Evaluation of Miami–Dade Pedestrian Safety Demonstration Project

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This study's purpose was to implement a comprehensive program to reduce pedestrian deaths and injuries among pedestrians in a large urban environment. Miami–Dade County, Florida, was selected as the study's focus. High-crash locations were targeted for countermeasure implementation and analysis. With pedestrian crash data (1996–2001), four zones within the county were identified as having abnormally high pedestrian crash experience. On the basis of crash characteristics and pedestrian factors (age, ethnicity), 16 education, enforcement, and engineering treatments were implemented to reduce pedestrian crashes in the four zones and countywide. A before-and-after study was used with three control groups to evaluate the effects of the pedestrian safety program on pedestrian crashes. A 3-year "after" period was used (2002–2004). Multivariate intervention autoregressive integrated moving average time-series analysis was used, along with nonparametric U-tests to test for statistically significant differences in pedestrian crash experience. Results showed that at the peak of the program effects in 2003 and 2004, the pedestrian safety program reduced countywide pedestrian crash rates by anywhere from 8.5% to 13.3%, depending on which control group was used. These effects translate to approximately 180 fewer crashes annually in the county, or 360 pedestrian crashes reduced for 2003 and 2004 combined, based on the more conservative 8.5% crash reduction. Countywide, the greatest crash reductions were found among children and adults as a result of the program. Educational and other measures to reduce crashes involving older pedestrians showed no effect. A number of lessons learned were identified for future program implementation.

The number of pedestrians killed in U.S. traffic crashes has declined more than 40% since peaking in the late 1970s and early 1980s. Still, in 2005 there were 4,881 recorded pedestrian fatalities, representing 11% of all U.S. traffic deaths (*1*). In urban areas, where pedestrian activity and traffic volumes are greater than in rural areas, pedestrians often make up 25% or more of traffic deaths.

During the 1970s, a research project series sought to identify causal factors of pedestrian crashes and appropriate countermeasures. The research by Snyder and Knoblauch (*2*) focused on urban pedestrian crashes, but subsequent studies extended the methodology to rural and freeway crashes (*3*). From this research evolved the basic pedestrian crash typology, which remains a cornerstone of much of NHTSA's pedestrian safety activity, as well as that of FHWA. Crash types describe behaviorally similar precrash actions that lead to characteristic pedestrian–motor vehicle collisions. For example, precrash actions may include "the pedestrian walked or ran into the roadway," "the pedestrian was struck at an unsignalized intersection or midblock location; either the motorist or the pedestrian may have failed to yield," or "the pedestrian was attempting to cross a roadway and was struck by a vehicle that was turning right or left." The aim in typing crashes is to gain a better understanding of underlying factors and causes so that appropriate countermeasures can be developed. The Pedestrian and Bicycle Crash Analysis Tool (PBCAT, v. 2.0), an automated typing software program developed for FHWA, includes 56 distinct pedestrian and bicycle crash types, which may be classed into 16 groups (*4*).

During the late 1990s, NHTSA also developed the concept of pedestrian safety zones, to focus improvements where the problem is greatest. By concentrating efforts where the majority of the problem or the target audience exists, funds are used more efficiently and activities that would be prohibitively expensive if applied to an entire community can be applied for the greatest benefit on a smaller scale. For example, in Phoenix, Arizona, six circular zones and one linear zone were identified that accounted for 54.9% of the city's older adult crash problem in about 4.6% of the land area (*5*).

The intent of this demonstration project was to extend application of the pedestrian safety zone approach to a large urban area and document and evaluate the process so that it could be replicated in other metropolitan areas with high numbers of pedestrian crashes. The project draws heavily upon previous NHTSA and FHWA research to identify and evaluate countermeasures for improving pedestrian safety (aimed at both pedestrians and motorists) and applies this knowledge on a broad scale to produce tangible, communitywide safety benefits.

PROJECT GOALS AND OBJECTIVES

The overall goal was to reduce pedestrian deaths and injuries in a large urban environment by implementing a long-term pedestrian safety program within the jurisdiction. The specific project objectives were to work with stakeholders in the community to

1. Obtain and analyze pedestrian crash data to identify zones of high incidence of pedestrian crashes and the special characteristics of those crashes;

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2. Identify and implement a comprehensive program of educational, engineering, and enforcement strategies (see Table 1 for details) aimed at both pedestrians and motorists to address the problems identified;
3. Evaluate the safety benefits of the program; and
4. Document the process for other cities or urban areas that may want to replicate the process.

PROJECT SITE

The project was conducted in Miami–Dade County, Florida. This location was selected because of the significant pedestrian injury and fatality problems the area was experiencing. In 2001, just before the project began, Florida was the fourth-largest state in terms of population (16.4 million) but ranked first in the number of pedestrian fatalities (489). Within the state of Florida, Miami–Dade County (in 2001) led the state in pedestrian deaths and injuries.

Miami–Dade County encompasses more than 2,000 mi^2 and in 2005 had a diverse population of nearly 2.4 million persons, making it the eighth most populous county in the United States. The county includes the city of Miami and 34 other jurisdictions. The Miami–Dade County government is responsible for all transportation operations and improvements within the area, and it works closely with the city of Miami and other local officials.

In addition to its large urban population and significant pedestrian safety problem, there were a number of other reasons that led to the site choice, including excellent sources of available data, multidisciplinary interest among local agencies, and strong leadership and support at the state and county levels.

PAST RESEARCH AND RELATED PROGRAMS

Relevant research and program evaluations that provided a basis for development of the Miami–Dade countermeasures and strategies are summarized here. Much of the following discussion is drawn from the work by Cleven and Blomberg (*8*).

In the early 1980s, efforts continued (*9, 10*) to understand pedestrian crashes and develop countermeasures to target contributing factors, crash types, and specific populations. Many studies were conducted to develop, produce, and test public information and education messages for children (*11, 12, 3*), for adults (*11*), and for older pedestrians (*13*). In general, the studies concluded that public information and education messages for children and adults can be successful in reducing crashes if the target audience receives adequate exposure; however, the authors did not quantify "adequate exposure" specifically. Successful products from these studies, such as the films "Stop and Look with Willy Whistle" and "Walking with Your Eyes" were used in the Miami–Dade project.

The pedestrian safety zone concept, described earlier, was a key approach in this study. It was developed by Blomberg and Cleven (*14*) as part of pedestrian programs in Phoenix and in Chicago, Illinois. The study found that identifying zones was an effective and economically efficient method of deploying pedestrian countermeasures. The process of crash typing was also applied in this study. Hunter et al. (*15*) used NHTSA typing methodology to type more than 5,000 pedestrian collisions in six states and develop crash factor and typology information that allows for the development of specific interventions.

Numerous cities have integrated education, enforcement, and engineering countermeasures into their pedestrian safety programs. From 1977 to 1980, the Denver Pedestrian Safety Project combined efforts from various organizations (*16*) to identify specific pedestrian crash problems and develop, implement, and evaluate appropriate countermeasures. These combined efforts were associated with significant reductions in pedestrian collisions in Denver compared with increases for three comparison cities over the same time period (*3*). In addition, pedestrian safety activities in Seattle, Washington, incorporated education, engineering, and enforcement activities to reduce the number of pedestrian crashes and injuries (*3*).

STUDY METHODOLOGY

Local Partnership Development

Several partnerships were developed between local, regional, and state agencies to promote a sustainable program and capitalize on existing activities. Key partners included

- Miami–Dade Safe Kids Coalition (through Miami Children's Hospital),
- Injury Prevention Coalition (through Jackson Memorial Hospital),
- Florida Department of Transportation (FDOT),
- Community traffic safety teams in Miami–Dade County,
- University of Miami School of Medicine,
- WalkSafe Program Task Force,
- Miami–Dade County Metropolitan Planning Organization (MPO),
- Public schools, and
- Department of Public Works.

Study Design and Data Sources

A comprehensive pedestrian safety program should ideally consist of proactive efforts to identify and systematically correct potential pedestrian safety problems before crashes occur, as well as a reactive response to identify and treat pedestrian crash locations. This study reports on the results of a comprehensive proactive and reactive (pedestrian crash-based) pedestrian safety program implemented in Miami–Dade County. The design for the Miami–Dade pedestrian demonstration included the use of pedestrian crashes as the sole outcome measure of effectiveness. Although intermediate measures of pedestrian and driver behavior were used in other evaluation studies of pedestrian countermeasures, they were not feasible in the current effort for at least two reasons. First, the interventions in the project were to be comprehensive and therefore would cover a multitude of potentially relevant behaviors, most of which would be difficult or costly to measure in a valid and reliable manner. Second, the available pedestrian crash data for Miami–Dade, both baseline and after interventions, were sufficiently large to support a sensitive assessment of program success based on crash reduction outcome.

With crashes as the project's evaluation measure, effort turned to building a database of crashes to support analyses of effectiveness. This phase involved selecting a source for crash data, retrieving and coding the data, and defining appropriate subsets for analysis for 1996–2004.

Data Collection and Processing

The Florida Department of Highway Safety and Motor Vehicles (DHSMV) database consisting of all the state's reported pedestrian-

TABLE 1 Countermeasures Implemented

No.	Countermeasure	Start Year	Location
Educational Countermeasures			
1	WalkSafe Program and Ryder Trauma Center Classroom Education. Program aimed at reducing the incidence of children struck by vehicles by educating elementary school-aged children, teachers, parents, and their communities about traffic safety. The program used an educational training intervention, appropriate engineering counter measures, and an enforcement component to help achieve its goal. An evaluation of the program was done by Hotz et al. (*6*).	2003	LC, LH
2	Pedestrian safety message mounted in bus and Metrorail train posters. Included six sets of different pedestrian education posters aimed at increasing pedestrian safety practices. The posters' safety messages were in English, Spanish, and Creole. The target audiences were primarily adults.	2003	Countywide
3	Walk to School Day sponsored by SAFE KIDS Walk This Way. Thousands of students from eight schools participated in Walk to School Day. The National SAFE KIDS Campaign provided banners, signs, pedestrian safety pamphlets, and walkability surveys. Over 100,000 copies of the "Walking Through the Years" brochure were distributed at events from 2001 to 2005, as well as 10,000 retroreflective zipper pulls and wrist bands.	1999	Countywide
4	Pedestrian education by the Community Affairs Bureau of the Miami–Dade Police Department. The Pedestrian Safety Section of the Miami–Dade Police Department's Community Affairs Bureau made numerous traffic safety presentations in schools, distributed several safety booklets and materials, and helped establish the WalkSafe Miami program. The target audiences were primarily children.	1999	Countywide
5	Haitian Creole Elementary School and older pedestrian safety education programs. The elementary school program consisted of four 45-min workshops conducted at three elementary schools, reaching 389 children. Both programs were supported by radio advertisements, Haitian websites, a brochure in Haitian Creole, and Haitian Creole trading cards.	2001	LC
6	Brochure: Safety Tips for Pedestrians in Haitian Creole. Pamphlet that provides pedestrian safety advice to adults. These were handed out at senior centers and by social service providers.	2002	LC
7	Heroes of Haitian Independence Trading Cards. Four cards that each depict a hero of Haitian independence on one side and provide pedestrian safety tips on the other. These were distributed at senior centers, schools, and health fair events.	2002	LC
8	Public service announcements (PSAs). PSAs about pedestrian safety were distributed and broadcast on city and county access channels in Spanish and English and on selected Spanish-speaking radio stations.	2003	Countywide
9	Brochure: Pedestrian, Walk Safely. Brochure providing families with the pedestrian safety advice in both English and Spanish. Brochures were delivered to organizations such as the Miami–Dade School Board, hospital, public library, police departments, and elected officials' offices.	2002	LC, LH
10	Walking Through the Years: Pedestrian Safety for Your Child. Brochure (in English and Spanish) providing safety guidelines to parents and caregivers to help protect children from pedestrian crashes. Brochures were delivered to organizations such as the Miami–Dade School Board, hospital and medical departments, public library, police departments, and elected officials' offices.	2002	LC, LH
11	Pedestrian Safety Workshops for Older Populations. The Miami–Dade MPO pedestrian–bicycle coordinator began providing workshops on pedestrian safety to older pedestrians and groups working with older populations in 2002. Presentations were made at more than 20 assemblies and senior health fair events.	2002	SB, LC, LH
12	Walking Through the Years: Pedestrian Safety for the Older Adult. Booklet prepared for older (65+) adults and implementers of programs for older adults. Brochures were delivered to organizations such as the Miami–Dade School Board, hospital and medical departments, retirement homes, public library, police departments, elder affairs, and elected officials' offices.	2002	SB, LH
13	Caminando a Traves de los Años: Seguridad para Peatones de Tercera Edad (65+). Booklet in Spanish prepared for implementers of pedestrian programs for the older (65+) adult. Brochures were delivered to organizations such as the Miami–Dade School Board, hospital, elder affairs, retirement homes, public library, police departments, and elected officials' offices.	2002	SB, LH
14	Nighttime Conspicuity Enhancements. More than 400 posters on nighttime conspicuity related to pedestrian safety were distributed to organizations to display in public buildings.	2002	SB, LC, LH
Enforcement Countermeasures			
15	Enforcement of Driver Yielding Behavior Study, Two Police Pedestrian Safety Training Programs, and Enforcement. Van Houten and Malenfant (*7*) conducted a study of driver yielding behavior at four crosswalks in each of two—an east and west—high-crash corridors in the City of Miami Beach. In 1 year, police stopped 1,562 motorists for failing to yield to pedestrians, with 1,218 of these stopped during the first 2 weeks of the program. Three hundred seven citations were issued, of which 188 were given during the first 8 weeks of the program. For enforcement results, review work by Van Houten and Malenfant (*7*). Additionally, police officers in Miami Beach and Miami Springs received training on pedestrian safety and enforcement activities that have been used to address a variety of violations and behaviors that often lead to collisions between pedestrians and motor vehicles.	2002	SB
Engineering Countermeasures			
16	Florida DOT Engineering Projects Related to Pedestrians. During the implementation period of January 2002 through December 31, 2004, numerous engineering and roadway treatments were implemented by the Florida DOT. These included measures such as adding raised medians on selected multilane roads, installing missing sidewalk links, installing pedestrian warning signs at specific locations, revising traffic signal timing, implementing safer facilities in selected school zones, and others.	2002	Countywide

NOTE: LC = Liberty City/Little Haiti, LH = Little Havana, MPO = metropolitan planning organization, SB = South Beach, DOT = Department of Transportation.

related crashes was the original data source used for the countywide crash evaluation. Additional effort was required to refine the data, assign crash types using PBCAT software, and perform address matching to locate the crash event within the electronic street map of a geographic information system (GIS).

Data Sample

Over the 9 years of the project period examined, there were 17,308 pedestrian crashes in the DHSMV, Miami–Dade County, which included 724 fatal crashes (4.2%). After all crash reports had been screened and geocoded, a total of 15,472 pedestrian–motor vehicle crashes remained, which were used in the zone analysis. Of these, 670 fatal injuries and 3,002 crashes involving serious injury were reported. Crashes fluctuated during the years of the study period, with an apparent downward trend in total crashes from 1996 to 1999, before the program countermeasures were implemented. Most of the countermeasures were implemented after January 2002, so the "before" period used in the analysis is 1996 through 2001, and the "after" period is 2002 through 2004. The first year of the after period was selected to be 2002 since some countermeasures were implemented near the beginning of 2002. Of course, more countermeasures were under way by 2003, so the combined program effects were expected to be more pronounced in 2003.

Generating Pedestrian Crash Maps

The team produced maps of pedestrian crashes for the before analysis period of 1996–2001. A crash location (pin) map was analyzed to reveal different crash-related factors, such as age of pedestrian, injury severity, light conditions, and crash type, based on data from the police report. The pedestrian crash data were combined with other Miami–Dade County GIS data to show the relationship of crashes to other spatial data, such as locations of schools, nursing homes, and transit stops and aerial images. These and other pedestrian crash maps were also later used at the zone level in the process of countermeasure development.

Identification of High-Crash Zones and Problems

The GIS software contains an algorithm that calculates data point density based on search criteria provided by the user. Crash density per acre is shown in bands of color that reveal areas where greater numbers of pedestrian crashes have occurred. This feature was used to identify high-crash areas, corridors, and intersections for priority-ranking of countermeasure resources. The end result of this process was an electronic map of pedestrian crashes, in which high-crash concentration areas are displayed.

From this analysis, four zones were identified for further investigation and targeted pedestrian safety measures: South Beach, Liberty City, Little Havana, and Little Haiti (Figure 1). The area of the identified four zones is 9,891 acres, less than 1% of the total area of Miami–Dade County. However, from 1996 to 2004, the number of pedestrian crashes in the four zones made up about 20% (3,078 of 15,474 crashes) of the total number of pedestrian crashes in Miami–Dade County.

For each zone, detailed crash maps were generated to show the pedestrian crash patterns that have occurred along various corridors and at certain intersections. Crash data were further analyzed by mapping crashes by pedestrian age, time of day, and other factors. This

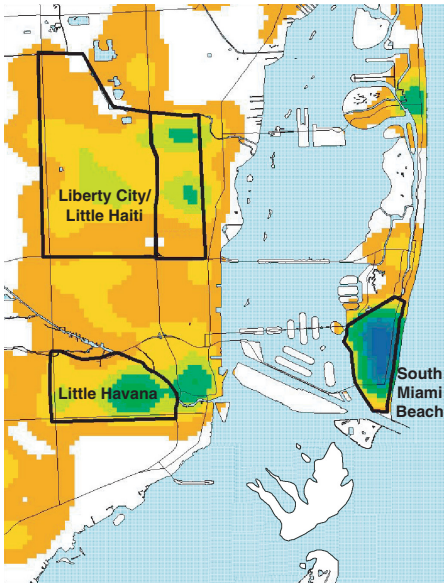

FIGURE 1 Miami–Dade zones with high pedestrian crash concentrations.

analysis revealed several general trends that further distinguished each study zone's pedestrian problems. For example, crashes in Liberty City and Little Haiti occurred primarily in the morning and afternoon periods and involved largely children and young adults. In Little Havana, a large percentage of the crashes involved older adult pedestrians who were identified on the police reports as Hispanic. In South Beach, a majority of the crashes occurred at night, particularly involving young adults, and during weekend periods.

In each of the four identified high-crash zones, a detailed review was conducted of the crash maps plus individual police crash reports. Project team members also conducted on-site investigations of the high-crash zones and visited many of the high-crash corridors and locations within each of these zones. The investigation team typically included local or state traffic engineers as well as Miami–Dade MPO representatives and study team members. Site reviews included the following activities:

- Reviewing all police crash reports for crashes that occurred at the site or corridor within the past 5 years;
- Observing site geometrics and traffic control devices, including signs, signals, number of lanes, presence and location of on-street parking, location of driveways, and so forth;
- Observing motorist and pedestrian behaviors as well as operation of the buses and passengers getting on and off the buses;
- Identifying obvious or potentially problematic roadway features that could contribute to pedestrian crashes; and
- Listing potential engineering, education, and enforcement treatments.

Description of Study Zones

The four zones had several common pedestrian safety and operational issues, including

- Lack of adequate lighting;
- Need for traffic and pedestrian signal maintenance and retiming;
- Lack of separate left-turn phasing at certain signalized intersections;

- Need to provide raised medians, traffic and pedestrian signals, or both, at several sites;
- Limited or blocked sight distance at intersections and along routes;
- Badly worn signs and crosswalk markings at signalized intersections;
- Heavy volumes of pedestrians who cross four- and five-lane streets to catch the bus, combined with heavy truck traffic;
- School routes in need of traffic engineering enhancements;
- Need for handicap-compliant curb ramps and pedestrian pushbutton signals; and
- Narrow or missing sidewalk links or sidewalks that are partially blocked.

The four zones also shared many behavior-related concerns:

- Motorists failing to yield to pedestrians in crosswalks and at unsignalized intersections;
- Motorists running red signals, particularly those making right turns on red;
- Motorists double parking, speeding, or parking too close to intersections;
- Pedestrian–vehicle conflicts and collisions in parking lots;
- Pedestrians walking or running into the street at midblock in front of oncoming traffic;
- Unaccompanied young school children walking to school and crossing wide streets; and
- Pedestrians crossing against the traffic signal or at midblock between parked cars.

Below is a brief description of some of the unique issues within each of the zones:

- South Beach. Many crashes involved young adult and older pedestrians and there was a high nighttime crash problem.
- Liberty City and Little Haiti. Many crashes involved young children who were struck by motor vehicles while walking to or from school; however, some of the crashes involved adults and older adults, particularly those trying to cross wide (four- and five-lane) streets.
- Little Havana. Little Havana's population is largely Hispanic, with a substantial percentage of people of Cuban origin; a high percentage of the pedestrian crashes involved older pedestrians of Hispanic descent.

These safety concerns helped local county and state officials determine which countermeasures were needed in each zone.

PEDESTRIAN SAFETY TREATMENTS

On the basis of the pedestrian safety issues identified, 16 pedestrian safety treatments were targeted at areas within Miami–Dade County and particularly within the four selected zones (see Table 1). Countermeasure implementation began at different times, and many have continued beyond the end point of the project.

ANALYSIS AND RESULTS

Countywide Crash Evaluation Results

For the countywide pedestrian crash evaluation, several control groups were identified to remove the effects of preexisting downward trends and other changes that could be mistaken for program effects. These control groups included Broward County (the county just north of Miami–Dade County, which includes Ft. Lauderdale), the six metropolitan counties in Florida (Duval, Hillsborough, Pinellas, Palm Beach, Orange, and Broward Counties combined), and all Florida pedestrian crashes (excluding Miami–Dade County). Pedestrian crash rates (pedestrian crashes per 100,000 population) were also determined for the county and control groups by month and year and used in the evaluations.

It was not considered feasible to determine the effect of each of the individual countermeasures on pedestrian crashes, since several of the treatments had similar or overlapping implementations and target populations. Thus, the evaluation focused on the overall pedestrian safety program. Multivariate intervention autoregressive integrated moving average (ARIMA) time-series analysis was used to determine the overall impact of the program.

To account for changes in the underlying population, the monthly counts were turned into rates per 100,000 population. The monthly total pedestrian crash rates are shown in Figure 2. The 12-month moving average in each series is also shown to help with interpreting or identifying the trends.

Miami–Dade had higher pedestrian crash rates than any of the other series, including the rest of Florida. The decrease in pedestrian crashes in Miami–Dade County is much more apparent in the per-capita figure, and it does appear to coincide with the time period during which the pedestrian safety program was under way. However, also apparent in the other control series are downward trends in pedestrian crashes that began some time before the interventions in Miami–Dade County. This downward trend is also apparent in the Miami–Dade County series but is much more gradual than the sharp decrease in the pedestrian crash rate that began in early 2002.

It is unknown why pedestrian crash rates were slowly decreasing in Florida during the time period shown, but some evidence shows that the drop could partly be a sign of decreased walking activities. Census data show that from 1990 to 2000, the proportion of people walking to work dropped from 2.51% to 1.71% in Florida. In Miami–Dade County, the share of people walking to work dropped from 2.53% to 2.15% (*17*). It was important to remove this trend from the Miami–Dade County series before evaluating the effect of the interventions; thus, control series were included in the analyses. Also, it should be noted that the pedestrian crash rate in Miami–Dade actually appears to have leveled off in early 2001 and then began to increase in the latter half of 2001. At this point there is a spike in the pedestrian crash rate. A similar spike can be seen in the Broward County series around January 2003. In other words, the pedestrian crash rate in Miami–Dade County was increasing in late 2001 before the countermeasure program was implemented, beginning in early 2002.

To determine the overall impact of the pedestrian safety program, ARIMA time-series analysis was used (*18, 19*). On the basis of the timeline for which interventions were implemented in Miami–Dade County, three different intervention points were tested in each model: January 2002, January 2003, and January 2004.

The key findings from the ARIMA countywide time-series evaluations are summarized as follows.

Reduction in Crashes

The first significant effect of the pedestrian safety program on overall pedestrian crashes was the intervention point in January 2003. The total effect of the Miami–Dade pedestrian safety program was estimated to be a 13.3% reduction in pedestrian crashes based on using Broward County as a control series and an 8.5% reduction based on using the six metropolitan counties or the statewide crash rates as control series. These reductions were significant at the 0.05

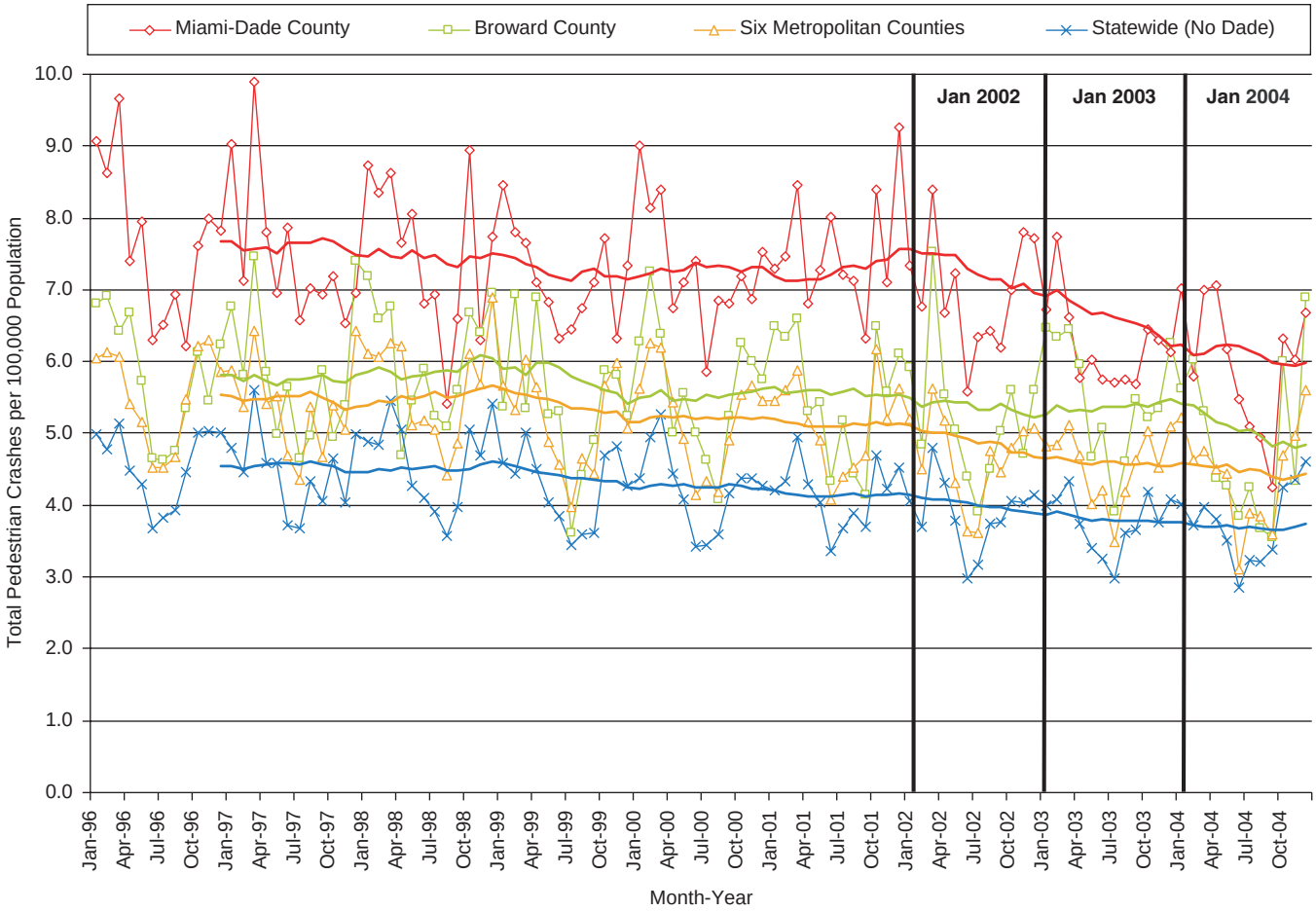

FIGURE 2 Monthly pedestrian crashes per 100,000 population in Miami–Dade County, Broward County, six metropolitan counties (combined), and statewide from 1996 to 2004.

level. The benefits of the pedestrian safety program continued beyond 2003 in that the average number of pedestrian crashes in 2004 remained lower than the pre-2003 level. However, no independent additive reduction was detected that could be associated with the pedestrian safety activities conducted during 2004. The ARIMA analyses showed that there was a large reduction in pedestrian crashes in Miami–Dade County during the combined 2003 to 2004 time period after other temporal trends (e.g., fuel prices and changes in traffic safety laws) and seasonality had been adjusted for by using the various comparison series of Florida jurisdictions. The conclusion that this reduction can largely be attributed to the overall pedestrian safety program is supported by the fact that the reductions in Miami–Dade pedestrian crashes were consistently larger than those for other Florida jurisdictions, regardless of how the comparison group was formed.

Thus, pedestrian crashes in Miami–Dade County were reduced by about 180 per year for a total of 360 fewer pedestrian crashes during the 2-year (2003–2004) after period, which was based on the more conservative 8.5% reduction estimate. A possible cause of this reduction is the combined pedestrian safety program efforts that began in 2003. The fact that pedestrian crashes per month leveled off during 2004 may indicate that additional countermeasures (or increased countermeasure intensity) are needed to achieve additional reductions in the monthly rate of pedestrian crashes after 2004 or that additional data points are necessary to be able to detect any additional independent effect of the activities in 2004.

The 180 crashes reduced per year was based on using the statewide (without Miami–Dade County) control group, which was one of the –8.5% estimates. The rationale was that this control group provided the most stable estimate of the expected change in Miami–Dade if the program had not been implemented. This value was selected of the three possibilities since (*a*) the metropolitan county analysis would have provided the same estimate and (*b*) one would have had to argue that the pedestrian crash rate would have increased in Miami–Dade during the postintervention period as it seems to have done in Broward County in order to choose that analysis as the better counterfactual representation of Miami–Dade.

The effect estimate from the statewide control series analysis provides an estimate of 0.6281 fewer pedestrian crashes per 100,000 population for Miami–Dade. The average monthly population of Miami–Dade in the post-2003 period (2,383,733) was then divided by 100,000 to get the monthly average number of hundreds of thousands of population in Miami–Dade (23.84). This figure was multiplied by the 0.6281 to get the monthly estimate of crashes saved (14.97) and finally multiplied by 12 to get an annual estimate of 179.67, or approximately 180 crashes saved per year.

If Broward County had been chosen as the appropriate control for calculating this number, there would have been 281 crashes saved per year. Justification of this number would have required making the argument that pedestrian crashes in Miami–Dade County would have increased in the postintervention period as they did in Broward,

which was not considered to be defensible given that the other two control groups gave such a consistent answer.

Crashes Involving Children

Several of the countermeasures that were part of the overall pedestrian safety program were directed at reducing crashes among children. One of the primary countermeasures was WalkSafe, which was a countywide pedestrian safety education program implemented in virtually all of the Miami–Dade County elementary schools. Examination of pedestrian crashes for children (considering ages 1 to 13 and ages 5 to 12 separately, to better account for elementary-age children affected by the intervention) showed mixed results on a countywide basis. Although Miami–Dade experienced a large decrease in pedestrian crashes among children after January 2003, so did some of the control jurisdictions. Specifically, the analysis results showed a significant reduction in child pedestrian crashes as of January 2003, with Broward County as the control series, which would correspond to an 18.5% decrease. However, the results of the analysis did not indicate a significant change (0.05 level) in the child pedestrian crash rates by using the six metropolitan county or statewide control series. This result was clearly affected by the continuing drop in child pedestrian crashes statewide and in the six metropolitan areas, particularly since October 2000.

Such gradual but steady reductions in crashes in these two control groups may have been the result of factors such as less walking exposure (e.g., fewer children walking to school), statewide pedestrian safety initiatives carried out by FDOT in recent years, or both. The Miami–Dade pedestrian safety education program WalkSafe was initiated in the latter part of 2003, and thus the full benefit of the educational program may have occurred later than the January 2003 intervention period. More discussion of such an evaluation for the high-crash zones is provided later.

Crash Rates for 14- to 64-Year-Old Pedestrians

The ARIMA analysis of 14- to 64-year-old pedestrian crash rates indicated a significant reduction among this age group in Miami–Dade County starting in January 2003, regardless of the control group used. There was a downward trend in crashes involving this age group in each of the control groups, as well as a steeper downward trend in Miami–Dade County. By using the statewide control series to estimate the magnitude of this effect, the 2003 intervention date was associated with a 0.60 monthly reduction in Miami–Dade 14- to 64-year-old pedestrian crashes per 100,000 population, or about an 8.6% annual reduction in the average level before the pedestrian safety program.

Older Pedestrians

The average crash rate for older pedestrians (i.e., pedestrians aged 65 and older) was lower in Miami–Dade County and also in each of the control groups in the after period compared with the before period. None of the ARIMA models, however, indicated a significant change in the rates for age 65 and older in Miami–Dade County at any of the intervention points after controlling for variability by using the control series. More discussion on this issue is provided later, particularly with respect to Little Havana, where several countermeasures were directed at older Hispanic pedestrians.

Gender and Time of Day

The effects of the 3-year program were also examined with respect to gender and time of day. These analyses showed mixed results, with generally greater reductions in crashes for men and during daylight hours (between 10:00 a.m. and 6:00 p.m.) when compared with Broward County crashes. Table 2 summarizes the results.

Zone-by-Zone Crash Evaluation Results

In addition to the countywide crash analysis, the project team evaluated changes in pedestrian crashes in each of the high-crash zones that were targeted for countermeasure implementation, including Liberty City, Little Haiti, Little Havana, and South Beach.

For the zone analysis, number of pedestrian crashes (not crash rates) was used. Since no untreated control sites were available for

TABLE 2 Summary of Results from Countywide Analysis

	Effect of Pedestrian Safety Program		
Crash Measure Evaluated	Statewide Control Group	Six Metro Control Group	Broward Control Group
Total pedestrian crash rate	Sig. decrease 8.5%	Sig. decrease 8.5%	Sig. decrease 13.3%
Child pedestrian crashes (age 1–13)	N.S.	N.S.	Sig. decrease 18.5%
School-age child pedestrian crashes (age 5–12)	N.S.	N.S.	N.S.
Pedestrian crashes (age 14–64)	Sig. decrease 8.6%	Sig. decrease	Sig. decrease
Pedestrian crashes (age 65+)	N.S.	N.S.	N.S.
Male crashes	Sig. decrease 7.3%	Sig. decrease	Sig. decrease 9.4%
Female crashes	N.S.	N.S.	N.S.
Time of day			
6:00 a.m.–10:00 a.m.	N.S.	N.S.	N.S.
10:00 a.m.–2:00 p.m.	Sig. decrease 16.3%	Sig. decrease 16.3%	Sig. decrease 16.3%
2:00 p.m.–6:00 p.m.	Sig. decrease	Sig. decrease	Sig. decrease
6:00 p.m.–10:00 p.m.	N.S.	N.S.	Sig. decrease 13.6%
10:00 p.m.–6:00 a.m.	N.S.	N.S.	N.S.

NOTE: N.S. = no statistically significant difference, Sig. decrease = statistically significant decrease at the .05 level after adjustment for the control group.

this analysis, the resulting crash effects are less precise than if acceptable control zones had been available. This analysis was primarily intended to document the trends in pedestrian crashes for the specific pedestrian age and ethnic groups that were the targets of the countermeasures in those zones. Nonparametric tests (e.g., Mann-Whitney U-tests) were used for statistical significance testing since the data were not normally distributed. It should be noted that two-tailed tests were used because the two-tailed test is more stringent than the one-tailed test and because the software used (Statistical Package for the Social Sciences) uses two-tailed tests for all analyses. The major findings appear in Table 3 and are summarized in the following sections.

Crash Frequency

Pedestrian crash frequency in Liberty City and South Beach decreased significantly for all pedestrian crashes from the before-program period to the after-program period, whereas Little Haiti and Little Havana showed no significant changes in overall monthly crash frequency. Results of the tests for statistical significance are shown in Table 3.

Child Pedestrians

For crashes involving school-age child pedestrians (aged 5 to 12), only Liberty City experienced significant decreases from the before-program period to the after-program period. Liberty City, which had been identified as having the highest concentration of child pedestrian crashes in the pretreatment period, experienced the greatest absolute reduction in child pedestrian crashes after the pedestrian safety program was implemented. For the four zones combined, there was an overall decrease in child pedestrian (aged 5 to 12) crashes from 3.84 per month (46 per year) to 2.43 per month (29 per year), a reduction of about 37%.

The child pedestrian safety education program WalkSafe was initially implemented at all of the schools in Liberty City and was next implemented in Little Haiti and then at approximately half of the 200 elementary schools throughout Miami–Dade County. Therefore, one might expect that any effect on reduced child pedestrian crashes would be more pronounced in those zones (i.e., Liberty City and Little Haiti), where the education programs began sooner and were also the most intense. In fact, the largest absolute reductions in child pedestrian crashes occurred in these two zones.

Adult Pedestrians

In terms of crashes involving adult pedestrians (aged 14 to 64), no significant changes were found in Little Haiti and Little Havana. From the preprogram to postprogram periods, both Liberty City (17.2% reduction) and South Beach (23.3% reduction) experienced a significant drop in the number of crashes involving adult pedestrians. The countywide decrease was not statistically significant. The comprehensive pedestrian safety program consisted of a variety of treatments directed at different age groups and ethnic populations. To help to better understand these results, it should be remembered that some of these countermeasures (e.g., posters on transit vehicles) were directed at adult pedestrians in each of these four zones and to a lesser extent in other parts of the county. South Beach was the zone that received a more extensive amount of pedestrian countermeasures (including being the only zone that received the special police safety enforcement program during the implementation period), which helps to understand why that zone experienced a significant reduction in crashes involving pedestrians in the 14- to 64-year-old age group.

TABLE 3 Mean Difference in Monthly Crashes from Preprogram Period to Postprogram Period

		Preprogram Period (01/1996–01/2002)		Postprogram Period (02/2002–12/2004)				
Age Group	Crash Zone	Mean	Std. Dev.	Mean	Std. Dev.	Mean Diff.	*T*-Test Sig.	Mann-Whitney *U*-Test Sig.
Total	Liberty City	10.21	3.68	7.60	2.70	–2.605	0.000[a]	0.000[a]
	Little Haiti	4.77	1.95	4.71	2.55	–0.053	0.905	0.798
	Little Havana	6.60	3.01	6.89	2.45	0.283	0.629	0.476
	South Beach	8.29	2.97	6.46	2.80	–1.831	0.003[a]	0.004[a]
Child pedestrian (1–13)	Liberty City	2.89	1.81	2.11	1.32	–0.776	0.026[a]	0.023[a]
	Little Haiti	1.30	1.15	0.83	0.89	–0.473	0.035[a]	0.047[a]
	Little Havana	0.68	0.80	0.43	0.61	–0.256	0.096	0.125
	South Beach	0.29	0.51	0.11	0.32	–0.173	0.070	0.079
School-age child pedestrians (5–12)	Liberty City	2.18	1.51	1.37	0.97	–0.807	0.005[a]	0.003[a]
	Little Haiti	0.96	0.99	0.66	0.72	–0.302	0.112	0.182
	Little Havana	0.48	0.71	0.31	0.53	–0.165	0.224	0.308
	South Beach	0.22	0.45	0.09	0.28	–0.133	0.110	0.116
Adult pedestrian (14–64)	Liberty City	5.90	2.28	4.89	2.62	–1.018	0.041[a]	0.026[a]
	Little Haiti	2.74	1.69	3.00	1.97	0.260	0.480	0.543
	Little Havana	3.60	2.09	3.91	1.65	0.312	0.441	0.297
	South Beach	6.26	2.48	4.80	2.21	–1.460	0.004[a]	0.007[a]
Older pedestrian (≥65)	Liberty City	0.68	0.80	0.43	0.61	–0.256	0.096	0.125
	Little Haiti	0.41	0.57	0.34	0.68	–0.068	0.589	0.305
	Little Havana	1.73	1.71	2.11	1.41	0.388	0.246	0.080
	South Beach	1.36	1.23	1.34	1.19	–0.013	0.958	0.989

[a]Indicates significance at ≤.05. Only two-tailed tests were conducted.

Older Pedestrians

With respect to older pedestrians (aged 65 and older), there was no significant decline in crashes in Liberty City, Little Haiti, or South Beach. In Little Havana, there was actually an increase in older pedestrian crashes. These results indicate that the pedestrian safety treatments directed at older adults (e.g., mostly safety education materials and radio and television public service announcements) did not have the intended effect.

Crash Reduction

Countywide, the largest amount of crash reduction involved adult pedestrians. Although it is not known specifically which of the 16 countermeasures may have accounted for this reduction, several of the countermeasures targeted adult pedestrians and drivers. These included the series of educational posters on buses, several of the safety brochures (e.g., "Pedestrians Walk Safely," "You and You Should Never Meet"), the pedestrian safety enforcement program, and others.

DISCUSSION AND LESSONS LEARNED

The study reveals that the combined Miami–Dade pedestrian safety program was associated with a significant reduction in pedestrian crashes countywide and particularly among adult and child pedestrians within certain focus zones. The analysis revealed that Miami–Dade experienced approximately 180 fewer pedestrian crashes per year or a reduction of 360 pedestrian crashes in the first 2 years (2003 and 2004) as a result of the program implementation. It is important to maintain all of the countermeasures at full strength in future years of the program to the extent possible in order to sustain pedestrian crash reductions.

In addition, the process of targeting countermeasures to specific ages and ethnic groups appears to have been particularly successful in Liberty City and South Beach. Liberty City was the zone that received the most intense pedestrian safety education programs in all of its elementary schools, and child pedestrian crashes experienced greater absolute crash reductions compared with other zones and proportionally higher reductions than countywide. After the pedestrian safety program, child pedestrian crashes decreased by 32.6% in the four targeted zones and decreased by 22.1% countywide. These reductions agree closely with the reduction of approximately 20% to 30% in child pedestrian crashes because of the educational programs "Willy Whistle" and "And Keep on Looking" conducted in cities with comparable size and evaluated by NHTSA in the 1980s and 1990s.

Of the four zones targeted for specific countermeasures, South Beach was the recipient of the most intense amount of countermeasures, including selective police enforcement, a variety of educational and media messages, as well as a few engineering treatments. It is therefore encouraging that a substantial reduction in pedestrian crashes (22%) occurred in South Beach along with a 25.6% reduction in Liberty City.

However, not all of the countermeasures were successful in reducing targeted crash types in all of the identified high-crash zones. Most notably, a variety of educational countermeasures (in English and Spanish) were implemented in Little Havana, where there had been a high prevalence of crashes involving older, Spanish-speaking pedestrians. Countermeasures included the distribution of educational material at senior centers, safety educational meetings, television and radio messages, and other educational measures. In spite of these efforts, there was no significant reduction in crashes involving older pedestrians or involving pedestrians in general. The reasons for the lack of success of the program in Little Havana are not known. Likewise, no significant reductions in pedestrian crashes resulted in Little Haiti as a result of the safety program. Such results may provide some understanding about what might be expected from similar pedestrian safety programs and perhaps also reveal how to address more challenging crash problems, such as crashes involving older pedestrians.

It should also be mentioned that the greater reduction in pedestrian crashes that resulted in the targeted zones in Miami–Dade County was consistent with similar findings from the previous crash zone studies for NHTSA in Phoenix, where high pedestrian crash zones (involving older pedestrians) were also targeted. In other words, the greatest reduction in pedestrian crashes occurred in the zones where countermeasure implementation was most extensive. The Phoenix study, however, focused primarily on crashes involving older pedestrians, and likely the high-crash zones there had much more saturation of countermeasures than those directed at older pedestrians in the larger Little Havana zone in Miami. Certainly more intensive education (with enforcement and engineering) treatments may be needed to have a clear reduction in older pedestrian crashes.

Additional lessons learned include the importance of quality GIS data in identifying problem locations and subpopulations, quantifying specific problem types, evaluating results, and communicating the issues of pedestrian safety to enlist the support of relevant agencies; the importance of interagency relationships; and the benefits of institutionalization of a comprehensive pedestrian safety program.

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