasing rather than remaining steady or falling back. The next analysis step involved assessing whether the same pattern existed for the six generalization sites.

Generalization Sites. The original study showed a positive effect (increased yielding) at the six generalization measurement sites where no intervention took place. As shown earlier in Table 2 and Figure 4, however, this effect was smaller than at the enforcement sites, but was of sufficient magnitude and consistency to suggest that the enforcement and education efforts may have spilled over beyond the six enforcement sites. Researchers, therefore, examined yielding data from the six generalization sites to evaluate any changes, either positive or negative, during the follow-up phase. The analysis followed the same approach as described above for the enforcement sites.

Figure 6 illustrates the yielding behavior for the three phases of the study (baseline, intervention, and follow-up) at the generalization sites. GPD did not apply any special

enforcement, education, or engineering to the six generalization sites providing the aggregate data shown in the figure. Nevertheless, there appears to be a dramatic increase in the yielding percentage during the follow-up phase. Researchers tested the significance of the change with time-series analyses as with the enforcement sites.

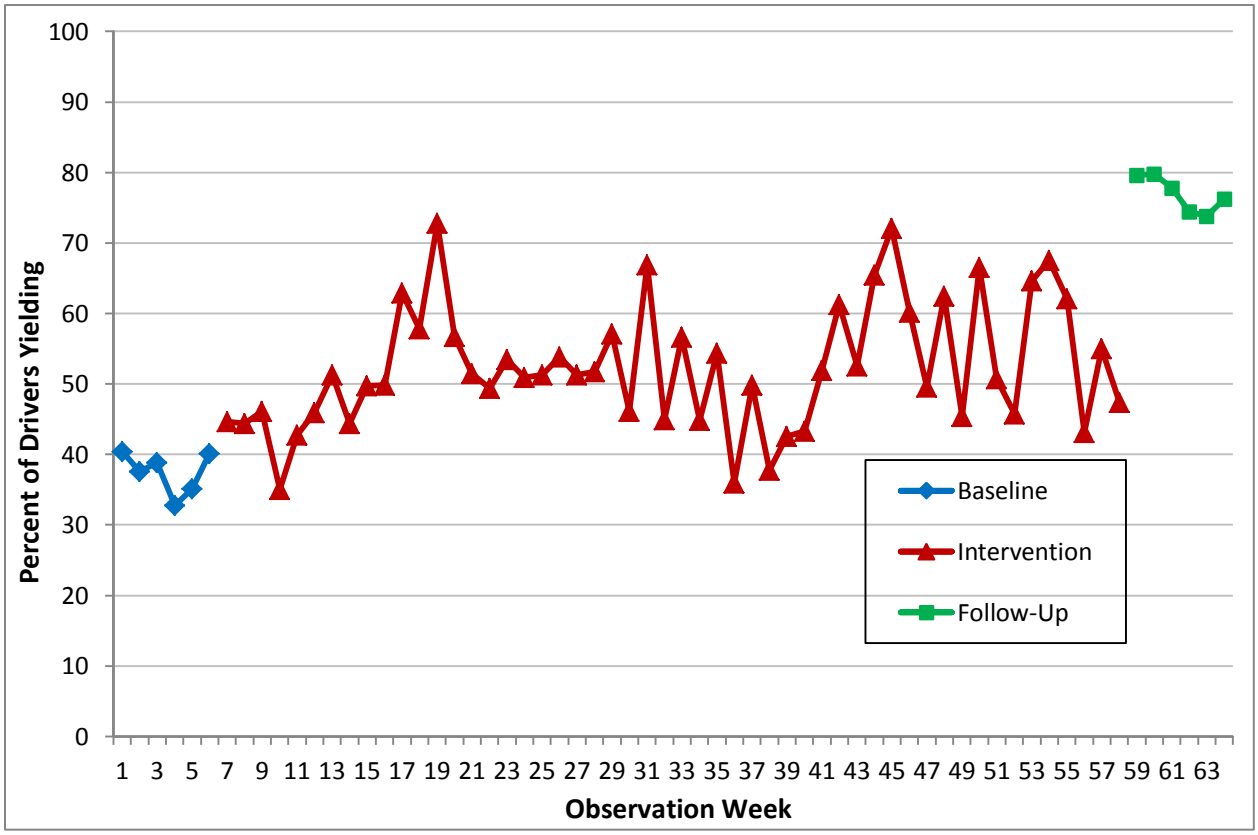

Figure 6. **Weekly Driver Yielding Percentage by Condition for Generalization Sites.**

Table 4 presents the results of the analysis of the pooled generalization sites. As with the earlier analysis, the overall follow-up level change value shown in the second column of Table 4 is the difference between projected and actual values for the follow-up period. The value of 20.4 (77.0 – 56.6) falls into the calculated 95% confidence interval shown in Table 4. Thus, the analysis shows that the observed increase of over 20 percentage points in the follow-up period is statistically significant. The analyses showed the follow-up yielding value to exceed both the baseline and the intervention levels.

Table 4
Statistical Results for Pooled Generalization Sites: Staged Crossings

Actual Observed Yielding Percentage in Follow-up Phase	Percentage Point Level Change from Intervention Phase	95% Confidence Interval on Level Change	*p-value* on Level Change
77.0	20.4	(12.4, 28.3)	<.001

As with the examination of the enforcement sites, researchers conducted a separate analysis for each of the six generalization sites. As shown previously in Table 2, great variability existed across the six generalization sites at the end of the enforcement period. For example, the location at NW 6th Street at the GPD ended the intervention period with a yielding rate of only 16.7% whereas the Museum Road location finished at 84.5%. All six sites increased from the end of the intervention to the follow-up, although only three (NW 6th Street at GPD, NW 41st Street at 2251 block, and SW 2nd Street at Courthouse) of the six showed statistically significant higher rates in the follow-up than were predicted. All six generalization sites were significantly above baseline in the follow-up. Interestingly, the site with the lowest driver yielding rates during the baseline and intervention periods (NW 6th Street at the GPD) demonstrated increased yielding at follow-up producing driver yielding rates similar to the other generalization sites.

Enforcement sites vs. generalization sites results. A comparison of the results obtained for the enforcement sites with those obtained for the generalization sites over the course of the three measurement periods reveals interesting patterns. First, a comparison of the baseline data in Figure 3 and Figure 4 indicates the overall baseline yielding level was lower for the enforcement sites than for the generalization sites. Researchers and personnel from the GPD selected the sites and assigned them to the enforcement or generalization conditions before collecting any yielding data. Thus, the existence of lower baseline yielding percentages at the enforcement sites was unintentional but must be considered when interpreting the results.

Second, the percentage of motorists yielding at the enforcement sites during the intervention phase increased rather consistently throughout the phase (Figure 3), whereas the corresponding generalization site data displayed little trend and much greater variation from week-to-week (Figure 4). In fact, the enforcement sites improved at about double the rate of improvement observed in the generalization sites during the intervention phase. Despite these rather obvious differences in yielding behavior between the enforcement and generalization sites during the first two phases, it is noteworthy that the overall follow-up levels for the enforcement and generalization sites shown in Table 3 and Table 4, respectively, were essentially identical (76.5 vs. 77.0).

Crash Results

Crash data were of interest as the ultimate safety outcome measure (Figure 7). From 2006 to 2010, there were on average 101.2 pedestrian crashes per year (SD=8.0, SE=3.6) in Gainesville. After the program ended, the average number of pedestrian crashes per year dropped to 83.0 (SD=7.0, SE=4.0), which represents a statistically significant decrease, $t(6)=3.232$, $p=.02$, Mann-Whitney U-test, 0.001, $p=.03$.

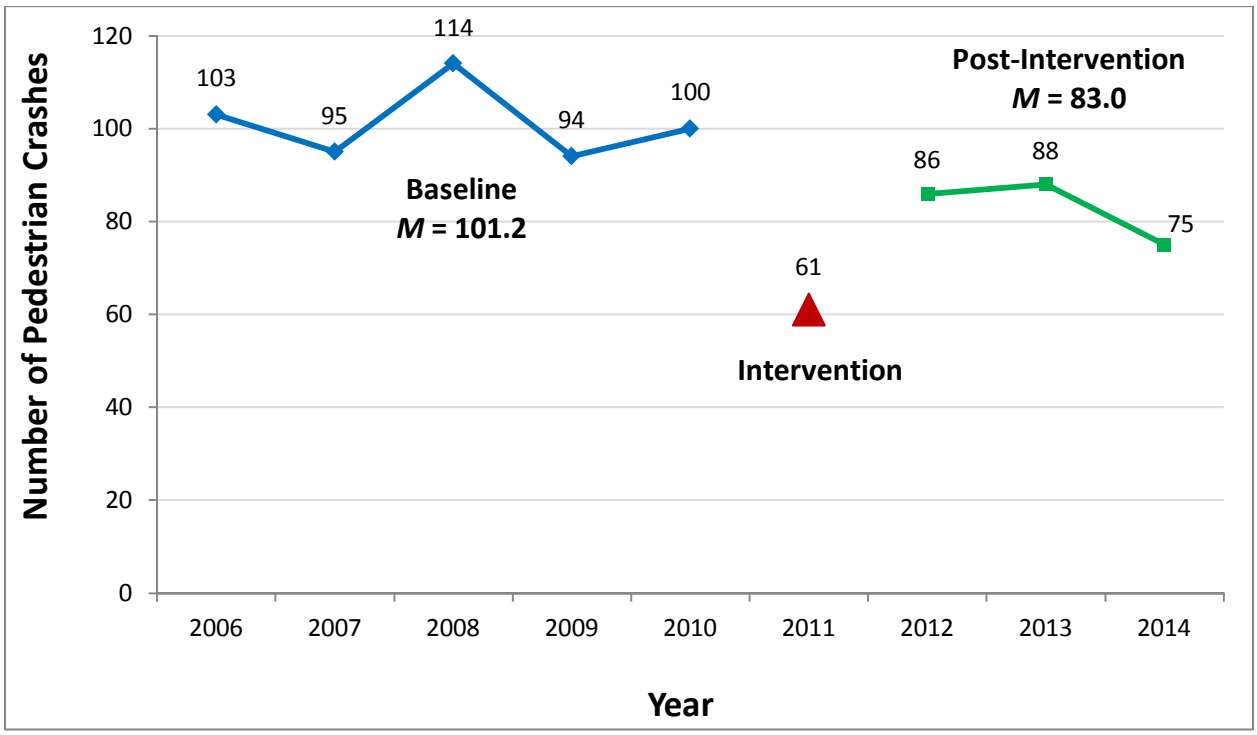

Figure 7. **Annual Pedestrian Crashes in Gainesville 2006 – 2014.**

Discussion

This study evaluated the extent to which increases in the percentage of drivers yielding to pedestrians in Gainesville, Florida observed in the original study persisted after a 4-year follow-up period. The results indicate 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 effect from the original study's enforcement and education program.

In order to consider the reasons for the observed improvement in yielding behavior 4 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. 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.
- The involvement of diverse groups such as the police, the university, and the media in the program may have resulted in a high level of earned media that potentiated the results. Unfortunately, the original study did not have the resources to monitor earned media after the original program ended and, therefore, only anecdotal reports are available.

The documented success of the original program provides a framework in which one can interpret the current results. 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 exists of continued high levels of enforcement or publicity once the original program ended. In fact, GPD personnel, who would have been fundamental to any enforcement efforts, adamantly report that no special enforcement of yield to pedestrian laws took place after the end of the program. As shown earlier in Figure 2, 2013 showed a slight increase in citations for failure to yield, but the level fell well below that for 2010, the intervention year.

With respect to observation reliability, observation procedures, observer training, and all but one of the observers remained identical in all three phases. Researchers also carefully checked inter-rater reliability and trained observers to a stringent criterion. This makes it highly unlikely that changes in the measurement process accounted for the largely unprecedented continued increase in program effectiveness in the follow-up period.

The results of this 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 even without conducting special yielding operations. 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 Gainesville HVE program suggests an association between the two. While pedestrian education 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 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 following 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.

- The observed initial and continued increases in yielding behavior at the generalization sites warrant note. A change of this strength is unusual. Further research on the factors that promoted its occurrence could yield valuable insights and, possibly, additional effective countermeasure implementation approaches.

- The observed significant increase in driver yielding rates 4 years after the intervention leads to the reasonable inference that a change occurred in driver perception of crosswalk enforcement and/or the need to yield to pedestrians at crosswalks. Fear of a citation, the desire to be a good citizen, greater awareness of pedestrians and laws, and social norming may all have played a role. The available data do not permit further analysis into this aspect of the driving public's response.

Limitations

This study took place in a single city with critical elements including the commitment of the local law enforcement agencies to the success of their efforts in promoting behavior change among motorists. The study therefore can shed little light on the amount of effort needed to

convince other cities, particularly larger cities served by several independent law enforcement agencies, to follow the same approach. Likewise, the remote possibility exists that drivers in Gainesville are not representative of the average or typical driver either when responding to programs of this type or when assessing the importance of yield to pedestrian laws.

The original study contract limited the extent and duration of enforcement and education that the program could apply. In this instance, the intervention level appears sufficient to have produced a notably positive result. The reader should not, however, assume that the same process and level of effort applied in Gainesville would have similar results in other locales. In particular, additional research is needed to determine whether the number and/or duration of enforcement waves needs to be increased in larger cities in order to produce similar changes in yielding behavior.

While good data exist on the intervention input in terms of enforcement and the number of feedback signs deployed, the study did not collect information on either the extent of earned media deployed or driver knowledge and recall of and attitudes towards the enforcement, signs, and media. Thus, potentially illuminating data on the mechanisms at work and whether the intervention achieved a tipping point are simply not available.

Finally, while same city control sites were incorporated into the original study to help determine generalization of the HVE program, external control sites were not part of the study. As external control sites were not used in the original study, it was unrealistic to recruit external control sites for the follow-up to document trends as there was no baseline for comparisons and even if sites had conducted similar yielding observations, they would have used a different protocol and methodology. Consequently, it is unknown if similar yielding changes took place in surrounding localities that may suggest additional factors affecting behavior change other than the HVE program. The reader should remain mindful of this caveat.

The limitations cited above, while constraining the explanation of the phenomena observed, should not deter other cities from trying a similar approach. The encouraging outcomes as well as the positive impressions of those involved in the implementation and evaluation of the program support the reasonableness of trying it in other locales, particularly where the rate of drivers yielding to pedestrians is low.

References

Durbin, J., & Watson, G. S. (1950). Testing for serial correlation in least squares regression, I. *Biometrika, 37*(3–4), 409–428. doi:10.1093/biomet/37.3-4.409. JSTOR 2332391.

Durbin, J. & Watson, G. S. (1951). Testing for serial correlation in least squares regression, II. *Biometrika, 38*(1–2), 159–179. doi:10.1093/biomet/38.1-2.159. JSTOR 2332325.

Huitema, B.E. (2011). *The analysis of covariance and alternatives: Statistical methods for experiments, quasi-experiments, and single-case studies* (2nd ed.). Hoboken, NJ: John Wiley and Sons, Inc.

Huitema, B. E., & McKean, J. W. (2000). Design specification issues in time-series intervention models. *Educational and Psychological Measurement, 60,* 38-58.

Huitema, B. E., & McKean, J. W. (2007). An improved portmanteau test for autocorrelated errors in interrupted time-series regression. *Behavior Research Methods, Instruments, & Computers, 39,* 343-349.

Hunter, W. W., Stutts, J. C., Pein, W. E., & Chante, L. C. (1996). *Pedestrian and bicycle crash types of the early 1990s* (Report No. FHWA-RD-95-163). Washington, DC: Federal Highway Administration. Available at www.pedbikeinfo.org/cms/downloads/PedBikeCrashTypes.pdf

Malenfant, L., Wells, J. K., Van Houten, R., & Williams, A. F. (1996). The use of feedback signs to increase observed daytime seat belt use in two cities in North Carolina. *Accident Analysis & Prevention, 28,* 771-777.

McKnight, S., McKean, J. W., & Huitema, B. E. (2000). A double bootstrap method to analyze linear models with autoregressive error terms. *Psychological Methods, 5,* 87-101.

National Center for Statistics and Analysis. (2016, May). *Pedestrians: 2014 data* (Traffic Safety Facts. Report No. DOT HS 812 270). Washington, DC: National Highway Traffic Safety Administration. Available at www-nrd.nhtsa.dot.gov/Pubs/812270.pdf

Van Houten, R., Ellis, R., & Marmolejo, E. (2008). Stutter-flash light-emitting-diode beacons to increase yielding to pedestrians at crosswalks. *Transportation Research Record, 2073,* 69-78.

Van Houten, R., Malenfant, L., Blomberg, R. D., Huitema, B. E., & Casella, S. (2013). *High-visibility enforcement on driver compliance with pedestrian right-of-way laws* (Report No. DOT HS 811 786). Washington, DC: National Highway Traffic Safety Administration. Available at www.nhtsa.gov/staticfiles/nti/pdf/811786.pdf

Wells, J. K., Malenfant, J. E. L., Williams, A. F., & Van Houten, R. (2000). Use of community program to increase seat belt use among shopping center patrons in Charlotte, North Carolina. *Journal of Safety Research, 31,* 93-99.

DOT HS 812 364
January 2017

U.S. Department of Transportation
National Highway Traffic Safety Administration

12808-010617-v2