Safety Effects of Marked vs Unmarked Crosswalks at Uncontrolled Locations:

Executive Summary and Recommended Guidelines

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Pedestrian & Bicycle Safety

Executive Summary:
Safety Effects of Marked vs Unmarked Crosswalks at Uncontrolled Locations

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for
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Background and Introduction

Pedestrians are legitimate users of the transportation system, and they should, therefore, be able to use this system safely and without unreasonable delay (figure 1). Crossing streets can be a difficult task with our current system of streets and highways, particularly for children, older adults, and people with disabilities. Providing marked crosswalks has traditionally been one measure used in an attempt to facilitate crossings. However, there have been conflicting studies and much controversy regarding the safety effects of marked crosswalks. Marked crosswalks are commonly used at intersections and sometimes at midblock locations. This study evaluated marked crosswalks at uncontrolled locations and offers guidelines for their use.

It is important to remember that providing marked (painted) crosswalks is only one of many possible engineering measures that may be used at a pedestrian crossing to improve safety and/or to reduce delay. Appropriate measures depend on site conditions. Whenever considering how to provide safer crossings for pedestrians, the question should NOT simply be: "Should I provide a marked crosswalk or not?" Instead, the question should be: **"What are the most effective measures that can be used to help pedestrians safely cross the street?"**

Figure 1. Pedestrians have a right to cross roads safely.

There are many different types of pedestrian crossing problems that cannot be addressed properly with only one treatment such as a marked crosswalk. It should be remembered that striping a crosswalk by itself may not change the behavior of all or even most vehicle drivers. The reader is strongly encouraged to consider the pedestrian crossing measures that are described at the end of this Executive Summary.

What is the Legal Definition of a Crosswalk?

The 1992 Uniform Vehicle Code (Section 1-112) defines a crosswalk as (1):

> "(a) That part of a roadway at an intersection included within the connections of the lateral lines of the sidewalks on opposite sides of the highway measured from the curbs, or in the absence of curbs, from the edges of the traversable roadway; and in the absence of a sidewalk on one side of the roadway, the part of a roadway included within the extension of the lateral lines of the existing sidewalk at right angles to the centerline.
>
> (b) Any portion of a roadway at an intersection or elsewhere distinctly indicated for pedestrian crossing by lines or other markings on the surface."

Thus, legal crosswalks exist at all public street intersections. The only way a crosswalk can exist at a midblock location is if it is marked. Further, according to the MUTCD (Section 3B-18), a crosswalk may be marked with paint, thermoplastic materials, and plastic tape, among other materials.(2)

Why Are Marked Crosswalks Controversial?

There has been considerable controversy in the U.S. regarding whether providing marked crosswalks will increase or decrease pedestrian safety at crossing locations that are not controlled by a traffic signal or stop sign. Many pedestrians consider marked crosswalks as a tool to enhance pedestrian mobility and safety. They view the markings as proof that they have a right to share the roadway, and in their opinion, the more the better. Many pedestrians do not understand the legal definition of a crosswalk and think that there is no crosswalk unless it is marked. They also think that the driver will be able to see the crosswalk markings as well as they do, and assume that it will be safer to cross where drivers can see the white crosswalk lines. When citizens request the installation of marked crosswalks, some engineers and planners still refer to the 1972 study by Bruce Herms (3) as justification for not installing marked crosswalks at uncontrolled locations. That study found an increased incidence of pedestrian collisions in marked crosswalks, compared to unmarked crosswalks at 400 uncontrolled intersections in San Diego, California. Questions have been asked about the validity of that study, and the study results have sometimes been misquoted or misused. Some have misinterpreted the results of that study which did <u>not</u> conclude that all marked crosswalks are "unsafe", and did not include school crosswalks in that study. A few other studies have also tried to address this issue since the Herms study. Some are not conclusive because of their methodology or sample size problems, while others have fueled the disagreements and confusion on this matter.

Where are Crosswalks Typically Installed?

The practice of where to install crosswalks differs considerably from one jurisdiction to another across the U.S., and engineers have been left with using their own judgment (sometimes influenced by political and/or public pressure) in reaching decisions. Some cities have developed their own guidelines on where marked crosswalks should or should not be installed. At a minimum, many cities tend to install

marked crosswalks at signalized intersections, particularly urban areas where there is a considerable amount of pedestrian activity. Many jurisdictions also commonly install marked crosswalks at school crossing locations (such as where adult crossing guards are used) and they are more likely to mark crosswalks at intersections controlled by a STOP sign. At uncontrolled locations (i.e., sites not controlled by a traffic signal or stop sign), some agencies choose to rarely, if ever, install marked crosswalks, while other agencies have installed marked crosswalks at selected pedestrian crossing locations, particularly in downtown areas. Some towns and cities have also chosen to supplement selected crosswalks with advance overhead or post-mounted pedestrian warning signs, flashing lights, "STOP FOR PEDESTRIANS IN CROSSWALK" signs mounted at the street centerline (or mounted along the side of the street or overhead), and/or supplemental pavement markings.

Study Purpose and Objective

Many highway agencies routinely mark crosswalks at school crossings and signalized intersections. While questions have been raised concerning marking criteria at these sites, most of the controversy on whether to mark crosswalks has pertained to the many uncontrolled locations in U.S. towns and cities. The purpose of this study was to determine whether marked crosswalks at uncontrolled locations (i.e., locations with no traffic signal or stop sign on the approach) are safer than unmarked crosswalks. Another objective was to provide recommendations on how to provide safer crossings for pedestrians. This includes providing assistance to engineers and planners when making decisions on:

- Where crosswalks may be installed where they do not currently exist.
- Where an existing crosswalk is acceptable, by itself.
- Where an existing crosswalk should be supplemented with additional improvements.
- Where one or more other engineering treatments (e.g., raised median, traffic signal with pedestrian signal) should be considered instead of having only a marked crosswalk.
- Where marked crosswalks are not appropriate.

The results of this study should not be misused as justification to do nothing to help pedestrians to safely cross streets. Instead, pedestrian crossing problems and needs should be routinely identified, and appropriate solutions should be selected to improve pedestrian safety and access. Deciding where to mark or not mark crosswalks is only one consideration in meeting that objective.

This Executive Summary is based on a major study for the Federal Highway Administration on safety effects of marked crosswalks vs. matched unmarked crossings which was conducted by the University of North Carolina's Highway Safety Research Center.(4)

Data Collection and Analysis Methodology

An ideal study design would involve removing all crosswalks in several test cities and randomly assigning sites for crosswalk marking and also to serve as unmarked control sites. However, it would be

impossible to get the level of cooperation from cities needed to conduct such a study due to liability considerations. Also such random assignment of crosswalk marking locations would result in many crosswalks not being marked at the most appropriate locations.

Thus, because of such real-world constraints, a treatment and matched comparison site methodology was used to quantify the pedestrian crash risk of marked vs. unmarked crosswalks. This allowed for selecting a large sample of study sites in cities throughout the U.S. where marked crosswalks and similar (unmarked) comparison sites were available. At intersections, the unmarked crosswalk "comparison site" was typically the opposite leg of the same intersection as the selected marked "treated" crosswalk site. For each marked midblock crosswalk, a nearby midblock crossing location was chosen as the comparison site on the same street (usually a block or two away) where pedestrians were observed to cross. (Even though an unmarked midblock crossing is not technically or legally a "crosswalk," it was a suitable comparison site for a midblock crosswalk).

A before/after experiment was not considered practical, because of regression-to-the-mean problems, limited sample sizes of new crosswalk installations, etc. A total of 1,000 marked crosswalk sites and 1,000 matched unmarked (comparison) crossing sites in 30 cities across the U.S. (see figure 2) were selected for analysis. Test sites were chosen without any prior knowledge of their crash history. School crossings were not included in this study because of crossing guards and/or special school signs and markings which may increase the difficulty of quantifying the safety effects of crosswalk markings.

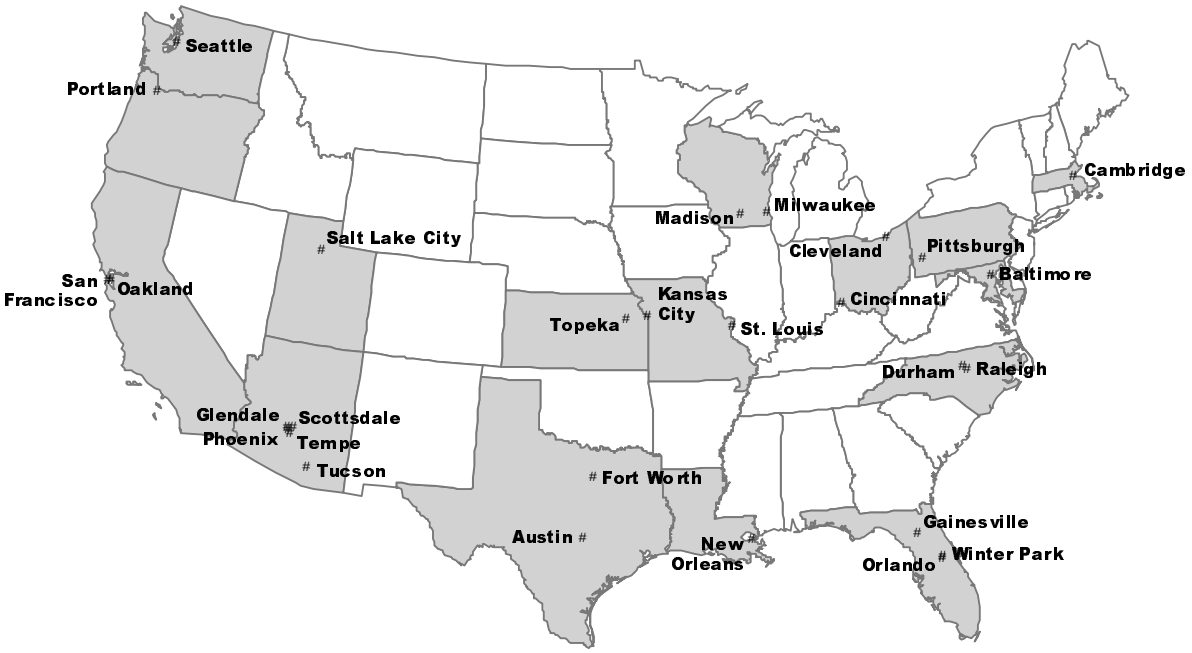

Figure 2. Cities and states used for study sample.

Test sites were selected from the following cities:

- East: Cambridge, MA, Baltimore, MD (city and county), Pittsburgh, PA, Cleveland, OH, Cincinnati, OH
- Central: Kansas City, MO, Topeka, KS, Milwaukee, WI, Madison, WI, St. Louis, MO (city and county)
- South: Gainesville, FL, Orlando, FL, Winter Park, FL, New Orleans, LA, Raleigh, NC, Durham, NC
- West: San Francisco, CA, Oakland, CA, Salt Lake City, UT, Portland, OR, Seattle, WA
- Southwest: Austin, TX, Ft. Worth, TX, Phoenix, AZ, Scottsdale, AZ, Glendale AZ, Tucson, AZ, Tempe, AZ

Detailed information was collected at each of the 2,000 sites, including pedestrian crash history (average of five years per site), daily pedestrian volume estimates, average daily traffic (ADT) volume, number of lanes, speed limit, area type, type of median, type and condition of crosswalk marking patterns, location type (midblock vs intersection), and other site characteristics. Various crosswalk marking patterns are given in the MUTCD.(2) Examples of crosswalk marking patterns found at the study sites are shown in figure 3 below. All of the 1,000 marked crosswalks had one of the marking patterns shown in figure 3 (i.e., none had a brick pattern for the crosswalk). Very few of the marked crosswalks had any type of supplemental pedestrian warning signs. Further, none of the test sites had traffic calming measures or special pedestrian devices (e.g., in-pavement flashing pavement lights).

Estimates of daily pedestrian volumes at each crosswalk site and unmarked comparison site were determined based on pedestrian volume counts at each site, which were expanded to estimated daily pedestrian volume counts based on hourly adjustment factors. Specifically, at each of the 2,000 crossing

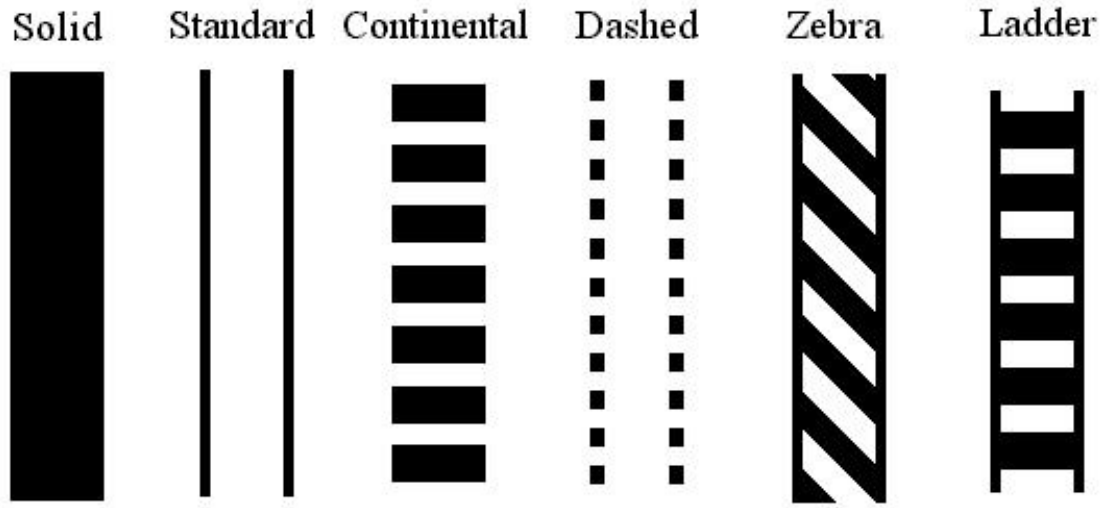

Figure 3. Illustration of crosswalk marking patterns.

locations, trained data collectors conducted on-site counts of pedestrian crossings and classified pedestrians by age group, based on observations. Pedestrian counts were collected simultaneously for one hour each at the crosswalk and comparison sites. Full day (8 to 12 hour) counts were conducted at a sample of the sites and used to develop adjustment factors by area type (urban, suburban, fringe) and by time of day. The adjustment factors were then used to determine estimated daily pedestrian volumes in a manner similar to that used by many cities and states to expand short-term traffic counts to average annual daily traffic (ADT).

This methodology was intended as a measure at the crosswalk and comparison sites for use as a control variable in the analysis. Collecting the volume counts simultaneously helped to control for time-related influences on pedestrian exposure.

The crash data periods varied somewhat from one city to another, and averaged approximately five years per site (typically between about January 1, 1994 to December 31, 1998). Police crash reports were obtained from each of the cities, except for Seattle, where detailed printouts were obtained for each crash. Crashes were carefully reviewed to assign a crash type and to insure accurate matching of the correct location (and whether the crash occurred at the location, i.e., at or within 20 feet of the marked or unmarked crossing of interest).

Standard pedestrian crash typology was used to review police crash reports and determine the appropriate pedestrian crash types (e.g., multiple threat, midblock dartout, intersection dash), as discussed later. All treatment (crosswalk) and comparison sites were chosen without prior knowledge of crash history. **All sites used in this study were intersection or midblock locations with no traffic signals or stop signs on the main road approach (i.e., uncontrolled locations).** This study focused on pedestrian safety, and therefore, data were not collected for vehicle-vehicle or single-vehicle collisions, even though it is recognized that marking crosswalks may increase vehicle stopping which may affect these collision types too.

The selected analysis techniques were deemed to be appropriate for the type of data in the sample. Due to relatively low numbers of pedestrian cashes at a given site (e.g., many sites with zero pedestrian crashes in a five-year period), Poisson modelling and negative binomial regression were used in the analyses of data. Using these analysis techniques allowed for determining statistically valid safety relationships. In fact, there were a total of 229 pedestrian crashes at the 2,000 crossing sites over an average of a five-year period per site. This translates to an overall average of one pedestrian crash per crosswalk site every 43.7 years.

All analyses between crash rates of marked vs. unmarked crosswalks took into account the traffic volume, pedestrian exposure, and other roadway features (e.g., number of lanes). To supplement the pedestrian crash analysis, a corresponding study by Knoblauch, et. al. (5) was also conducted of pedestrian and driver behavior before and after marked crosswalks were installed at selected sites in New York, Minnesota, California, and Virginia, as discussed in more detail in a later section.

Study Results

Significant Variables

1. Poisson and negative binomial regression models were fit to pedestrian crash data at marked and unmarked crosswalks. These analyses showed that several factors in addition to crosswalk markings

were associated with pedestrian crashes. Traffic and roadway factors found to be related to a greater frequency of pedestrian crashes include higher pedestrian volumes, higher traffic ADT, and greater number of lanes (i.e., multi-lane roads with three or more lanes had higher pedestrian crash rates than two-lane roads). For this study, a center two-way-left-turn lane was considered to be a travel lane and not a median.

2. Surprisingly, after controlling for other factors (e.g., pedestrian volume, traffic volume, number of lanes, median type), speed limit was not significantly related to pedestrian crash frequency. Certainly, one would expect that higher vehicle speed would be associated with an increased probability of a pedestrian crash; all else being equal. However, the lack of association found in this analysis between speed limit and pedestrian crashes may be due to the fact that there was not a lot of variation in the range of vehicle speed or speed limit at the study sites (i.e., 93 percent of the study sites had speed limits of 25 to 35 mph). Another possible explanation, as hypothesized by Garder, is that pedestrians may be more careful when crossing streets with higher speeds than at lower speeds; that is, they may avoid short gaps on high-speed roads, which may minimize the effect of vehicle speed on pedestrian crash rates.(6) In terms of speed and crash severity, the analysis showed that speed limits of 35 mph and above were associated with a greater percentage (43 percent) of fatal and A-type injuries compared to sites having lower speed limits (23 percent of crashes resulting in fatal or A-injuries).

3. The presence of a raised median (or raised crossing island) was associated with a significantly lower pedestrian crash rate at multi-lane sites with both marked and unmarked crosswalks. These results were in basic agreement with a major study by Bowman (7) and also a study by Garder (8), which found safety benefits for pedestrians due to raised medians and refuge islands, respectively. Further, on multi-lane roads, medians which were painted (but not raised) and also center two-way-left-turn lanes did **not** offer significant safety benefits to pedestrians, compared to multi-lane roads with no median at all.

4. There was also a significant regional effect; that is, sites in western U.S. cities had a significantly higher pedestrian crash rate than eastern U.S. cities (after controlling for pedestrian exposure, number and lanes, median type, and other site conditions). The reason(s) for these regional differences in pedestrian crash rate is not known, although it could relate to regional differences in driver and pedestrian behavior, higher vehicle speeds in western cities, differences in pedestrian-related laws, variations in roadway design features, and/or other factors.

5. All of the variables related to pedestrian crashes (i.e., pedestrian volumes, traffic ADT, number of lanes, median existence and type, and region of the country) were then included in the models for determining effects of marked vs. unmarked sites. Factors having <u>no</u> significant effect on pedestrian crash rate include: area type (e.g., residential, CBD), location type (i.e., intersection vs. midblock), speed limit, traffic operation (one-way or two-way), condition of crosswalk marking (excellent, good, fair, or poor) and crosswalk marking pattern (e.g., parallel lines, ladder type, zebra stripes). One may expect that crosswalk marking condition may not necessarily be related to pedestrian crash rate, since the condition of the markings may have varied over the five-year analysis period, and the condition of the markings was observed only at one point in time. Further, in some regions, the crosswalk markings may be less visible during or after rain storms or snow storms. It is also recognized, however, that some agencies may maintain and restripe crosswalks more often than other agencies included in the study sample.

Marked vs. Unmarked Crosswalk Comparisons

6. The results revealed that on **two-lane** roads, there were no significant differences in pedestrian crashes for marked vs. unmarked crosswalk sites. In other words, pedestrian safety on two-lane roads was

not found to be different, whether the crosswalk was marked or unmarked. Further, this conclusion is based on a sample size of 914 crossing sites on two-lane roads, of the 2,000 total sites. Specifically, binomial comparison of pedestrian crash rates for marked vs. unmarked sites within subsets by ADT, median type, and number of lanes are shown in figure 4.

7. **On multi-lane roads with ADT's of 12,000 or less,** there were also no differences in pedestrian crash rates between marked and unmarked sites. On multi-lane roads with **no raised medians** and ADT's above 12,000, sites with marked crosswalks had higher pedestrian crash rates than unmarked crossings. On multi-lane roads (roads with 3 to 8 lanes) with **raised medians** and vehicle ADT's above 15,000, a significantly higher pedestrian crash rate was associated with marked crosswalk sites compared to unmarked sites.

8. Best-Fit curves on multi-lane undivided roads were produced for pedestrian crashes (per million pedestrian crossings) at marked and unmarked crosswalks as a function of traffic ADT, as shown in figure 5. Similar analyses were conducted for multilane divided roads. This analysis for multi-lane undivided roads revealed that:

- For traffic volumes (ADT's) of about 10,000 and below, pedestrian crash rates were about the same (i.e., less than .25 pedestrian crashes per million pedestrian crossings) between marked and unmarked crosswalks.

- For ADT's above about 10,000, the pedestrian crash rate for marked crosswalks becomes increasingly worse as ADT increases. The crash rate at unmarked crossings increases only slightly as ADT increases.

Note that each point on the graph represents dozens of sites; that is, all of the sites corresponding to the given ADT group. For example, the data point for marked crosswalks with ADT's of greater than 15,000 corresponds to more than 400 sites. All of these and other analyses in this study, accounted for differences in pedestrian crossing volume, traffic volume, and other important site variables.

The results given above may be somewhat expected. Wide, multi-lane streets are difficult for many pedestrians to cross, particularly if there is an insufficient number of adequate gaps in traffic due to heavy traffic volumes and high vehicle speeds. Further, while marked crosswalks in themselves may not increase measurable unsafe pedestrian or motorist behavior (based on Knoblauch study (5)), one possible explanation is that installing a marked crosswalk may increase the number of at-risk pedestrians (particularly children and older adult pedestrians) who choose to cross there instead of at the nearest signal-controlled crossings.

The pedestrian crossing counts at the 1,000 marked crosswalks and 1,000 unmarked comparison crossings from this study may partially explain the difference. Overall, 66.1 percent of the observed pedestrians crossed at marked crosswalks versus 33.9 percent at unmarked crossings. More than 70 percent of pedestrians under age 12 and above age 64 crossed at marked crosswalks, while about 35 percent of pedestrians in the 19-35 year old age range crossed at unmarked crossings, as shown in figure 6. The age group of pedestrians was determined from on-site observation.

An even greater percentage of older adults (81.3 percent) and young children (76.0 percent) chose to cross in marked crosswalks on multi-lane roads compared to two-lane roads. Thus, installing a marked

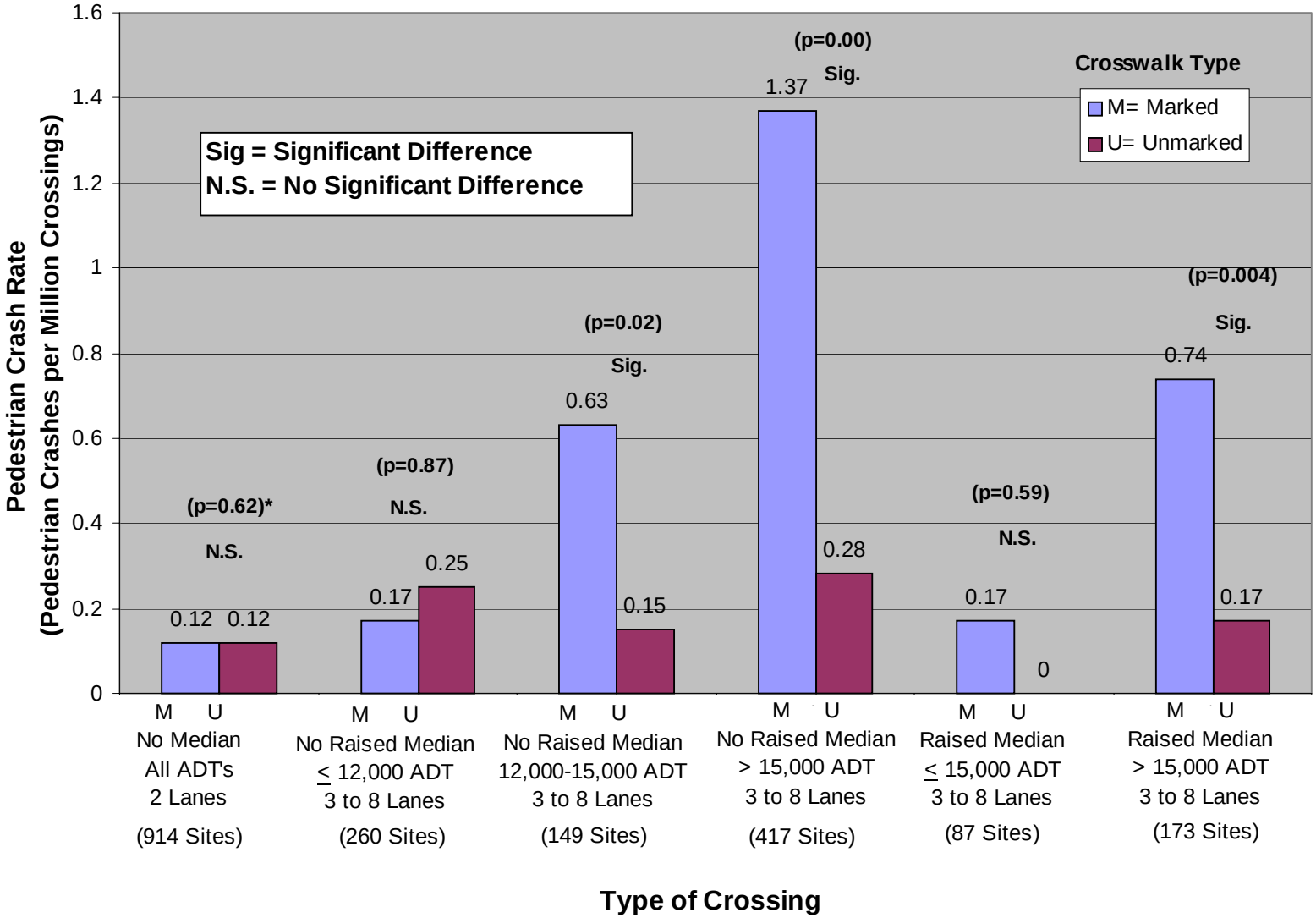

Figure 4. Pedestrian crash rate vs type of crossing.

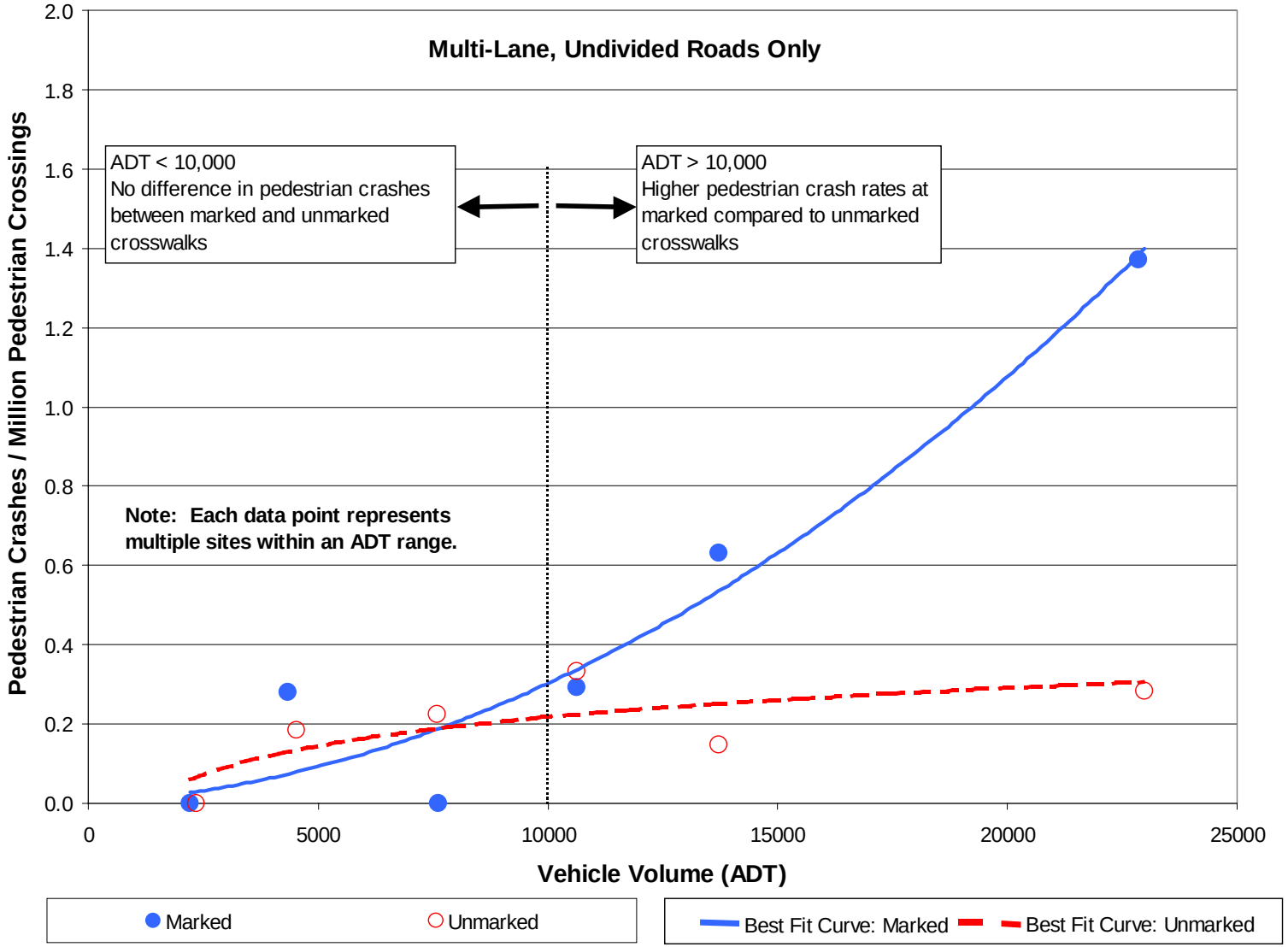

Figure 5. Pedestrian crash rates by traffic volume for multi-lane crossings with no raised medians - marked vs. unmarked crosswalks.

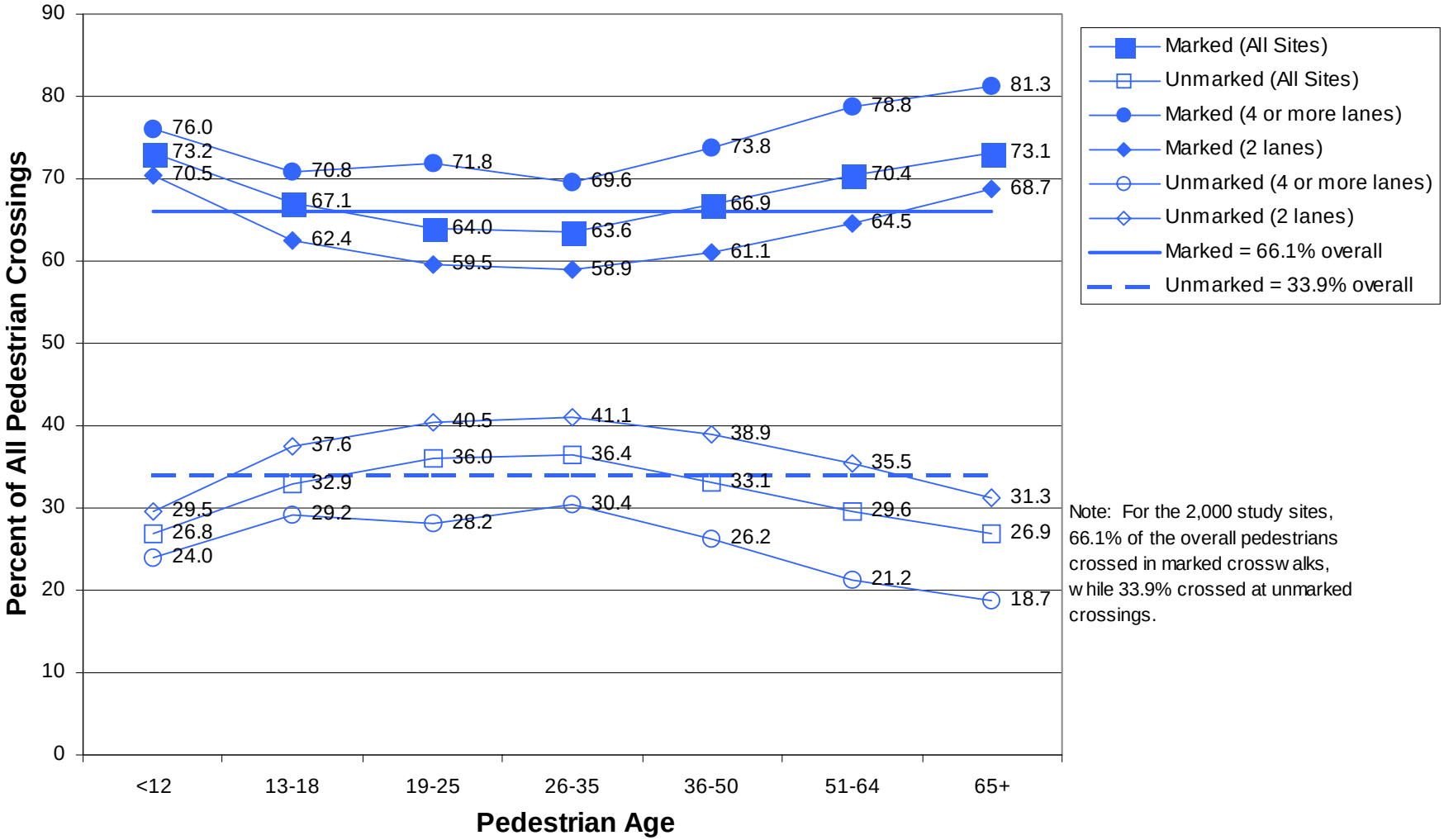

Figure 6. Percent of pedestrian crossing volumes at marked and unmarked crosswalks by age group and road type.

crosswalk at an already undesirable crossing location (i.e., wide, high-volume street) may increase the chance of a pedestrian crash occurring at such sites if a few at-risk pedestrians are encouraged to cross where adequate crossing facilities (e.g., traffic signal and/or pedestrian signals) are not provided. This explanation might be evidenced by the many calls to traffic engineers from citizens who state: "Please install a marked crosswalk so that we can cross the dangerous street near our house." Unfortunately, simply installing a marked crosswalk without other more substantial crossing facilities often does not result in a majority of motorists stopping and yielding to pedestrians, contrary to the expectations of many pedestrians.

9. On 3-lane roads (i.e., one lane in each direction with a center two-way left turn lane), crash risk was slightly higher for marked compared to unmarked crosswalks, but this difference was not significant (based on a sample size of 148 sites).

Pedestrian Crash Types

10. The greatest difference in pedestrian crash types between marked and unmarked crosswalks involved "multiple threat" crashes. A multiple threat crash involves a driver stopping in one lane of a multi-lane road to permit pedestrians to cross, and an oncoming vehicle (in the same direction) strikes the pedestrian who is crossing in front of the stopped vehicle. This crash type involves both the pedestrian and driver failing to see each other in time to avoid the collision (see figure 7). To avoid multiple threat collisions, drivers should slow down and look around stopped vehicles in the travel lane, and pedestrians should stop at the outer edge of a stopped vehicle and look into the oncoming lane for approaching vehicles before stepping into the lane.

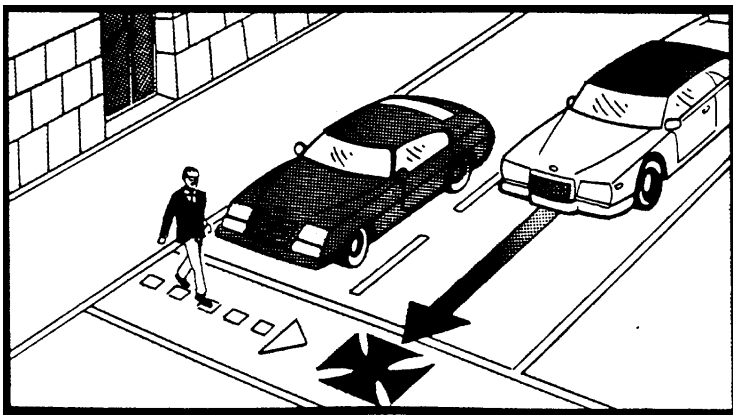

Figure 7. Illustration of multiple threat pedestrian crash.

A total of 17.6 percent (33 out of 188) of pedestrian crashes in marked crosswalks were classified as multiple threat. None of the 41 pedestrian crashes in unmarked crosswalks were multiple threat. This finding may be the result of one or more of the following:

1) Drivers may be more likely to stop and yield to pedestrians in marked crosswalks compared to unmarked crossings, since at least one motorist must stop for a pedestrian in order to set up a multiple threat pedestrian collision. Also, pedestrians may be more likely to step out in front of oncoming traffic in a marked crosswalk than at an unmarked location in some instances.

2) A second explanation relates to the fact that most (66.1 percent) of the total pedestrians who are crossing multi-lane roads are crossing in a marked crosswalk, as shown earlier in figure

5. Further, of the pedestrian age groups most at risk (the young and the old), an even greater proportion of these pedestrians (76 percent and 81.3 percent, respectively) are choosing to cross multi-lane roads in marked crosswalks.

3) Another possible explanation could be that some pedestrians crossing in a marked crosswalk may be less likely to search properly for vehicles (compared to an unmarked crossing) when stepping out past a stopped vehicle and into an adjacent lane (i.e., pedestrians not realizing that they need to search for other oncoming vehicles after one motorist stops for them).

Further research on pedestrian and motorist behavior could help to gain a better understanding of the causes and potential effects of countermeasures (e.g., advance stop lines) related to these crashes. There is also a need to examine the current laws (and a possible need for changes in the laws) on motorist responsibility to yield to pedestrians and how these laws differ between states. A distribution of pedestrian crash types is shown in figure 8, which includes all of the 229 pedestrian collisions at the 2,000 study sites.

11. Motorists failing to yield (on through movements) represented a large percentage of pedestrian crashes in marked crosswalks (41.5 percent) and unmarked crosswalks (31.7 percent). Likewise, vehicle turn and merge crashes, also generally the fault of the driver, accounted for 19.2 percent (marked crosswalks) and 12.2 percent (unmarked crosswalks) (see figure 8). These results indicate a strong need for improved drivers enforcement and education programs that emphasize the importance of yielding to or stopping for pedestrians. More pedestrian-friendly roadway designs may also be helpful in reducing such crashes, by slowing vehicle speeds, providing pedestrian refuge (e.g., using raised medians), and/or better warning motorists of pedestrian crossings.

12. A substantial proportion of pedestrian crashes involved dart-out, dash, and other types of crashes in which the pedestrian stepped or ran in front of an oncoming vehicle at unmarked crosswalks (23 of 41, or 56.1 percent) and a lesser proportion at marked crosswalks (41 of 188, or 21.8 percent). Police officers sometimes unjustifiably assign fault to the pedestrian, which suggests the need for more police training. Specifically, it may be questioned why so many pedestrian crashes were designated by the police officer as “pedestrian fails to yield,” since in most states, motorists are legally required to yield the right-of-way to pedestrians who are crossing in marked or unmarked crosswalks. Of course, some state ordinances do specify that pedestrians also bear some responsibility to avoid a collision by not stepping into the street directly into the path of an oncoming motorist who is to close to the crosswalk to stop in time to avoid a collision. It is likely that police officers often rely largely on the statement of the motorist (e.g., “the pedestrian ran out in front of me” or “came out of nowhere”) in determining fault in such crashes, particularly when the driver was not paying proper attention to the road, the pedestrian is unconscious, and there are no other witnesses at the scene. It is also true, however, that a major contributing factor is the unsafe behavior by the pedestrian. Keeping that in mind, dart-outs, dashes, and failing to yield by pedestrians was indicated by police officers as a contributing cause in 27.9 percent (64 of 229) of pedestrian crashes at the study sites. These results are indicative of a need for improved pedestrian educational programs, which is in agreement with recommendations in other important studies related to improving safety of vulnerable road users (9). Further, speeding drivers often contribute to dart out crashes, in addition to unsafe pedestrian behaviors. Creating more pedestrian friendly crossings, such as with curb extensions, traffic calming measures, etc. may also be useful in reducing many of these crashes, as discussed later.

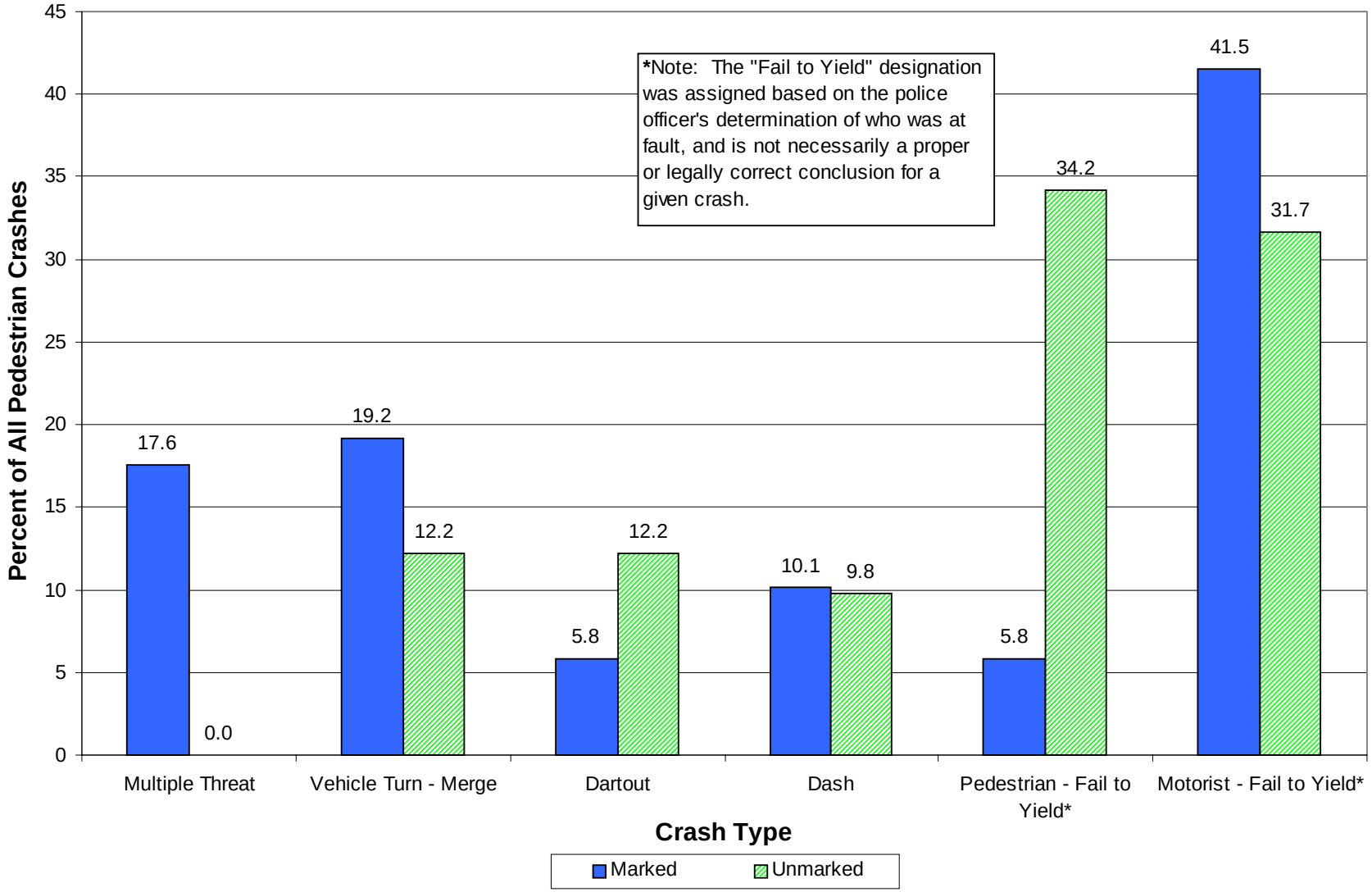

Figure 8. Pedestrian crash types at (uncontrolled) marked and unmarked crosswalks.

Pedestrian Crash Severity

13. An analysis was conducted to compare pedestrian crash severity on marked vs. unmarked crosswalks. Crash severity did not differ significantly between marked and unmarked crosswalks on two-lane roads. On multi-lane roads, there was evidence of more fatal plus A-injury pedestrian crashes at marked compared to unmarked crosswalks. This result is likely due to the fact that older pedestrians are more likely than any other age group to walk in marked rather than unmarked crosswalks. Further, they are much more likely to sustain fatal and serious injuries than younger pedestrians. As mentioned earlier, speed limits of 35 mph and above were associated with a greater percentage (43 percent) of fatal and A-type injuries; whereas sites with lower speed limits had 23 percent of pedestrian crashes resulting in fatal or A-type injuries.

Lighting and Time of Day

14. Nighttime pedestrian crash percentages were about the same at marked and unmarked crosswalks (approximately 30 percent). In terms of time of day, the percent of pedestrian crashes in marked crosswalks tended to be higher than for unmarked crosswalks during the morning (6 to 10 am) and afternoon (3 to 7 pm) peak periods, but lower in the midday (10 am to 3 pm) and evening (7 pm to midnight) periods. This is probably because pedestrians are more likely to cross in marked crossings than unmarked crossings during peak traffic periods (e.g., walking to and from work) than during other times. Adequate nighttime lighting should be provided at marked crosswalks to enhance the safety of crossing pedestrians at night.

Age Effects

15. A separate analysis was conducted of pedestrian crashes and crossing volumes by age of pedestrian. For virtually every situation studied (i.e., marked and unmarked crossings on two-lane and multi-lane roads), pedestrians aged 65 and above were overrepresented in pedestrian crashes compared to their relative crossing volumes. Figure 9 shows the relative proportion of crashes (C) and exposure (E) for various age groups for marked crosswalks on two-lane and multi-lane roads. For a given age group, when the proportion of crashes (C) exceeds the proportion of exposure (E), then crashes are overrepresented; that is, pedestrians in that population group are at greater risk of being in a pedestrian crash than would be expected from their volume alone.

The pedestrian age groups younger than 65 showed no clear increase in crash risk compared to their crossing volumes. One possible reason that young pedestrians were not over-involved in crash occurrence is the fact that many crashes involving young pedestrians (particularly aged 5 to 9) occur on residential streets, whereas this study did not include school crossings and most sites were drawn from collector and arterial streets which are less likely frequented by unescorted young children.

Also, some of the young children counted in this study were crossing with their parents or other adults which may have reduced their risk of a crash. Some of the possible reasons that older pedestrians are at greater risk when crossing streets compared to other age groups (at marked and unmarked crossings and on two-lane and multi-lane situations) include the fact that older adults are more likely (as an overall group) than younger pedestrians to have:

- Slower walking speeds (and thus greater exposure time)
- Visual and/or hearing impairments

- Difficulty in judging the distance and speed of on-coming traffic
- More difficulty keeping track of vehicle coming from different directions, including turning vehicles.
- Inability to react (e.g., stop, dodge, or run) as quickly as younger pedestrians to avoid a collision under emergency conditions (in some cases, due to prescription medication, which may affect judgment and/or ability to react to motor vehicles)

Driver and Pedestrian Behavior at Crosswalks

16. A complementary study was conducted by Knoblauch (5) of pedestrian and motorist behavior and also vehicle speed before and after crosswalk installation at sites in New York, Virginia, Minnesota, and California (on 2-lane and 3-lane streets) to help gain a better understanding of the effects of marked vs. unmarked crosswalks. The study results revealed that very few motorists stopped or yielded to pedestrians either before or after marked crosswalks were installed. After marked crosswalks were installed, there was a small increase in pedestrian looking behavior (before stepping into the street). Also, there was approximately a 1 mph reduction in vehicle speeds after the marked crosswalks were installed.(5) These behavioral study results by Knoblauch tend to contradict the "false sense of security" claims attributed to marked crosswalks, since observed pedestrian behavior actually improved after marked crosswalks were installed at the study sites. However, it should also be remembered that measures, such as "pedestrian awareness" and "expectation about motorists stopping for them" cannot be collected by field observations alone. It should be mentioned that installing marked crosswalks or other measures can affect pedestrian level of service if they increase the number of motorists who stop and yield to pedestrians. Future studies using focus groups of pedestrians and also questionnaire surveys of pedestrians in the field could shed light on such measures.

Study Conclusions and Recommendations

Pedestrians are legitimate users of the transportation system, and they should, therefore, be able to use this system safely. Pedestrian needs in crossing streets should routinely be identified, and appropriate solutions should be selected to improve pedestrian safety and access. Deciding where to mark crosswalks is only one consideration in meeting that objective. The study results revealed that under no condition was the presence of a marked crosswalk <u>alone</u> at an uncontrolled location associated with a significantly lower pedestrian crash rate, compared to an unmarked crosswalk. Further, on multi-lane roads with traffic volumes above about 12,000 vehicles per day, having a marked crosswalk was associated with a higher pedestrian crash rate (after controlling for other site factors) compared to an unmarked crosswalk. Therefore, adding marked crosswalks alone (i.e., with no engineering, enforcement, or education enhancement) is not expected to reduce pedestrian crashes for any of the conditions included in our study. On many roadways, particularly multi-lane and high-speed crossing locations, more substantial improvements are often needed for safe pedestrian crossings, such as adding traffic signals (with pedestrian signals) when warranted, providing raised medians, speed-reducing measures, and/or others. Additionally, development patterns that reduce the speed and number of multi-lane roads should be encouraged.

Since sites in this study were confined to those having no traffic signal or stop sign on the main road approaches, it follows that these results do not apply to crossings controlled by traffic signals, stop or yield signs, traffic calming treatments, or other devices. They also do not apply to school crossings, since such sites were purposely excluded in the site selection process.

- Difficulty in judging the distance and speed of on-coming traffic
- More difficulty keeping track of vehicle coming from different directions, including turning vehicles.
- Inability to react (e.g., stop, dodge, or run) as quickly as younger pedestrians to avoid a collision under emergency conditions (in some cases, due to prescription medication, which may affect judgment and/or ability to react to motor vehicles)

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The results of this study have some clear implications on the placement of marked crosswalks and the design of safer pedestrian crossings at uncontrolled locations. These include:

1. Pedestrian crashes are relatively rare at uncontrolled pedestrian crossings (1 crash every 43.7 years per site in this study), however, the certainty of injury to the pedestrian, and high likelihood of a severe or fatal injury in a high speed crash makes it critical to provide a pedestrian-friendly transportation network.

2. Marked crosswalks alone (i.e., without other substantial treatments such as traffic signals with pedestrian signals or traffic calming treatments) are not recommended at uncontrolled crossing locations on multi-lane roads (i.e., 4 or more lanes) where traffic volumes exceed approximately 12,000 vehicles per day (with no raised medians) or approximately 15,000 ADT (with raised medians that serve as refuge areas). This recommendation is based on the analysis of pedestrian crash experience, as well as exposure data and site conditions described earlier. To further add a margin of safety, and/or to account for future increases in traffic volume), the authors recommend against installing marked crosswalks <u>alone</u> on two-lane roads with ADT's above 12,000 or on multi-lane roads with ADT's above 9,000 (with no raised median). The authors of this study also recommend against installing marked crosswalks on roadways with speed limits above 40 mph. Instead, enhanced crossing treatments (e.g., traffic and pedestrian signals, and/or raised medians) are recommended. Specific recommendations are given later in table 1 regarding installation of marked crosswalks and other crossing measures. It is important for motorists to understand their legal responsibility to yield to pedestrians at marked and unmarked crosswalks, which may vary from state to state. Also, pedestrians should use proper caution when crossing streets, regardless of who has the legal right-of-way, since it is the pedestrian who suffers the most physical injury in a collision with a motor vehicle.

3. On two-lane roads and lower-volume multi-lane roads (ADT's below 12,000), marked crosswalks were not found to have any positive or negative effect on pedestrian crash rates at the study sample sites. Marked crosswalks may encourage pedestrians to cross the street at such sites. However, it is recommended that crosswalks **alone** (without other crossing enhancements) not be installed at locations which may pose unusual safety risks to pedestrians. Pedestrians should not be encouraged to cross the street at sites with limited sight distance, complex or confusing designs, sites with certain vehicle mixes (many heavy trucks), or other dangers, without first providing adequate design features and/or traffic control devices.

4. At uncontrolled pedestrian crossing locations, installing marked crosswalks should not be regarded as a magic cure for pedestrian safety problems. However, they also should not be considered as a negative measure which will necessarily increase pedestrian crashes in all cases. Marked crosswalks are appropriate at some locations (e.g., at selected low-speed two-lane streets at downtown crossing locations) to help channel pedestrians to preferred crossing locations but should also have other roadway improvements (e.g., raised medians, traffic and pedestrian signals) when used at other locations. The guidelines presented in table 1 are intended to provide guidance for installing marked crosswalks and other pedestrian crossing facilities.

   Note that speed limit was used in the table 1 in addition to ADT, number of lanes, and presence of median. In developing the table, roads with higher speed limits (above 40 mph)

Table 1. Recommendations for installing marked crosswalks and other needed pedestrian improvements at uncontrolled locations.*

Roadway Type (Number of Travel Lanes and Median Type)	Vehicle ADT ≤ 9,000			Vehicle ADT > 9000 to 12,000			Vehicle ADT < 12,000 - 15,000			Vehicle ADT > 15,000		
	Speed Limit**											
	≤ 30 mph	35 mph	40 mph	≤ 30 mph	35 mph	40 mph	≤ 30 mph	35 mph	40 mph	≤ 30 mph	35 mph	40 mph
2-Lanes	C	C	P	C	C	P	C	C	N	C	P	N
3-Lanes	C	C	P	C	P	P	P	P	N	P	N	N
Multi-Lane (4 or More Lanes) With Raised Median†	C	C	P	C	P	N	P	P	N	N	N	N
Multi-Lane (4 or More Lanes) Without Raised Median	C	P	N	P	P	N	N	N	N	N	N	N

* These guidelines include intersection and midblock locations with no traffic signals or stop sign on the approach to the crossing. They do not apply to school crossings. A two-way center turn lane is not considered a median. Crosswalks should not be installed at locations which could present an increased safety risk to pedestrians, such as where there is poor sight distance, complex or confusing designs, substantial volumes of heavy trucks, or other dangers, without first providing adequate design features and/or traffic control devices. Adding crosswalks alone will **not** make crossings safer, nor necessarily result in more vehicles stopping for pedestrians. Whether marked crosswalks are installed, it is important to consider other pedestrian facility enhancements, as needed, to improve the safety of the crossing (e.g., raised median, traffic signal, roadway narrowing, enhanced overhead lighting, traffic calming measures, curb extensions). **These are general recommendations; good engineering judgment should be used in individual cases for deciding where to install crosswalks.**

** Where speed limit exceeds 40 mph, marked crosswalks alone should not be used at unsignalized locations.

C = Candidate sites for marked crosswalks. Marked crosswalks must be installed carefully and selectively. Before installing new marked crosswalks, an engineering study is needed to show whether the location is suitable for a marked crosswalk. For an engineering study, a site review may be sufficient at some locations, while a more in-depth study of pedestrian volumes, vehicle speeds, sight distance, vehicle mix, etc. may be needed at other sites. It is recommended that a minimum of 20 pedestrian crossings per peak hour (or 15 or more elderly and/or child pedestrians) exist at a location before placing a high priority on the installation of a marked crosswalk alone.

P = Possible increase in pedestrian crash risk may occur if crosswalks are added without other pedestrian facility enhancements. These locations should be closely monitored and enhanced with other pedestrian crossing improvements, if necessary, before adding a marked crosswalk.

N = Marked crosswalks alone are not recommended, since pedestrian crash risk may be increased with marked crosswalks. Consider using other treatments, such as traffic signals with pedestrian signals to improve crossing safety for pedestrians.

† The raised median or crossing island must be at least 4 ft wide and 6 ft long to adequately serve as a refuge area for pedestrians in accordance with MUTCD and AASHTO guidelines.

were considered to not be appropriate for adding marked crosswalks alone. This is because virtually no crosswalk sites were found in the 30 U.S. cites where speed limits exceed 40 mph (and thus could not be included in the analysis). Also, high-speed roadways present added problems for pedestrians and thus require more substantial treatments in many cases. That may be why Germany, Finland, and Norway do not allow uncontrolled crosswalks on roads with high speed limits.(6)

5. For 3-lane roads, adding marked crosswalks alone (without other substantial treatments) is generally not recommended for ADT's above 12,000, although exceptions may be allowed under certain conditions (e.g., lower speed roads).

6. If nothing else is done beyond marking crosswalks at an uncontrolled location, pedestrians will not experience increased safety (under any situations included in the analysis). This finding is in some ways consistent with the companion study by Knoblauch (5) which found that marking a crosswalk will not necessarily increase the number of motorists that will stop or yield to pedestrians. Research from Europe shows the need for pedestrian improvements beyond uncontrolled crosswalks (10,11).

7. In some situations (e.g., low-speed, two-lane streets in downtown areas), installing a marked crosswalk may help consolidate multiple crossing points. Engineering judgment should be used to install crosswalks at preferred crossing locations (e.g., at a crossing location at a street light as opposed to an unlit crossing point nearby). Also, higher priorities should be placed on providing crosswalks where pedestrian volume exceeds about 20 per peak hours (or 15 or more of elderly pedestrians and/or children).

8. Marked crosswalks and other pedestrian facilities (or lack of facilities) should be routinely monitored to determine what improvements are needed.

What Are Possible Measures to Help Pedestrians Cross Streets Safely?

9. **Although simply installing marked crosswalks by themselves cannot solve pedestrian crossing problems, the safety needs of pedestrians must not be ignored. More substantial engineering and roadway treatments need to be considered as well as enforcement and education programs and possibly new legislation to provide safer and easier crossings for pedestrians at problem locations. Transportation and safety engineers have a responsibility to consider all types of road users in roadway planning, design, and maintenance. Pedestrians must be provided safe facilities for travel.**

   A variety of pedestrian facilities have been found to improve pedestrian safety and/or ability to cross the street under various conditions. (Ref. 7 to 22) Examples of some of these pedestrian improvements include:

   - Providing raised medians (figure 10) or intersection crossing islands on multi-lane roads, which can significantly reduce pedestrian crash rate and also facilitate street crossing. Also, raised medians may provide aesthetic improvement and may control access to prevent unsafe turns out of driveways. Refuge islands should be at least four feet wide (and preferably 6 to 8 feet wide) and of adequate length to allow for pedestrian storage

Figure 10. Raised medians and crossing islands can improve pedestrian safety on multi-lane roads.

for standing and waiting for gaps in traffic before crossing the second half of the street. When built, the landscaping should be designed and maintained to provide good visibility between pedestrians and approaching motorists.

- Installing traffic signals (with pedestrian signals), where warranted (see figure 11).

Figure 11. On some high-volume or multi-lane roads, traffic and pedestrian signals are needed to better accommodate pedestrian crossings.

- Reducing the effective street crossing distance for pedestrians by narrowing the roads or by providing curb extensions figure 12) and/or raised pedestrian islands at intersections.

Figure 12. Curb extensions at intersections or midblock locations will shorten the crossing distance for pedestrians.

Another option is to reduce four-lane undivided road sections to two through lanes with dual left-turn lane or left-turn bays. Reducing the width of lanes may result in slower speeds in some situations, which can benefit pedestrians who are attempting to cross the street. This creates enough space to provide median islands. The removal of a travel lane may also allow enough space for sidewalks and/or bike lanes.

- Installing traffic calming measures may be appropriate on certain streets to slow vehicle speeds and/or reduce cut-through traffic, as described in the ITE "Traffic Calming: State of the Practice."(17) Such measures may include:

  - raised crossings (raised crosswalks, raised intersections) (see figure 13).

Figure 13. Raised crosswalks can control vehicle speeds on local streets at pedestrian crossings.

- street narrowing measures (chicanes, slow points, “skinny street” designs).

- intersection designs (traffic mini-circles, diagonal diverters).

Some of these traffic calming measures may not be appropriate on major collector or arterial streets.

- Providing adequate nighttime lighting for pedestrians (figure 14). Adequate nighttime lighting should be provided at marked crosswalks, and areas near churches, schools, and community centers with nighttime pedestrian activity.

Figure 14. Adequate lighting can improve pedestrian safety at night.

- Designing safer intersections for pedestrians (e.g., crossing islands, tighter turn radii.).

- Narrower widths and/or access management (e.g., consolidation of driveways).

- Constructing grade-separated crossings or pedestrian-only streets (see figure 15). It should be mentioned that grade-separated crossings are very expensive and should only be considered in extreme situations, such as where pedestrian crossings are essential (e.g., school children needing to cross a six-lane arterial street), street crossing at-grade is not feasible for pedestrians, and no other measures are considered to be appropriate. Grade-separated crossings must also conform to ADA requirements.

- Various pedestrian warning signs, flashers, and other traffic control devices are sometimes used to supplement marked crosswalks (figure 16).

However, the effects of supplemental signs and other devices at marked crosswalks are not well known under various roadway conditions. According to the MUTCD, pedestrian crossing signs should only be used at locations that are unusually hazardous or at locations where pedestrian crossing activity is not readily apparent.(2)

Figure 15. Grade-separated crossings are sometimes used when other measures are not feasible to provide safe pedestrian crossings.

Figure 16. Pedestrian warning signs are sometimes used to supplement crosswalks.

- Building narrower streets in new communities to achieve desired vehicle speeds.

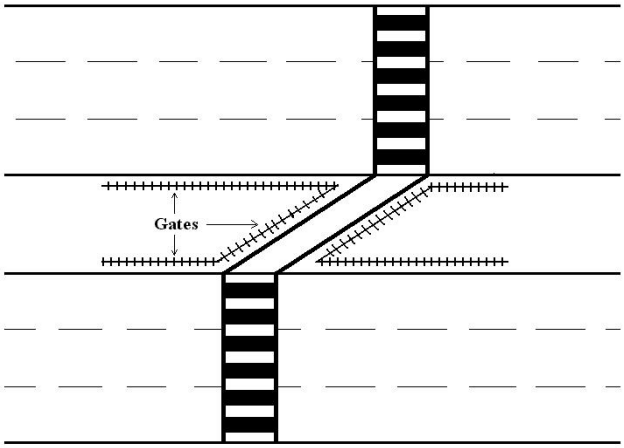
- When designing new street networks, the frequency of two-lane or three-lane arterials should be increased so fewer multi-lane arterials are required.

10. Whenever a marked crosswalk is installed on an uncontrolled multilane road (i.e., 3 or more lanes), consideration of an advance stop line is recommended at a point up to approximately 30 feet in advance of the crosswalk along with the sign "STOP HERE FOR CROSSWALK".

The distance for the stop line and sign should be set based on vehicle speeds at each site, with lesser distances for lower speed approaches. This will encourage motorists to stop further back from the crosswalk, thereby improving sight distance and stopping distance for approaching motorists in the adjacent lanes. Adding such advance stop lines with the "STOP HERE FOR CROSSWALK" sign has been found by Van Houten (18) to increase the percent of vehicles that stop further back from the crosswalk, which could reduce the likelihood of pedestrian multiple threat collisions on multilane roads. Research is needed, however, to better quantify the effects of advance stop lines on driver behavior and pedestrian crashes.

11. It is recommended that parking be eliminated on the approach to uncontrolled crosswalks to improve vision between pedestrians and motorists.

12. Some agencies provide railings in the medians of multi-lane roads which direct pedestrians to the right and increase their likelihood of looking for oncoming vehicles coming from their right in the second half of the street (figure 17).



Angled Crosswalk in Median - Plan View

Figure 17. Railings in the median direct pedestrians to the right and may reduce pedestrian crashes on the second half of the street.

13. Proper planning and land use practices should be applied so pedestrians are not unnecessarily forced or encouraged to cross a busy street. For example, busy arterial streets should be used as a boundary for school attendance or school busing. Major pedestrian generators should not be separated from each other or from their parking facilities by a busy street.

14. The current MUTCD pedestrian signal warrant should be reviewed to determine whether the warrant should be modified more easily to allow for installing a traffic signal at locations where pedestrians cannot safely cross the street (and where no alternative safe crossings exist nearby). Consideration must always include pedestrians with disabilities, and proper accommodations must be provided to meet Americans with Disabilities (ADA) requirements.

15. There should be continued research, development, and testing/explanation of innovative traffic control and roadway design alternatives that could provide improved access and safety for pedestrians attempting to cross streets. For example, in-pavement warning lights, variations in pedestrian warning signs (including signs placed in the centerline to reinforce motorists yielding to pedestrians), roadway narrowing, traffic calming measures, automated speed monitoring techniques, etc. deserve further research and development to determine their feasibility under various traffic and roadway conditions.

More details of these and other pedestrian facilities are given in the *Pedestrian Facilities User's Guide: Providing Access and Safety*, recently developed for FHWA(19) and in the ITE publication *Design and Safety of Pedestrian Facilities*, (20) and ITE's "The Traffic Safety Toolbox (Chapter 19 - Designing for Pedestrians)."(21)

PROPOSED
RECOMMENDATIONS FOR INSTALLING MARKED CROSSWALKS

Produced for Federal Highway Administration

by:
University of North Carolina
Highway Safety Research Center

November, 2000

The primary intent of these recommendations is to help improve the safety and access for pedestrians in crossing streets, as opposed to just being a tool to say "no" to marked crosswalks. Marked crosswalks are best used in combination with other treatments. Before removing a crosswalk or making a decision not to install a crosswalk at a given location, treatments to reduce motor vehicle speed (e.g., traffic calming measures), the number of lanes, and/or other measures to facilitate pedestrian street crossings (e.g., traffic signals with pedestrian signals, raised medians) should be fully explored.

Marked pedestrian crosswalks **may** be used to delineate preferred pedestrian paths across roadways under the following conditions.

(a) At stop signed or signalized locations. Vehicular traffic might block pedestrian traffic when stopping for a stop sign or red light; and marking crosswalks may help to reduce this.

(b) At non-signalized street crossing locations in designated school zones. Use of adult crossing guards, school signs and markings, and/or traffic signals should be used in conjunction with the marked crosswalk, as needed.

(c) At non-signalized locations where engineering judgment dictates that the number of motor vehicle lanes, pedestrian exposure, the average daily traffic (ADT), the posted speed limit, and the geometry of the location would make the use of specially designated crosswalks desirable for traffic/pedestrian safety and mobility. This must consider the conditions listed below and also in table 1.

Marked crosswalks alone (i.e., without traffic signals and pedestrian signals) should **not** be used under the following conditions:

(a) Where the speed limit exceeds 40 mph.

(b) On a roadway with four or more lanes without a raised median or crossing island which has (or will soon have) a daily traffic volume (ADT) of 12,000 or above.

(c) On a roadway with four or more lanes with a raised median or crossing island which has (or will soon have) an ADT of 15,000 or above.

The intent of table 1 is to provide initial guidance on whether an uncontrolled location might be a candidate for a marked crosswalk and, therefore, whether an engineering study should be completed at that location. An engineering study should be used to analyze other factors including (but not limited to)

gaps in traffic, approach speed, sight distances, illumination, the needs of special populations and distance to the nearest traffic signal.

The spacing of marked crosswalks should also be considered, so that they are not placed too close together. Overuse of marked crosswalks may breed driver disrespect for them, and a more conservative use of them is generally preferred. Thus, it is recommended that in situations where marked crosswalks are acceptable (see table 1) that a higher priority be placed on their use at locations having a minimum of 20 pedestrian crossings per peak hour (or 15 or more elderly and/or child pedestrians per peak hour). In all cases, good engineering judgment must be applied.

Other Factors

Distance of Marked Crosswalks from Signalized Intersections: Marked crosswalks should not be installed in close proximity to traffic signals, since pedestrians should be encouraged to cross at the signal in most situations. The minimum distance from a signal for installing a marked crosswalk should be determined by local traffic engineers based on pedestrian crossing demand, type of roadway, traffic volume, and other factors. The objective of adding a marked crosswalk is to channel pedestrians to safer crossing points. It should be understood, however, that pedestrian crossing behavior may be difficult to control merely by the addition of marked crosswalks. The new marked crosswalk should not unduly restrict platooned traffic, and should also be consistent with marked crosswalks at other unsignalized locations in the area.

Other Treatments: In addition to installing marked crosswalks (or in some cases, instead of installing marked crosswalks), there are other treatments that should be considered to provide for safer and easier crossings for pedestrians at problem locations. Examples of these pedestrian improvements include:

- Providing raised medians (or crossing islands) on multi-lane roads.

- Installing traffic signals (and pedestrian signals) where serious pedestrian crossing problems exist.

- Reducing the pedestrian exposure distance for pedestrians by:

  - providing curb extensions
  - providing pedestrian islands
  - reducing four-lane undivided road sections to two through lanes with left-turn bay (or a two-way left turn lane), sidewalks, and bicycle lanes.

- When marked crosswalks are used on uncontrolled multi-lane roads, consideration should be given to install advance stop lines be installed as much as 30 ft prior to the crosswalk (with a sign: “STOP HERE FOR CROSSWALK”) in each direction to reduce the likelihood of a “multiple threat” pedestrian collision.

- Bus stops should be located on the far side of uncontrolled marked crosswalks.

- Installing traffic calming measures to slow vehicle speeds and/or reduce cut-through traffic. Such measures may include:

- Raised crossings (raised crosswalks, raised intersections, speed humps)
- Street narrowing measures (chicanes, slow points, “skinny street” designs)
- Intersection designs (traffic mini-circles, diagonal diverters).
- Others (see ITE Traffic Calming Guide for further details)(17)

Some of these measures are better suited to local or neighborhood streets than to arterial streets.

- Providing adequate nighttime street lighting for pedestrians in areas with nighttime pedestrian activity where illumination is inadequate.

- Designing safer intersections and driveways for pedestrians (e.g., crossing islands, tighter turn radii), which account for the needs of pedestrians.

In developing the proposed U.S. guidelines for marked crosswalks and other pedestrian measures, consideration was given not only to the research results in this study, but also to crosswalk guidelines and related pedestrian safety research in England, Germany, the Netherlands, Canada, Norway, Hungary, Sweden, and Australia.(9, 10, 11, 13, 14, 15, and 16). More details of these foreign guidelines and studies are provided in the full FHWA report.(4) More details of pedestrian facilities are given in the 1999 *“Pedestrian User Guide: Providing Safety and Mobility”* for FHWA,(19) the ITE *Design and Safety of Pedestrian Facilities*,(20) the ITE Traffic Safety Toolbox,(21) and the City of Seattle Guide entitled, *Making Streets that Work*,(22) among others.

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