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Evaluation of Countermeasures: A Study on the Effect of Impactable Yield Signs Installed at Intersections in San Francisco

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ABSTRACT

The present study evaluated the effect of impactable signs that used the yield-symbol as approved by the National Committee on Uniform Traffic Control Devices (NCUTCD) in the 2003 *Manual of Uniform Traffic Control Devices* (*MUTCD*). Impactable *yield* signs are low-cost signs constructed of flexible material. The signs were installed in the medians adjacent to crosswalks at selected non-signalized intersections to instruct drivers to yield the right-of-way to pedestrians. This paper examines the effect on safety characteristics of the intersections of these signs at three stop-sign controlled intersections in San Francisco over two follow up periods.

Since these signs were installed recently, there were no post-installation crash data for comparison with the pre-installation crash data. As such, surrogate measures, including (a) driver yielding behavior, (b) conflicts among drivers and pedestrians crossing the intersection, (c) waiting time for pedestrians, and (d) time taken by pedestrians to cross a given crosswalk were documented. Previous studies have indicated that impactable *yield* signs are effective in increasing the rate of drivers yielding to pedestrians. Video recordings were taken at the intersection pre- and post-installation to observe any changes in behavior. Analyses of these recordings yielded data for baseline and the first and second follow-up periods respectively. Testing the first and second follow-up data against the baseline data reveal that, a substantial increase in yielding behavior by drivers occurred immediately after installation as well as during the second follow-up period. No significant effect was observed in any other variables.

INTRODUCTION

The city of San Francisco has recorded consistent high rates of pedestrian fatality for several years *(1), (2), (3), (4).* In 2004, 710 pedestrian injuries and 20 pedestrian fatalities were recorded in San Francisco and constituted the second highest rates of pedestrian injuries and third highest fatality rates for California *(5)*. Several projects are being undertaken to improve safety for pedestrians in San Francisco *(6), (7)*. At the national level, the Federal Highway Administration (FHWA) has sponsored studies to improve pedestrian safety and evaluate new technologies *(8*). Toward this end, the FHWA has funded the PedSafe project in San Francisco, Las Vegas, and Miami. In San Francisco, the PedSafe Project is a joint endeavor between the Traffic Safety Center at the University of California, Berkeley, and the San Francisco Department of Parking and Traffic (SFDPT). The study was conducted in two phases. Phase I included: (a) conducting a zone analysis to determine seven of the highest pedestrian injury-prone zones in San Francisco; (b) conducting a crash analysis utilizing the Pedestrian and Bicycle Crash Analysis Tool (PBCAT); (c) conducting observations at intersections within the study zones; (d) reviewing both traditional and "intelligent" countermeasures; and (e) developing recommendations and a countermeasure plan for Phase II of the project.

As part of Phase II, impactable *yield* signs were installed at or near selected intersections as one of the countermeasures recommended in Phase I. The current study outlines a methodology to evaluate the effectiveness and efficiency of these signs.

It is common practice to evaluate the effectiveness of a countermeasure in preventing crashes by using vehicle crash data at the location of a countermeasure. After crash statistics are obtained for a sufficient period of time for the data to be stable, the rate of crashes before and after the installation can be compared. The impactable *yield* signs being studied were installed in November, 2005. Hence the efficacy of these countermeasures using crash data cannot yet be evaluated because of insufficient post-installation crash data. Therefore, the preliminary analysis was performed using surrogate measures used in previous studies as a proxies for crash data *(9), (10), (11), (12), (13), (14)*. We expected the *yield* signs to primarily increase the number of times drivers would yield the right-of-way to pedestrians. Data samples of the surrogate measures before and after installations at various intersections were collected and the difference tested for statistical significance. Based on the results of these tests conclusions on the effect of these signs have been drawn.

The paper includes a description of the impactable *yield* signs followed by a review of previous studies on the effect of these signs. The locations of signs in San Francisco are listed, and the salient characteristics of the intersections under study are discussed. The design of the experiment and their measures of effectiveness are followed by analysis of the effect of the countermeasures. The paper concludes with a summary of the study and a discussion of the results.

DESCRIPTION & BACKGROUND

Impactable *yield* signs, also referred to as "in-roadway knockdown signs" are low height signs that are located in the median of intersections or midblock locations, usually adjacent to the crosswalk. These signs instruct drivers to yield to pedestrians in the crosswalk. Figure 1 gives a picture of the impactable *yield* sign used in the study. Made from flexible material, these signs return to their original position after being hit by a motorist. The background literature discusses several studies dealing with surrogate measures and different types of yield-to-pedestrian signs.

Madison Yield to Pedestrian Signs

A study conducted in Madison, Wisconsin *(9)* examined in-roadway yield to pedestrian signs. Although not made of flexible material, their effect is comparable to impactable *yield* signs since their position and height are similar to that of impactable yield signs. The Madison study lays out detailed criteria for defining a *yield*. Only instances of interactions between motorists and pedestrians are considered as the denominator in calculating the percent of yields. The post installation data was collected 30 or more days after installation. The study observed from 0 to 10 percent of motorists yielding to pedestrians before the signs were installed compared to 10 to 20 percent after installation. The study concludes that the signs led to an increased rate of motorists yielding to pedestrians, except in the case where the sign was placed on a wide raised median, the width of which moved it farther from the vehicular lanes and possibly reduced its impact.

FIGURE 1 Impactable *yield* sign *(8)*

FHWA Traffic Cones

The New York Pedestrian Safety Cones Study *(10)*, evaluated devices consisting of a traffic cone fitted with an orange, retro-reflective safety jacket bearing the sign, "State Law – Yield to Pedestrians in Your Half of the Road" *(10)*. The study notes that the signs are made of flexible material and are more 'forgiving' when struck by a vehicle compared to similar signs installed on metal posts. These signs also do not damage the vehicle or become projectiles to pedestrians. Three measures of effectiveness were considered: pedestrians for whom motorists yielded; pedestrians who ran, aborted or hesitated; and pedestrians who crossed in the crosswalk. The post installation data were collected within a month of installation. While seven intersections were studied, only six had adequate sample size for recording a significant change in the percent of pedestrian for whom motorists yielded. Four intersections out of the six, demonstrated a significant change in the percent of pedestrian for whom motorists yielded from 62 to 81 percent.

However, only two of the seven intersections with a significant sample size recorded a significant decrease in the percent of pedestrians who ran, aborted or hesitated, and, in contrast, one intersection experienced an increase in the rate. Similarly, for pedestrians who crossed within the crosswalk, only two out of the seven intersections noted a significant increase in the percent. The effect of motorist yielding had less effect on pedestrian running behavior than might have been expected. Also, the signs did not significantly increase use of the crosswalk since there are always some pedestrians who do not cross at the crosswalk. The study concluded that the cones, while being less expensive compared to the overhead and other signs considered in the study, were an effective device for increasing driver yielding behavior**.**

Nova Scotia, Canada: In-Street Pedestrian Yield Signs

In Nova Scotia, 24 locations were studied that had pedestrian-activated flashing beacons and advance-yield markings on the pavement *(11).* The sites involved one-way and two-way operations and urban and rural sites. The measures of effectiveness considered were: reduction in 'erratic' behavior by drivers and pedestrians; distance from the crosswalk that vehicles stopped; and percent of drivers stopping for pedestrians. Drivers stopping six meters or more before the crosswalk increased from 13 percent to 54 percent, and the percent stopping three meters or more before the crosswalk increased from 37 percent to 83 percent. These increases were statistically significant.

Michigan State University: Portable Signs

Portable yield-to-pedestrian signs were used at Michigan State University campus with new crosswalk markings *(12)*. Used during daytime hours, they increased the number of drivers who yielded, although drivers reverted to previous habits when the signs were moved away. Based on the positive results, the researchers decided to double the number of applications next term and use a longer term, fixed-base structure.

Iowa Yield-to-Pedestrian Signs

Impactable yield signs were installed in three sites in Cedar Rapids, Iowa *(13).* Three measures of effectiveness were used including: (a) vehicle speed changes at intersections during periods in which pedestrians were present, (b) percentage of 'first vehicles' that stopped when a pedestrian stepped from the curb, and (c) percentage of aborted or hurried crossings by pedestrians. The post-installation data were collected four months after installation of the countermeasures. Researchers concluded that the signs had a positive although minimal effect on pedestrian behavior. Results were not uniform. The improvements observed were speed reduction by vehicles at one site and increased driver compliance at the other. Also, at one of the locations, where there were competing demands for attention (i.e., railroad crossing, bike path, and intersection), the change in driver behavior was not marked, indicating decreased compliance with the sign once one's own safety was jeopardized. The low pedestrian volume at two of the three sites limited the ability to measure changes in driver/pedestrian behavior. The study observed that with larger sample sizes, small changes in vehicle speeds may be statistically significant, but a small change will not necessarily lead to an overall increase in pedestrian safety. This study further determined that positioning the signs farther from the crosswalk will cause less physical damage to the signs. Applications with center medians or wider turning or storage bays are best candidate locations.

These background studies all indicate that signs have been effective in increasing the rate of yields by vehicles to pedestrians. Some have recorded the improvement in more details, segregating between drivers that stopped at different distances from the crosswalk. In the current study, researchers focused on changes in behavior associated with yield signs over time and recorded observations at two different periods after their installation.

STUDY OBJECTIVE & SCOPE

Of the studies discussed, only the Nova Scotia study used a symbol sign similar to that used in the current study. The symbol sign was later adopted by the National Committee on Uniform Traffic Control Devices (NCUTCD) in the *2003 Manual of Uniform Traffic Control Devices (MUTCD).* The present study aims to evaluate the effectiveness of this symbol sign. It further aims to illustrate the evolution of user behavior over time by observing the change in the surrogate measures of effectiveness over two time periods: the first period was one month and the second period was three to four months after installation of the signs.

Since selection of intersection for the study is not random, bias in results may have resulted, and extent of improvement may not be generalized for impactable yield signs in general, but hold for the specific intersections only.

TREATMENT INTERSECTIONS: LOCATIONS & CHARACTERISTICS

Four sites at three intersections were selected for observing the effect of impactable yield signs. These include the intersections of 16th Street and Capp Street, Mission Street and France Avenue, and, Mission Street and Admiral Avenue. Two of four study sites were located at a marked and an unmarked crosswalk of the same intersection, at 16th and Capp. The intersection of 16th and Capp is located in the heart of San Francisco, while Mission and France, and, Mission and Admiral are located more towards the south of the city. The locations of the treatment intersections are indicated in Figure 2.

These treatment intersections are medium-sized low-speed intersections, located in institutional, commercial or industrial areas. Street parking is present at all intersections. Two intersections are four legged of which Mission and Admiral is a skewed intersection; Mission and France is a T-intersection. All intersections are stop controlled and have two-way flow. The intersection of 16th and Capp, being located in the heart of San Francisco, had observed the maximum number of crashes since June 2000. Table 1 outlines the salient characteristics of the intersections.

TABLE 1 Characteristics of the Site Intersections (*14*), (*15*), (*16*)

Intersection Characteristics	**16th & Capp**	**Mission & France**	**Mission & Admiral**
Location of Study Crosswalk	Crossing 16th both on the eastside (unmarked) and Westside (marked) of intersection	Crossing Mission on the south side of intersection	Crossing Mission on the south side of intersection
Type of Intersection	4-legged	3-legged	4-legged
Number of Lanes (1st street/2nd street)	3/2	4/2	4/2
Flow (1st street/2nd street)	2 way/2 way	2 way/2 way	2 way/2 way
Type of Control	STOP sign on Capp	STOP sign on France	STOP sign on Admiral
Adjacent landuse	Institutional/Commercial	Commercial	Industrial
Street Parking	Yes	Yes	Yes
Marked crosswalk	3	1	2
Speed (miles per hour)	25	25	25
Total number of Crashes (June 2000-June 2005)	10	4	7
Notes			Admiral is staggered across intersection

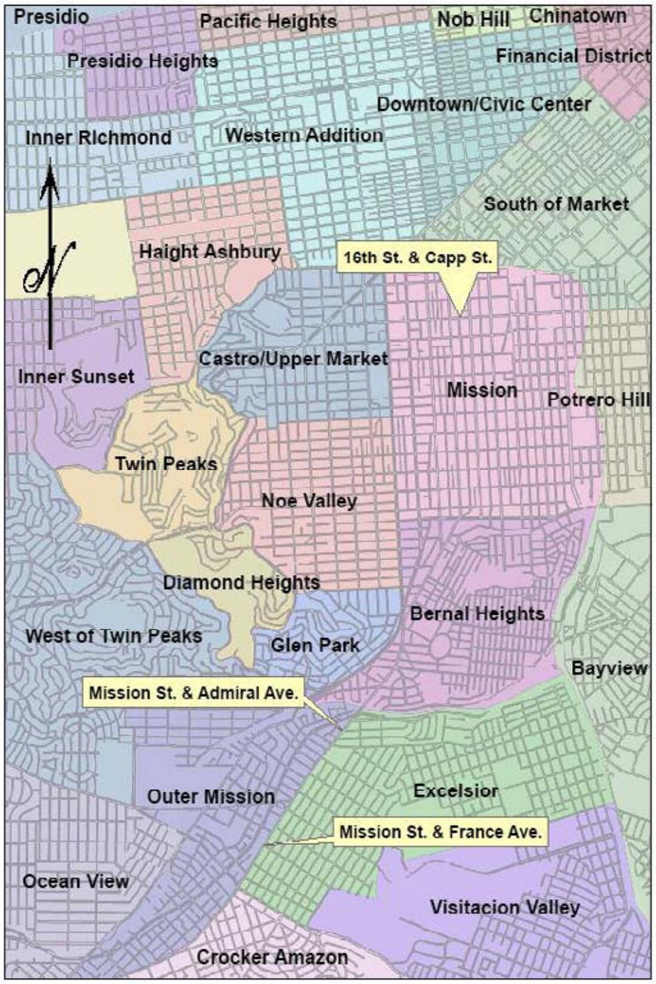

FIGURE 2 Locations of intersections

STUDY DESIGN

The evaluation study was designed as a pre-post design. Video recordings of the intersections were made before the installations (baseline data) and during two periods after installations. The purpose of the second follow-up survey was to ascertain the effect of the signs after the novelty effect wore out. The surveys were conducted during the same hours on every weekday, between 1 p.m. to 3 p.m. and between 4 p.m. to 6 p.m. The various dates of survey are indicated in Table 2.

TABLE 2 Date of Survey at the Study Sites *(17)*

Site	Intersection Approach	Countermeasure	Baseline Survey	Date of counter-measures	1st follow up	2nd follow up
16th and Capp	On 16th eastside crosswalk	2 sided YTP sign	6/20/05	11/09/05	12/12/05	2/28/06
16th and Capp	On 16th Westside crosswalk	2 sided YTP sign	6/28/05	11/09/05	12/13/05	3/1/06
Mission and France	Southside crosswalk on Mission	2 sided YTP sign	6/15/05	11/5/05	12/5/05	3/2/06
Mission and Admiral	Southside crosswalk on Mission	2 sided YTP sign With painted island	7/21/05	11/6/05	11/28/05 & 11/29/05	3/3/06

MEASURES OF EFFECTIVENESS

As part of the PedSafe project, a study plan was developed that outlined the procedure for evaluating many different countermeasures using surrogate variables *(18)*. The current study examined 14 different measures of effectiveness, primary among which were: frequency of pedestrian-vehicle conflicts, percentage of drivers yielding to pedestrians, and percentage of pedestrians trapped in the roadway.

The measures of effectiveness chosen to test the impactable yield signs were selected based on hypotheses developed for the study plan. Table 3 lists the hypotheses on different aspects and the possible measures of effectiveness for impactable yield signs.

TABLE 3 Measures of Effectiveness (MOEs) of impactable yield signs *(18)*

Aspect	Hypothesis	MOEs
Safety surrogates	Reduce vehicle-pedestrian conflicts	Frequency of vehicle-pedestrian conflicts
	Increase driver yield to pedestrians	Percent of drivers yielding to pedestrians
	Allow pedestrians to clear crosswalk on time	Number of pedestrians trapped in the roadway
	Increase number of pedestrian crossing within designated crosswalk	Percent of captured pedestrian crossings
Pedestrian Mobility	Reduce delay to pedestrians	Pedestrian delay

For the purpose of this study, terms were defined as follows *(19):*

- **Conflict:** A conflict involved an evasive action by a motorist or a pedestrian, where the vehicle and pedestrian were on a collision course. Evasive action was evidenced by a motorist stopping, slamming on the brakes, or swerving, or by a pedestrian suddenly stepping back, lunging back, or running forward to avoid being struck by a vehicle. For a conflict to be scored, evasive action (by either the motorists or the pedestrian) had to be observed.

- **Vehicle Yield:** A vehicle yield was recorded when a driver yielded to a pedestrian by stopping or slowing down to let the pedestrian cross in front of the car.
- **Trapped in the Roadway:** This was recorded when a pedestrian was stuck in the roadway (in a lane, on a lane line, or on the center line) when traffic was too close and did not yield. This generally resulted from a pedestrian selecting a gap in the traffic that was too short for them to completely cross the road before encountering oncoming vehicles.
- **Captured pedestrians:** This was defined as the percentage of crossings in which the pedestrian was in the crosswalk.
- **Pedestrian Delay/Wait:** This was defined as the interval between the time at which a pedestrian arrives at an intersection and the time when she starts crossing.

ANALYSIS

We studied selected measures of effectiveness (e.g., car yielding, conflicts etc.) using the video recordings taken before and after installation of the signs. Baseline measures were compared with each set of follow-up data to record differences between the two. Using two-tailed tests, p-values were obtained for each of these differences to test for statistical significance. This analysis was based on the assumption that a significant change in the baseline to first follow up value was due to the initial effect of the sign. In some cases the initial effect may have been manifested through increased compliance to the sign message. In others it may cause undesirable results due to general user confusion. A statistically significant change between the baseline and the *second* set of follow up data was interpreted as the actual effect of the sign; i.e. the effect that the sign message had on the majority of regular users of the intersection.

For calculating the pedestrian composition, the percentage of pedestrians who look at start and at midpoint, the percent of trips in the crosswalk, and, average wait and crossing time, the total number of pedestrians was considered as the denominator. For calculating the percent of car yield, percent of conflicts and percent of pedestrian trapped in the crosswalk whereas, only the number of pedestrian-vehicle interactions was considered as the denominator.

RESULTS

Tables 4 through 7 represent the observations for the different measures of effectiveness for the four study intersections.

Observations at 16th & Capp (unmarked)

Table 4, representing the unmarked crosswalk at 16th and Capp, shows an increase in the percent of adults and males, although the percentage increase in males is not statistically significant at the 95 percent confidence level at the time of at the first follow up survey.

The wait time reduced significantly at the first follow-up period and was marginally reduced compared to baseline at the second follow-up period. The crossing time increased significantly during both follow-up periods, possibly brought about by inaccurate expectations of the pedestrian. The marginally increased number of pedestrians trapped in the first follow-up period, although the difference by the second follow-up was not significant, also supports the inaccurate user expectation hypothesis. There was a statistically significant increase in the percent of trips in the crosswalk. The increase in percent car yield though not significant at the time of the first follow up survey became significantly different from baseline by the second follow-up period, that being the desired outcome due to the signs. Although there was a change in the percent of males and adults, this did not substantially alter impact the main results of this study.

Observations at 16th & Capp (marked)
Table 5 lists the observations at the marked intersection of 16th and Capp. Over time there was no significant change in the pedestrian composition and as such it did not affect the results. Although the cross time did not change at first, there was a significant increase later. The percent car yield increased significantly. While there was no initial significant change in the percent trapped, there was a significant decrease over time, possibly a positive manifestation of the increased car yield. Both the baseline and post-installation percentages of vehicular yields were observed to be higher for the marked crosswalk as compared to the unmarked crosswalk.

Observations at Mission & France
In Table 6, no significant change in pedestrian composition was observed in Mission and France, except that the percentage of adults increased significantly at first. As such, pedestrian composition possibly had no bearing on the results. The wait time reduced significantly by the second follow up period. The cross time also improved similarly. However, the percent of trips in the crosswalk reduced significantly at the time of the second follow up too. As in the other cases, there was a significant increase in the percent of car yields both initially and later..

Observations at Mission & Admiral
In Table 7, at Mission and Admiral, the pedestrian composition did not change significantly over time except for an initial significant increase in the percentage of adults which could not have influenced the results. The wait time remained fairly constant. Crossing time increased initially but was not significantly longer by the second period. Car yield was significantly higher and conflicts were significantly lower both initially and during the second follow-up period.

The common observations across all intersections are summarized in the next section.

TABLE 4 Observations at 16th & Capp (unmarked)

16TH/ CAPP UNMARKED	Baseline	1st Follow-up	p-value comparing outcome to baseline	2nd Follow-Up	p-value comparing outcome to baseline
Total Pedestrians	**86**	**112**		**145**	
Gender (Percent male)	70.2	79.5	0.07	83.9	0.01
Age(Percent adult)	77.9	92.9	0.02	87.5	0.02
Average Wait (seconds)	2.6 (4.4)*	1.7 (2.1)	0.04	1.8 (2.7)	0.06
Average Cross (seconds)	9.2 (4.6)	11 (4.4)	0.00	10.4 (3.0)	0.02
Percent of trip in crosswalk	36	63.8	0.00	58.1	0.00
Pedestrian/Vehicle Interactions	**96**	**120**		**109**	
Percent vehicular yield	39.6	48.3	0.10	59.6	0.00
Percent conflict	6.3	6.7	0.45	2.8	0.12
Percent trapped	8.3	15	0.06	11	0.26

* The figures in parentheses show the standard deviation

TABLE 5 Observations at 16th & Capp (marked)

16TH/ CAPP MARKED	Baseline	1st Follow-up	p-value comparing outcome to baseline	2nd Follow-Up	p-value comparing outcome to baseline
Total Pedestrians	**368**	**405**		**364**	
Gender (Percent male)	66.3	64.9	0.34	69.5	0.18
Age(Percent adult)	92.1	85.7	0.00	91.2	0.33
Average Wait (seconds)	4.6 (6.3)	4.3 (5.5)	0.24	4.7 (8.5)	0.43
Average Cross (seconds)	10.9 (2.8)	10.9 (2.9)	0.50	11.5 (3.4)	0.00
Percent of trip in crosswalk	89.4	90.2	0.36	91.3	0.19
Pedestrain/Vehicle Interactions	**519**	**488**		**447**	
Percent vehicular yield	60.5	70.7	0.00	73.6	0.00
Percent conflict	6.9	8.8	0.13	6.7	0.45
Percent trapped	3.3	3.7	0.37	1.3	0.02

TABLE 6 Observations at Mission & France

MISSION/FRANCE	Baseline	1st Follow-up	p-value comparing outcome to baseline	2nd Follow-Up	p-value comparing outcome to baseline
Total Pedestrians	**126**	**100**		**115**	
Gender (Percent male)	58.1	62.1	0.27	57	0.43
Age(Percent adult)	82.1	82.3	0.48	80.9	0.41
Average Wait (seconds)	7.9 (9.2)	7.5	0.39	5.5(8.4)	0.02
Average Cross (seconds)	12.7 (2.7)	13.1	0.18	12.1 (2.7)	0.04
Percent of trip in crosswalk	98.7	98.3	0.40	93.8	0.02
Pedestrian/Vehicle Interactions	**195**	**144**		**126**	
Percent car yield	36.9	61.1	0.00	61.9	0.00
Percent conflict	0	0	0.50	0	0.50
Percent trapped	0	0	0.50	0	0.50

TABLE 7 Observations at Mission & Admiral

MISSION/ADMIRAL	Baseline	1st Follow-up	p-value comparing outcome to baseline	2nd Follow-up	p-value comparing outcome to baseline
Total Pedestrians	**28**	**40**		**37**	
Gender (Percent male)	74.1	56.8	0.06	82.1	0.22
Age(Percent adult)	78.6	97.5	0.01	91.9	0.07
Average Wait (seconds)	6.2 (5.9)	7.5 (7.6)	0.22	8.2 (7.8)	0.12
Average Cross (seconds)	10.2 (2.3)	12.1 (4.5)	0.01	10.8 (2.9)	0.18
Percent of trip in crosswalk	82.7	84.9	0.40	94.7	0.07
Pedestrian/Vehicle Interactions	**45**	**70**		**41**	
Percent car yield	20.0	52.9	0.00	70.7	0.00
Percent conflict	26.7	12.9	0.04	7.3	0.01
Percent trapped	8.9	5.7	0.26	4.9	0.23

RESULTS

A large majority of males (56.8 percent to 83.9 percent) and of adults (77.9 percent to 92.9 percent) constitute the pedestrian at all four intersections. The only significant result that was common to all four sites was the increase in the rate of car yields as shown in Figure 3. None of the other variables indicated significant changes across all four intersections. All increases from baseline data, except for the increase at the 16th and Capp unmarked crosswalk for the first follow up survey were significant at the 99.5% confidence level. The increase in car yields followed different rates at the different intersections. While at Mission and Admiral, there were large increases both at first and second follow up survey, at Mission and France, there was a large increase at the time of the first follow up survey and not much increase after that. As such, this study concludes that the impactable yield signs definitely caused vehicles to yield more to pedestrians.

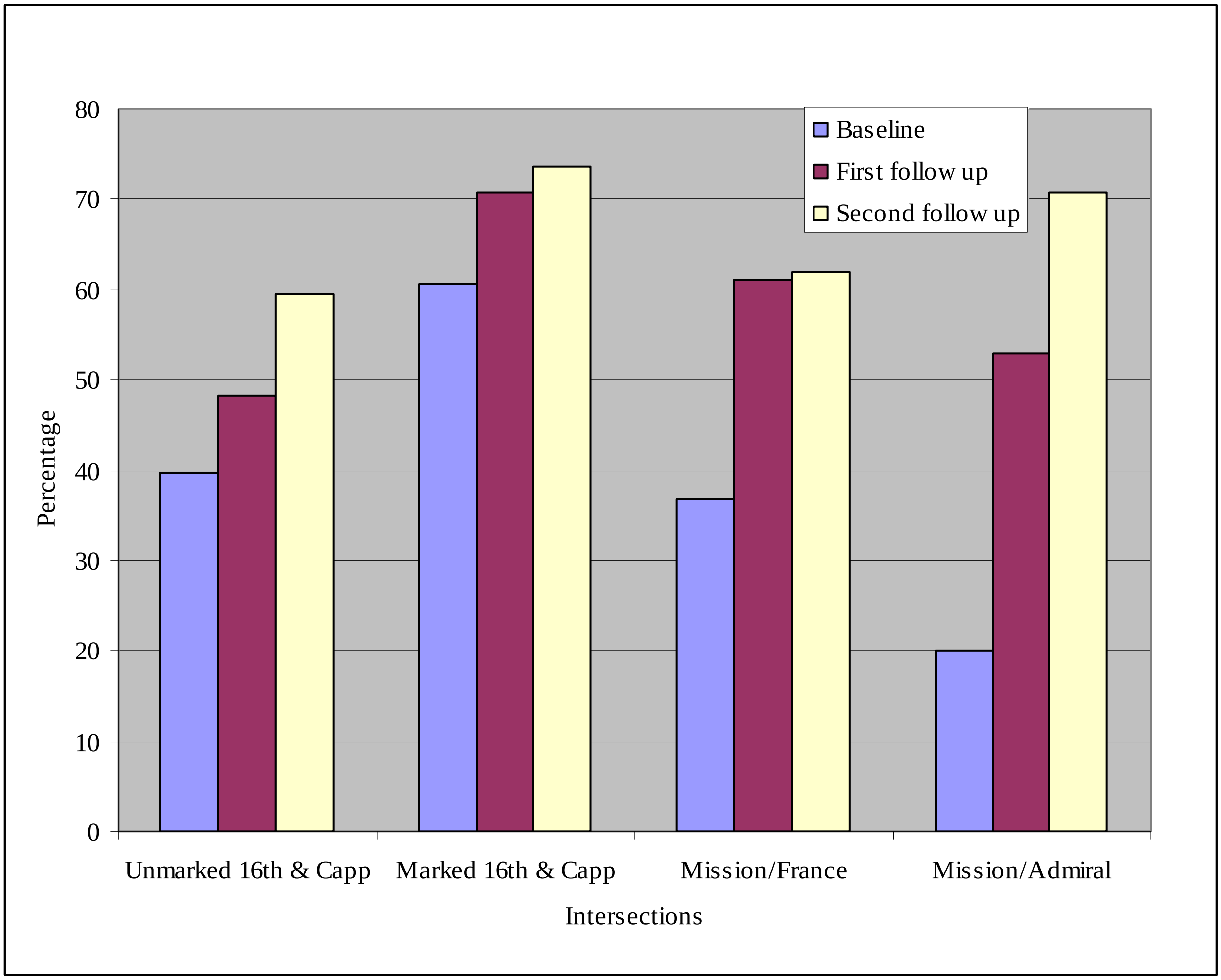

FIGURE 3 Increases in the percentage of car yields

The increase in the rate of car yields caused changes in other measures of effectiveness. Some of these changes were positive for instance, reduction in the number of conflicts, cross time or wait time. Some changes were detrimental to safety, for instance reduced percent of trips in the crosswalk and increased cross time.

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DISCUSSION

The study examined the latest approved version of a low-cost symbol sign that was associated with a significant increase in driver yielding behavior. Pedestrian composition was observed generally to be random and uncorrelated with the results. The outcome of significant increase in car yield is consistent with all other studies conducted on yield–to- pedestrian signs of different types. Being placed in the median adjacent to the crosswalk makes the sign more visible and provides an alert at a very appropriate time, a possible reason behind its success.

However its location in the median makes it prone to collision and damage. The flexible material and installation aims to counter the damage. With increasing experience, engineers are now capable of locating the signs in an equally visible but less collision-prone location, by making slight alterations in its placement, so as not to be in the possible path of a vehicle. Yet the signs do sometime need replacement due to wear and vandalism. For instance, it was reported that a couple of weeks after installation, the sign at Mission and France lost its ability to return to vertical position. Such instances are also corroborated by the other studies, one of which mentions that the San Francisco traffic has not been kind to these signs *(20)*. At the same time, studies have noted pedestrians to appreciate these signs and make requests for re-installation when the signs were removed due to adverse weather conditions *(9).*

As with many similar studies, a limitation of this study is the lack of comparison or control intersections. However, exogenous changes were monitored to ensure minimal influence on the results of the study. There were no events leading to changes in normal traffic patterns. Furthermore, no advertising campaign took place concurrently with the study that could have influenced yielding behavior. As such, the research team concluded that the changes observed in drivers' behavior were brought about mostly by the yield signs. This study was inconclusive on the effect of the signs on the other surrogate measures observed.

Two separate periods of post-installation observation illustrate how the effect of the countermeasures on the users varies over time. Percent car yield was observed to increase over time in all cases. However, in other measures of effectiveness, a significant increase was often followed by a reduction as in percent trapped for the unmarked crosswalk of the 16^{th} and Capp.

Regardless of whether the initial percent yield was as low as 20 percent or as high as 60 percent, the after- installation percent yield varied between 60 to 74 percent. This may be a possible indication that although effective, the effect of impactable yield signs could only achieve a certain percent of improvement. Further studies on the subject are required to examine this possibility.

The research team concluded that yield signs are useful in causing vehicles to yield to pedestrians, as observed in the study locations. However, it is only crash data that can indicate whether the signs are effective in preventing crashes, which is the primary aim of erecting these signs. Conflicts, in some cases are the closest approximates to crashes, and the signs have been seen to reduce conflicts in some cases, although not significantly, in this study. Some of the measures of effectiveness indicate the possibility that the increase in the expectation of safety brought about to pedestrians is detrimental because it might cause pedestrians to become less vigilant (*9*), although there are studies that counter this theory too. As a study observes that an increase in yielding from 0 to 50 percent is not as effective as an increase from 50 to 100 percent *(10)*, since the former does not fully cure the situation and may cause false expectations. This is an area that needs further research. There is a need for further research, especially including crash data, to validate the conclusions drawn through the use of surrogate measures. Research is also necessary to achieve a more durable yet low-cost installation.

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