San Francisco PedSafe II Project Outcomes and Lessons Learned

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ABSTRACT

This paper presents the project outcomes and lessons learned from the San Francisco PedSafe, a comprehensive pedestrian safety planning and engineering project funded by the Federal Highway Administration. It assesses the effectiveness of the Phase I pedestrian safety plan targeted to higher-injury areas by evaluating the Phase II implementation of a range of mostly low-to-moderate-cost innovative safety improvements.

A total of 13 countermeasures (comprised of nine general engineering countermeasures and four Intelligent Transportation Systems (ITS) countermeasures) were implemented by the San Francisco Municipal Transportation Agency (SFMTA) and evaluated by the University of California- Berkeley, Traffic Safety Center (TSC) in a three-year period (2004-2007). Regarding the effectiveness of the 13 countermeasures, six were considered generally successful; three were considered less successful and four were considered inconclusive. The six most successful countermeasures included: flashing beacons (with automated and push button actuation), in-street pedestrian signs, video detection to adjust signal timing, pedestrian head starts (leading pedestrian intervals), portable changeable message speed limit signs, and “Turning Traffic Must Yield to Pedestrians” signs. A summary of countermeasure evaluation result highlights is also reported.

This paper describes the methodology of countermeasure evaluation, including video data, tools used in data analysis, the advantages and limitations of this method, and possible improvements. In addition, general lessons learned of countermeasure implementation, as well as recommendations for further research are also described.
BACKGROUND

San Francisco is a relatively dense city with 800,000 residents in 47 square miles (or 15,500 residents per square mile). Based on police records for a five-year period (July 1996 through June 2001), a lower-bound estimate of 4,791 collisions reported in San Francisco involved pedestrians, which is an average of about 2.6 collisions per day (1).

In 2002, San Francisco became one of three U.S. cities (San Francisco, Las Vegas and Miami) selected for Federal Highway Administration (FHWA) funding for the PedSafe Project, a project that analyzed the city’s high pedestrian crash locations and developed a plan for implementing and evaluating various pedestrian safety countermeasures at these locations. Although the three cities implemented many of the same countermeasures, there were variations in their approaches and experiences (1).

The San Francisco PedSafe project was conducted in two phases by San Francisco Municipal Transportation Agency (SFMTA) and the University of California- Berkeley, Traffic Safety Center (TSC). During Phase I, a comprehensive picture of pedestrian injury collisions problem in San Francisco was assessed, including identification of areas of the city with higher pedestrian injury densities that seemed particularly amenable to improvement with lower-cost, innovative measures. These areas were identified by following FHWA’s Zone Guide for Pedestrian Safety. An analysis of potential countermeasures for decreasing pedestrian-related collisions was conducted and a detailed plan for implementation and evaluation of these countermeasures was formulated. Phase I used the Pedestrian/Bicyclist Crash Analysis Tool (PBCAT), Crossroads ™ software and other statistical software for the analysis of pedestrian collision patterns and identification of potential countermeasures. In addition, the actual police reports were also reviewed to understand the problems specific to each location. Countermeasures considered included traffic control devices (signals, signs, and markings), other physical improvements (including measures related to Americans with Disabilities Act), reflective materials, and education/outreach. Most countermeasures are low to moderate in cost ranging from under $5,000 per installation to $20,000. The relative costs of selected countermeasures are listed in Table 1. The Phase I concept plan and final report of Phase I were approved by the SFMTA Board of Directors, the policy making commission for traffic, parking, and public transit improvements, in April 2003 (2).

Phase II of the San Francisco PedSafe project consisted of the implementation and evaluation of the Phase I PedSafe Concept Plan, funded through a combination of federal and local sources. Implementation and evaluation took place from 2004 to 2007, and tested a combination of innovative technologies and approaches to improving pedestrian safety in seven areas of San Francisco that had higher levels of pedestrian injuries. A total of 13 countermeasures (comprised of nine general engineering countermeasures and four Intelligent Transportation Systems (ITS) countermeasures) were implemented by the San Francisco Municipal Transportation Agency (SFMTA) and evaluated by the University of California-Berkeley, Traffic Safety Center (TSC) in a three-year period (2004-2007). In addition, a public outreach program offering general safety tips and education about specific measures was presented at five senior centers and six public elementary and middle schools in or near study zones.

This paper describes the methodology of countermeasure evaluation, including video data, tools used in data analysis, the advantages and limitations of this method, and possible improvements. In addition, general lessons learned of countermeasure implementation, as well as recommendations for further research are also described.
METHODS

Study Design

This is a pre/post study of changes in pedestrian safety following the implementation of 13 potential countermeasures for decreasing pedestrian-related collisions. The countermeasures and locations for installation were selected during Phase I of the PedSafe Project (3).

During Phase II, the evaluations of the countermeasures were organized with baseline (pre-countermeasure installation) and follow up (post countermeasure installation) video observations and intercept surveys for each countermeasure. When it was possible, two follow up video observations were conducted in order to measure changes in observed trends over time. The overall follow-up survey then combines the observations for the first and the second follow up survey to obtain a composite result. Baseline pre-installation data were recorded at all study locations for each countermeasure. All data collection and observations were performed during weekdays between 12 p.m. and 6 p.m.

Ideally, when there are enough installations of countermeasures and collision and injury data are available in a sufficient time span, these data will be used to evaluate the effectiveness of countermeasures (4,5). Due to the limited time frame of this study, analysis of post-countermeasure pedestrian injury rates was not feasible, since such analysis requires long-term collision data collection. As used in previous studies (6,7,8,9,12), surrogate measures of effectiveness (MOEs) (i.e. factors that correlate with pedestrian injury collisions) were used instead. A list of MOEs used in PedSafe II is discussed in the data analysis section of this paper.

Carry-over effects and citywide impacts were not analyzed as part of this report since they were studied separately by the Science Applications International Corporation (SAIC).

According to SAIC, carry-over effects and citywide impacts were analyzed by forming group zones in close proximity within the city, and measured by evaluating safety, mobility, and customer satisfaction. The hypothesis of carry-over effects is that by deploying multiple countermeasures across designated area to improve pedestrian safety, the impacts of all the countermeasures will spread around the area even at locations where no countermeasures are installed. For example, “in-roadway knockdown signs” will increase driver yielding within the area by making drivers more aware of pedestrians. The evaluations showed that the carry-over effects and citywide impacts were inconclusive due to factors such as pedestrian and traffic volumes, traffic signal timing plans, construction, etc. However, the results of this evaluation are not to suggest that there were no benefits of the countermeasures program. Quite the contrary; the countermeasures are likely to show positive site impacts (10).

Countermeasure Overview and Locations

Among the 13 countermeasures, there were nine general engineering countermeasures and four Intelligent Transportation Systems (ITS) countermeasures implemented in the higher pedestrian injury areas throughout San Francisco. The selected countermeasures were tailored to the crash pattern and intersection characteristics. For example, LOOK pavement stencils were selected for intersections with a higher level of collisions where pedestrian was considered primarily at fault, and flashing beacons were selected for uncontrolled locations with the heaviest volumes and most significant collision records. A map of where countermeasures were installed
is shown in Figure 1. The purpose of each countermeasure is listed in Table 1. The countermeasures are listed as the following (ITS countermeasures denoted by asterisks):

1. **IN-STREET PEDESTRIAN SIGNS**  
   16th Street & Capp Street  
   (Marked Crosswalk)  
   16th Street & Capp Street  
   (Unmarked Crosswalk)  
   Mission Street & France Avenue  
   Mission Street & Admiral Avenue

2. **“TURNING TRAFFIC MUST YIELD TO PEDESTRIANS” SIGNS**  
   Mission Street & Ocean Avenue  
   Mission Street & Avalon Avenue  
   Mission Street & Persia Avenue  
   Guerrero Street & 16th Street

3. **“LOOK” PAVEMENT STENCILS**  
   Harrison Street & 4th Street  
   Mission Street & 17th Street  
   Columbus Avenue & Broadway  
   Geary Boulevard & 6th Avenue

4. **MODIFIED SIGNAL TIMING**  
   Valencia Street & 16th Street  
   Harrison Street & 9th Street  
   Geary Boulevard & Van Ness Avenue  
   Geary Boulevard & Laguna Street

5. **PEDESTRIAN HEAD START**  
   Howard Street & 6th Street  
   Howard Street & 8th Street  
   Harrison Street & 10th Street  
   Mission Street & 6th Street

6. **ADVANCED STOP LINES & RED VISIBILITY CURB ZONES**  
   Geary Boulevard & 11th Street  
   Market Street & Noe Street

7. **FLASHING BEACONS***  
   16th Street & Capp Street  
   Mission Street & Santa Rosa Avenue

8. **PORTABLE CHANGEABLE MESSAGE SPEED LIMIT SIGNS***  
   16th Street & Capp Street  
   Mission Street & France Avenue  
   Geary Boulevard & 11th Street  
   Mission Street & Admiral Avenue

9. **ADA CURB RAMPS**  
   Market Street & Castro Street

10. **MEDIAN REFUGE ISLANDS**  
    Geary Boulevard & Stanyan Street  
    Geary Boulevard & 6th Street

11. **AUTOMATIC DETECTION OF PEDESTRIANS TO ADJUST CROSSING TIME***  
    Howard Street & 9th Street

12. **CHANGEABLE MESSAGE SPEED LIMIT SIGNS***  
    Market Street & Castro Street  
    Folsom Street & 7th Street  
    Harrison Street & 7th Street

13. **RETRO-REFLECTIVE MATERIALS**  
    (Public outreach program implemented at schools and senior centers, not at intersections)
FIGURE 1. Map of Intersections Where Countermeasures Were Installed

Data: San Francisco Department of Telecommunications and Information Systems
DATA COLLECTION

Twenty-nine intersections were video recorded for four to twelve hours before and after countermeasure implementation. These recordings were made between June 2005 and February 2007. The primary data sources are these video recordings but manual observation data were also used. The manually collected data come from the PedSafe I study in 2002, and additional data were collected in 2006 and summer 2007.

The pedestrian/driver observations were completed before and after installation of the countermeasures and were based on countermeasure-specific protocols, which were developed according to the Measures of Effectives (MOEs) provided by the Federal Highway Administration (FHWA) (11). In some cases, multiple baseline and follow-up observations were conducted to assess the variation in the impact of the countermeasure over time. Statistical tests (Fishers exact test for contingency tables with low values, and t-test for difference of means/proportions) were performed.

Additionally, pedestrian intercept surveys were conducted at study intersections to determine trends in crossing behavior, awareness of the countermeasure, and perceptions of safety. One hundred pedestrians were surveyed post countermeasure installation at each location. Drivers were not surveyed due to limited resource of the study. Survey questions varied between countermeasures. The questions and results are presented for each countermeasure for which a survey was conducted. Demographic data (gender, age range, and ethnicity) were also collected for each pedestrian during the survey.

DATA ANALYSIS

The video recordings were analyzed with observers counting and marking some or all of the following occurrences serving as MOEs as explained):

- **Pedestrian Arrival at the Intersection** (time stamp)
- **Pedestrian Beginning to Cross** (time stamp)
- **Pedestrian Reaching the end of crosswalk** (time stamp)
- **Vehicle/Pedestrian Interaction**- marked when vehicle and pedestrian follow a potentially conflicting path.
- **Vehicle Yielding**- marked if a vehicle slows or stops to allow the pedestrian to pass.
- **Distance of Yielding**- the distance a driver stops/yields before reaching a crosswalk at an intersection (the distance between the front bumper of the vehicle and the near edge of the painted crosswalk where the pedestrian is crossing or the vehicle and the crosswalk at the point at which the driver first begins to brake in advance of the mid-block crossing).
- **Vehicle Conflict**- an occurrence in which either the pedestrian or driver of the vehicle seems uncomfortable; for example, when a driver suddenly brakes, or when a pedestrian significantly changes stride or gait when a vehicle is present.
- **Pedestrian Trapped**- marked when s/he is forced to stop in the intersection while vehicles are present.
- **Vehicle Crosswalk Blockage**- marked if a vehicle yields or stops while in a crosswalk.
- **Pedestrian Delay**- the time elapsed between when a pedestrian arrives at the intersection intending to cross and when s/he starts to cross.
• **Pedestrian Crossing Time** - the time elapsed between when s/he steps off the curb and arrives and steps up onto the curb across the street.

MOEs were derived from one or more of these occurrences according to the hypotheses or potential impacts of each countermeasure developed for the study plan. Not all MOEs were made in regard to all countermeasures. Observations were made based on purpose of the countermeasure and intersection characteristics.

In general, all pedestrians crossing each intersection were observed. Age, gender, crossing time, and pedestrian delay were recorded. As indicated in Figure 2, a subset of all pedestrians was created to include only those who encountered a vehicle. If one or more pedestrians encountered one vehicle, this was counted as one interaction. The categories of vehicle/pedestrian interactions include vehicle yield, vehicle/pedestrian conflicts, vehicle blockage, and pedestrian trapped, and these were coded only if a vehicle and pedestrian had an interaction. However, there is some scope of subjectivity in the relationships between these subcategories (vehicle yield, vehicle/pedestrian conflict, vehicle blockage, and pedestrian trapped). The same pedestrian/vehicle interaction may be interpreted as two different categories by two different observers. To reduce subjectivity to a minimum during video analysis, a standard set of ‘protocols’ were to be followed by each video observer. These protocols explained the procedure as well as the different definitions to be followed for video analysis.

All video observers were trained on how to use the Playback Tool, how to follow the protocols, what the MOEs are, how to recognize them and how to logistically keep track of incomplete and completed video recordings. Upon completion of video observation, observational results were first organized and analyzed in Excel spreadsheet, and then further analyzed in STATA 9 (14). In addition, periodic spot checking indicated adequate interrater reliability.

![FIGURE 2 Observational Division Diagram](image-url)
The PlayBack Tool

All video recordings were observed and occurrences of the MOEs were coded by using the PlayBack Tool (Figure 3), which was developed by the California Partners for Advanced Traffic and Highways (California PATH, a research agency that is part of UC Berkeley Institute of Transportation Studies) to manually capture “time stamps” when an event of interest occurs. The play speed can be changed and events can be “time stamped,” i.e., mark the precise time when an event occurred.

Using this tool, pedestrian movements such as arrival at the intersection and crossing time, as well as when a vehicle yields or when a conflict occurs. Pedestrian characteristics such as age and gender were also recorded.

Statistical Tests

Two types of statistical tests were performed using Stata 9 (14). Fisher’s exact analysis was conducted to find significant differences in discrete variables and t-tests for differences in continuous measures (15). The continuous measures include pedestrian delay time and crossing time. All other variables (gender, age, yielding, conflict, etc) are discrete variables. Significance was established in cases where the p-value was less than 5 percent (p < 0.05).

RESULTS

The following table (Table 1) is a summary of the impacts of PedSafe countermeasures on pedestrian and driver behavior and attitudes. Video recorded observation results are only reported in this table if they were statistically significant (p<0.05).
TABLE 1. San Francisco FHWA PedSafe Project: Data Highlights

All countermeasures are considered standard devices (in federal traffic engineering manual, Manual of Uniform Traffic Control Devices, MUTCD), unless otherwise noted. “Low-cost” is typically under $5,000 per installation, “medium” is $5,000 to $20,000, and “high” is greater than $20,000.

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<th>COUNTER-MEASURE</th>
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<th>RELATIVE COST</th>
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<tr>
<td>1. In-Street Pedestrian Signs</td>
<td>Used in median of uncontrolled crosswalks to encourage drivers to yield to pedestrians and to help delineate the crosswalk. Designed to be safe and visible next to moving traffic.</td>
<td>Video recorded pedestrian/driver behavior at 4 crosswalks (including marked and unmarked crosswalks at one location). Interviewed pedestrians at one of the four intersections.</td>
<td>Significant increases in drivers yielding at all 4 crosswalks (53% pre vs. 68% post overall).</td>
<td>About 27% of respondents felt signs made them feel safer, but only 18% of respondents correctly identified the recent safety change.</td>
<td>Low</td>
<td>High rate of damage to signs unless they are placed on a raised island or are completely out of turn path.</td>
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<td>2. “Turning Traffic Must Yield to Pedestrians” Signs</td>
<td>Mounted at street corners of intersections to encourage turning drivers to yield to pedestrians. Usually used at signalized intersections.</td>
<td>Video recorded pedestrian/driver behavior at 4 crosswalks, 3 of them 4-leg, and 1 a 3-leg, 3 of 4 were signalized. Focused on turning drivers who would see signs.</td>
<td>Small but significant impact on drivers yielding at all 4 corners.</td>
<td>About 28% of respondents felt signs made them feel safer, but almost none correctly identified the recent safety change initially.</td>
<td>Low</td>
<td>Standard Manual of Uniform Traffic Control Devices MUTCD sign used.</td>
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<td>3. LOOK Pavement Stencils</td>
<td>Thermoplastic “LOOK” stencils applied on pavement in crosswalks (within 4 feet of curb) to encourage pedestrians to look for approaching vehicles. Tested at signalized intersections only, but could also be used at unsignalized intersections.</td>
<td>Video recorded pedestrian/driver behavior at 4 intersections. Interviewed pedestrians at one of the four intersections.</td>
<td>Mixed impacts on pedestrians looking behavior; increased at 1 intersection and decreased at 2 intersections. No significant change in vehicle/pedestrian conflicts except at only one intersection.</td>
<td>About 29% of respondents felt safer, but only about 8% correctly identified the recent safety change.</td>
<td>Low</td>
<td>Stencils are highly susceptible to fading and blemishes. Used Chinese/English at one location. MUTCD compliant, but not explicitly included. Difficult to observe whether or not the pedestrian looked.</td>
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<td>4. Modified Signal Timing</td>
<td>All-Red phase extensions at 3 intersections intended to reduce conflicts for pedestrians who are late crossing. At one intersection, accompanied by installation of pedestrian signals for crossing minor street, and at another pedestrian clearance increased, but Walk phase shortened (due to area-wide cycle change). Also, longer cycle and longer pedestrian crossing time at 4th intersection.</td>
<td>Video recorded 2 all-red intersections. Manual observations for 2 other intersections. Interview survey at 1 all-red intersection.</td>
<td>Findings are too complicated and generally minor to summarize.</td>
<td>About 60% of respondents felt the signal timing change made them &quot;extremely safe&quot; or &quot;more safe.&quot; However, virtually none realized initially that there had been a timing change.</td>
<td>Low</td>
<td>Not possible to isolate simple timing changes. Substantial difference in the changes tested at different intersections.</td>
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<td>5. Pedestrian Head Start</td>
<td>4-second leading pedestrian interval added at 3 intersections with heavy left turns from one-way streets, and at one 2-way intersection with more balanced turning movements. Intended to allow pedestrians to start crossing and establish right-of-way before heavy turn movements block them.</td>
<td>Video recorded pedestrian/driver behavior at 4 intersections. Survey at 1 intersection.</td>
<td>Significant reduction in vehicles turning in front of pedestrians at three intersections (6.2% pre- vs. 4% post-overall).</td>
<td>About 56% of respondents felt the signal timing change made them feel &quot;extremely safe&quot; or &quot;more safe.&quot; However, only 9% correctly identified the recent safety change.</td>
<td>Low</td>
<td>Impact of pedestrian head start could be enhanced with red turn arrow.</td>
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<td>6. Advanced Stop Lines and Red Visibility Curb Zones</td>
<td>Line 4-10 feet before crosswalk (controlled or uncontrolled) to discourage intrusion into crosswalk and to provide better visibility, reduce multiple threat problem. In some cases accompanied by red visibility curb zones.</td>
<td>Video recorded pedestrian/driver behavior at 2 intersections. Both had relatively small samples for some variables. Interviewed pedestrians at 1 intersection.</td>
<td>Generally inconclusive results for pedestrian/driver behavior.</td>
<td>About 37% said change made them feel safer, however none correctly identified the change initially.</td>
<td>Low</td>
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<td>7A. Flashing Beacons – Push Button Activated</td>
<td>Used at uncontrolled crosswalk to warn drivers to yield to pedestrians.</td>
<td>Video recorded pedestrian/driver behavior at one intersection.</td>
<td>Significant reductions in vehicle/pedestrian conflicts (6.7% pre vs. 1.9% post), significant increase in vehicle yielding (70 to 80%). Only 17% used push button, although another 27% crossed while beacon was on.</td>
<td>No pedestrian interview survey.</td>
<td>Medium</td>
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<td>7B. Flashing Beacons – Infrared Detection</td>
<td>Used at uncontrolled crosswalk to warn drivers to yield to pedestrians. Automated detection useful because substantial share of pedestrians typically do not push button.</td>
<td>Video recorded pedestrian/driver behavior at one intersection.</td>
<td>Significant reduction in vehicle/pedestrian conflicts (6.1% pre vs. 2.9% post) and significant reduction in number of pedestrian trapped (4.1% to 0%), significant increase in vehicle yielding (82% to 94%).</td>
<td>No pedestrian interview survey.</td>
<td>High (higher than push button type)</td>
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<td>8. Portable Changeable Message Speed Limit Sign</td>
<td>Used mid-block to notify drivers they are speeding. Trailer typically moved daily, so duration of impacts may be limited, but drivers don’t “tune it out.”</td>
<td>Video recorded pedestrian/driver behavior at 4 intersections. Collected pre/post vehicle speed data.</td>
<td>Inconclusive impacts on driver behavior at crosswalks. Should have no impacts on pedestrian behavior. Significant speed reductions (by 1-6 MPH).</td>
<td>No interview survey because trailer only deployed for one day per location.</td>
<td>Medium</td>
<td>More a general speed control measure than pedestrian-specific measure.</td>
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<td>9. ADA Curb Ramps</td>
<td>Used for safer, easier crosswalk entry by those in wheelchairs, with strollers, etc. The SF installation separated curb ramp from gas station driveway at one corner to reduce potential for conflicts between gas station traffic and pedestrians.</td>
<td>No driver/pedestrian behavior analysis because curb ramps not expected to have observable change on measures of effectiveness.</td>
<td>The primary safety benefit was to separate gas station traffic from pedestrians at one corner.</td>
<td>Interviewed pedestrians at one intersection, but results not considered reliable.</td>
<td>Medium</td>
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<td>10. Pedestrian Refuge Island</td>
<td>Used at controlled and uncontrolled crossings to provide a safer median refuge to encourage pedestrians to stop and defer crossing until safer. Also, may slow turns.</td>
<td>Video recorded pedestrian/driver behavior at 2 intersections. Interviewed pedestrians at 1 intersection.</td>
<td>Inconclusive impacts on driver and pedestrian behavior. Only 3% of pedestrians stayed on island 8+ seconds.</td>
<td>Among respondents, 70% felt safer and 36% noticed the improvement.</td>
<td>Medium</td>
<td>New islands were in “shadow” of existing long median islands (i.e., median waiting area was already semi-protected), so impact may have been reduced.</td>
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<td>11. Automated Video Detection of Pedestrians to Adjust Signal Timing</td>
<td>Used to extend crossing time when pedestrians are detected likely to finish on the red. Implementation extended the solid Red Hand (Don’t Walk) phase and Green Ball phase up to three additional seconds.</td>
<td>Video recorded pedestrian/driver behavior at one intersection. Also collected data on extension frequency and duration. Most pedestrians surveyed did not notice the change, but this was to be expected since the countermeasure is virtually invisible to pedestrians.</td>
<td>Non-significant reduction in pedestrians finishing crossing on solid red hand (14 to 12%). Device also successfully extended crossing time for late pedestrians.</td>
<td>Among respondents, 49% said they felt safer and 22% said drivers yielded more often.</td>
<td>High, both capital and labor to set up.</td>
<td>Vendor believes this is the only such video application in the US. Detection logic should be changed so vehicles encroaching on crosswalk don’t trigger extension.</td>
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<td>12. Fixed Changeable Message Speed Limit Sign</td>
<td>Used mid-block to notify drivers they are speeding. As a permanent sign, the effects at one location more likely to endure, but drivers may “tune out.”</td>
<td>Video recorded pedestrian/driver behavior at 3 intersections. Also measured pre/post vehicle speeds. Interviewed pedestrians at 1 intersection.</td>
<td>Inconclusive pedestrian/driver behavior impacts. No significant speed reduction on arterial streets.</td>
<td>About 42% of pedestrians felt countermeasure made them feel safer, but none identified the change correctly initially (hardly visible from intersection).</td>
<td>Medium</td>
<td>For the PedSafe project signs were installed on arterial streets where it may be difficult for drivers to know if sign speed applies to them or to others, although in some cities they are used only on neighborhood collector streets, often near schools.</td>
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<td>13. Retro-Reflective Materials</td>
<td>Retro-reflective materials (zipper pulls, belts, arm bands, etc.) increase visibility of the wearers particularly in low light conditions. The materials were distributed to six schools and five senior centers as part of the PedSafe public outreach program.</td>
<td>One month after distribution of the materials, researchers made observations in the neighborhood of several schools where students had received the materials.</td>
<td>The materials were not seen in use during the follow up observation and it was concluded that they were not being widely used by the students.</td>
<td>No interview survey</td>
<td>Variable</td>
<td>It was difficult to schedule presentations and distribution, particularly in schools.</td>
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</table>
Hua, Gutierrez, Markowitz, Banerjee and Ragland (2008)

The overall conclusions regarding the effectiveness of the countermeasures are listed in Table 2. For more details on the conclusions, how they were determined, and the results for individual countermeasures and intersections, including information on countermeasure costs, maintenance experience, and ease of implementation, please refer to the specific countermeasure in the San Francisco PedSafe Phase II Final Data Report and Implementation Report February 2008 (1).

**TABLE 2. Overall Tentative Conclusions of Effectiveness of Countermeasures (CMs)**

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<thead>
<tr>
<th>CMs Considered Most Successful</th>
<th>CMs Considered Not Successful</th>
<th>CMs Considered Inconclusive</th>
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<tr>
<td>• Flashing Beacons</td>
<td>• Look Pavement Stencils</td>
<td>• Modified Signal Timing</td>
<td>For countermeasure-specific details, please refer to the San Francisco PedSafe II Final Data Report and Implementation Report.</td>
</tr>
<tr>
<td>• Automatic Video Detection with Signal Extension</td>
<td>• Advanced Stop Lines and Red Visibility Curb Zones</td>
<td>• Refuge Island</td>
<td></td>
</tr>
<tr>
<td>• In-Street Pedestrian Signs</td>
<td>• Retro-reflective Materials</td>
<td>• ADA Curb Ramps</td>
<td></td>
</tr>
<tr>
<td>• Pedestrian Head Start</td>
<td>• &quot;Turning Traffic Must Yield to Pedestrians&quot; Signs</td>
<td>• Changeable Message Speed Limit Signs</td>
<td></td>
</tr>
<tr>
<td>• Portable Changeable Message Speed Limit Signs</td>
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</tbody>
</table>

Regarding the outreach program, the primary audience for the presentation outreach encompassed the residents of communities in the seven PedSafe zones. In-person presentations were conducted at six public elementary and middle schools and five senior centers, providing general safety tips and information about the PedSafe project and other topics related to pedestrian safety. However, the results were not systematically evaluated; therefore, they were not discussed in the paper.

**DISCUSSION**

This project was successful in demonstrating the ability of a local government and university team to develop a data-based plan to improve pedestrian safety, focusing on higher-injury areas, and then to implement and evaluate the plan. There is a wide range of pedestrian safety countermeasures available that can be tailored to specific location characteristics. A package of such measures can reduce vehicle/pedestrian conflicts, increase driver yielding, and bring about other changes in driver and pedestrian behavior that should, over the long term, decrease the number of pedestrian injuries. However, due to the project scheduling, it was not possible to directly observe the impacts on pedestrian-involved crashes, which would require several years of post-installation data to have meaningful results.

PedSafe Phase II was conducted over a period of three years. Extensive engineering efforts began in 2004, including additional feasibility research and design layouts for a broad range of innovative devices and interventions. Implementation of the countermeasures took place from Spring 2005 through Fall 2006, with final refinement of several devices in early 2007. Therefore, the final evaluation results represent surrogate data. It was not feasible to analyze the actual impacts of the countermeasures on pedestrian injuries due to the short time after device installation and the lag in receiving crash data.
It was not possible to make conclusions about the overall effectiveness of the countermeasures as they varied by neighborhood or pedestrian characteristics (e.g., age group). This was primarily because the number of installations for each countermeasure was limited. However, it is likely that such factors were important. As indicated in other studies, pedestrian demographics and street characteristics would impact the effectiveness of the countermeasure (6,12). For example, the low level of use of the push button to actuate the flashing beacons at 16th & Capp may have been partly due to the generally younger age profile of pedestrians, the relatively narrow crossing, and the extremely lively (disturbing) street activity in this area.

According to the intercept survey conducted for each countermeasure, pedestrians appeared to appreciate most countermeasures, but showed minimal awareness of which devices were installed. There were essentially no common suggestions by pedestrians surveyed for improving intersection safety; their suggestions varied widely.

Indeed, pedestrian safety is heavily affected by a wide range of factors beyond the control of a project such as PedSafe. These include such factors as: driver licensing and other traffic law changes; police enforcement activities; employment and other economic activity fluctuations; vehicle safety improvements (e.g., braking abilities), and other safety efforts (such as red light photo-enforcement programs). The ability of a project with the budget the size of this PedSafe effort to have a major citywide impact is limited, although it can certainly catalyze significant changes.

During data analysis, clear and consistent definitions of the pedestrian/driver behavior measures of effectiveness (MOEs) are needed. There are no accepted, universal definitions of five key project MOEs, including: Vehicle/Pedestrian Interaction, Vehicle Yielding, Vehicle/Pedestrian Conflict, Vehicle Crosswalk Blockage, and Pedestrian Trapped.

The vehicle/pedestrian conflict was particularly challenging to define. The subjective definition used stated that a conflict happened if the driver swerved or braked quickly (not smoothly) or if the pedestrian changed stride or gait, apparently showing concern about an imminent collision. This was a less restrictive definition than a “near miss” as it did not require the pedestrian and vehicle to come “within inches” nor require the driver to “slam on the brakes.” However, it would not include the routine, smooth changes in speed that drivers and pedestrians make frequently as they yield to avoid a collision.

Thus defined, the occurrence of a conflict was rare enough that it was quite difficult to detect an adequate number of conflicts during baseline observations to make a statistically significant improvement possible. A strict definition can make statistical significance impossible to achieve even with a reasonable sample size.

LESSONS LEARNED

Besides the impacts of specific countermeasures on pedestrian and driver behavior discussed above, several lessons were learned during implementation of countermeasures, data collection and analysis.

Implementation

Developing and implementing a comprehensive pedestrian safety plan requires a long time frame. The San Francisco project took nearly six years, including almost two years for planning, two years for design/procurement/approvals, and two years for implementation and
evaluation. However, this time frame was partly the result of an extensive and extremely labor-intensive data collection and analysis effort. (In San Francisco, it generally takes 2-3 years to install pedestrian signals at a typical location, from funding commitment through design and construction, usually as part of a large signal contract.)

Three major organizations were involved in the implementations of the countermeasure namely SFMTA, the San Francisco Police Department (SFPD), and Population Research Systems, the company contracted to UC Berkeley Traffic Safety Center to collect video and administer intercept surveys. A project involving multiple organizations and requiring data to be collected at various levels needs to be co-coordinated very minutely. There were coordination issues at times between the many bodies involved in this research. This was the main issue for the study not being implemented as a staggered implementation study as earlier planned.

Additionally, street reconstruction “erased” some previous pedestrian safety measures, such as advanced limit lines and ladder style crosswalks.

Ideally, the interval between the time of baseline observations and that of installation of countermeasures should be as short as practically possible. However, in some cases baseline observations for Pedsafe I had to be used, although these were recorded several years before the post-installation data collection. This allowed the possibility of uncontrolled changes to take place in the time interval between the baseline and the first follow up survey. This could influence the results obtained and the conclusions drawn.

Furthermore, some of the camera angles were incorrect and producing different viewpoints for the same intersections, which then prevented adequate assessment of driver and pedestrian behavior at several intersections, and observations made at these intersections were discarded.

When video recordings are captured from different viewpoints, for the same intersection, video observers often must first determine which crosswalk to observe. In some cases, the wrong crosswalk was selected and observed. Additional preparation time was necessary to determine which crosswalk was to be observed. The “Street View” application in Google Maps helped considerably with this task. In Street View, aerial photographs of intersections and their surroundings could be obtained from different viewpoints. This process took 15 to 20 minutes per intersection. Without the “Street View” feature, determining which intersection to observe would have required an additional site visit.

Although not strictly necessary for accuracy, capturing all video recordings from the same angle of observation for each intersection would greatly simplify the process. Video observers could then use the same reference points and apply the same rules when coding events. Maintaining proper records of past camera angles is crucial for accurate analysis later. In cases where intersections appear visually quite similar to each other, the wrong crosswalk may be video recorded or observed.

To summarize, our primary recommendations in improving video data collections are that there should be better communication and co-ordination between all the agencies involved. Next, complete records should be maintained of previous recording angles.

**Data Collection and Analysis**

Video data collection has the advantage of allowing repeated viewings and precise time stamping of events (such as pedestrian wait time duration). However, the labor requirements for tabulating video recorded events were several times greater than for manual data collection. The
field of vision was also often more restricted than optimal, possibly obscuring important vehicle actions. The amount of information provided by video footage (particularly after conversion into a format that is compatible with the playback software) is far less than a live observer could collect, making it more difficult, for example, to determine whether there was a vehicle/pedestrian conflict.

In theory, video footage could be analyzed for vehicle speeds. However it was difficult to do this with the necessary precision. There were occasional problems with converted video recordings skipping frames or running at inconsistent speeds, making sensitive timing analyses difficult.

FURTHER RESEARCH

The primary opportunity for additional research would be an evaluation of the actual pedestrian injury impacts of the countermeasures. This would require follow up observations 3-6 years after device installation. In order to obtain a meaningful sample size, several years of post-installation data are needed.

As described in the discussion section, clear and consistent universal definitions of the pedestrian/driver behavior measures of effectiveness (MOEs) are needed. These universal definitions should not only explain the occurrences of each incident, but also address the relationships between them. The five key project MOEs include Vehicle/Pedestrian Interaction, Vehicle Yielding, Vehicle/Pedestrian Conflict, Vehicle Crosswalk Blockage, and Pedestrian Trapped. As surrogate MOEs, they are frequently used in countermeasure evaluation studies (6,7,8,9,12); however, questions such as whether these occurrences could happen at the same time remain unanswered. Clear and consistent universal definitions will set a standard among research studies and keep all the researchers on the same page, as well as allow city planners, policy makers and others to utilize different research findings in improving the cities, policies, etc.

Video data collection is a time-consuming process. In order to take a full advantage of video data collection, i.e. the precision and repeated viewing, methodologies and technologies need to be developed to enable automated video analysis. Currently, a few research groups have developed tools to allow researchers obtain pedestrian and vehicle time stamps. These tools are able to recognize and distinguish the differences of moving subjects on the video screen and determine whether the moving subject is a human, a bicycles or a vehicle; however, accurate results cannot be obtained unless the correct camera position and angles are used and the background environment cannot be too complex (huge amount of pedestrians and vehicles).

CONCLUSION

Overall, in PedSafe Phase II, 13 countermeasures, mostly low to moderate cost, were installed at 29 intersections based on PedSafe I analysis of crash patterns and assessment of intersection characteristics at higher injury density sites The countermeasures were evaluated by accessing surrogate measures of effectiveness (MOEs) through video observations and pedestrian intercept surveys. The six most successful countermeasures (based on positive impact on driver and pedestrian behaviors, considering installation cost) included: flashing beacons (with automated and push button actuation), in-street pedestrian signs, video detection to adjust
signal timing, pedestrian head starts (leading pedestrian intervals), portable changeable message speed limit signs, and “Turning Traffic Must Yield to Pedestrians” signs.

Intercept surveys were conducted to determine how pedestrians viewed the countermeasures indicated that pedestrians were unaware of the improvements made in general; however, once they were informed about these improvements, they gave positive feedback, with a majority stating that the improvement made them feel safer.

Future studies of the impacts of these countermeasures on pedestrian injury are needed to see their long-term effects. Developing universal definitions for essential measure of effectiveness is also needed for more accurate observations and study outcomes.

Better communications between different agencies involved at variable stages of the study would ensure successful countermeasure installation, data collection and analysis. This would also save large amount of time expended in the subsequent steps in the study.

Video data collection had the benefit of allowing repeated re-viewing and precise timing of events, but the labor requirements were several times greater than for manual data collection. Cost-benefit of using manual and video data collection needs to be further assessed; in general, cost seems much higher than the benefit. However, with the development of automated video analysis, the potential benefits could far exceed cost.

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