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Effects of Traffic Calming Measures on Pedestrian and Motorist Behavior

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By slowing down vehicle traffic, shortening crossing distances, and enhancing motorist and pedestrian visibility, traffic calming treatments may benefit pedestrians who are crossing the street. The effects of selected traffic calming treatments on pedestrian and motorist behavior were evaluated at both intersection and midblock locations. Before and after data were collected in Cambridge, Massachusetts (bulbouts and raised intersection), Corvallis, Oregon (pedestrian refuge island), Seattle, Washington (bulbouts), and Sacramento, California (refuge islands). The key findings include that none of the treatments had a significant effect on the percentage of pedestrians for whom motorists yielded, the treatments usually did not have a significant effect on average pedestrian waiting time, and refuge islands often served to channelize pedestrians into marked crosswalks. The raised intersection in Cambridge also increased the percentage of pedestrians who crossed in the crosswalk. While traffic calming devices have the potential for improving the pedestrian environment, these devices by themselves do not guarantee that motorists will slow down or yield to pedestrians.

Continued growth and decentralization throughout the United States has increased the number of cars on streets and highways. High traffic volumes and speeds, especially on residential streets, reduce the quality of life for residents because of concerns about safety, noise, and pollution. As a result, many neighborhood residents and local officials have expressed interest in undertaking traffic calming as a means of decreasing the dominance of automobiles.

Traffic calming encompasses a series of physical treatments that are meant to lower vehicle speeds and volumes by creating the visual impression that certain streets are not intended for high-speed or cut-through traffic. Thus, traffic calming can improve safety for pedestrians and reduce noise and pollution levels. Examples of these measures include bulbouts, speed humps, chicanes, and traffic circles. Past research on speed humps, bulbouts, and roadway narrowing is summarized. Findings from a new evaluation of bulbouts, raised crosswalks and intersections, and refuge islands in four communities are also reported. Whereas earlier studies usually focused on vehicle speeds and volumes, this study looked at motorist-yielding and pedestrian-crossing behavior.

OVERVIEW

The research reported in this paper is part of a national research effort to evaluate the operational and safety effects of pedestrian treatments such as traffic calming, crosswalks, sidewalks, automated pedestrian detection, and illuminated pedestrian push buttons at traffic signals.

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Past Research on the Effects of Speed Humps

Also known as road humps, undulations, or "sleeping policemen," speed humps have the purpose of promoting the smooth flow of traffic at speeds of about 32 to 40 km/h (20 to 25 mph). The speed hump is an elongated bump with a circular arc cross-section (round top) or flat top, rising to a height of 76 mm (3 in) above the normal pavement surface and having a length of 3.7 m to 6.7 m (12 ft to 22 ft) in the direction of vehicular travel (Figure 1). Speed humps usually extend the full width of the road, excluding the gutter to allow for drainage (*1*).

Raised crosswalks are flat-top speed humps with crosswalk markings painted on the top (Figure 2). Raised crosswalks elevate pedestrians above the surface of the roadway and can make them more visible to motorists. Raised crosswalks cause motorists to slow at the most critical location, where pedestrians cross, and they are generally designed to keep pedestrians at one level so that there is no need for curb ramps. Drainage is accommodated by pipes along the gutter or other design features. Speed humps have been evaluated in many cities. The following paragraphs summarize some of those studies.

In Omaha, Nebraska, before and after data at ten speed-hump locations found a significant reduction (at the 5 percent significance level) in the 85th percentile speeds. Data collected from 19 locations showed that the number of accidents involving personal injury decreased. However, residents complained about the speeding that still existed, as well as about vehicle damage and increased noise levels. City officials were concerned about emergency vehicle access and response time, potential liability, and the need to monitor signs and pavement markings for the speed humps (*2*).

In Bellevue, Washington, sixteen speed humps were installed in five residential neighborhoods. Prior to installation, the 85th percentile speeds were 58 to 63 km/h (36 mph to 39 mph). After installation, they went down to 39 to 43 km/h (24 to 27 mph). Traffic volumes fell when alternate routes existed. Most residents felt that the humps were effective and favored their continued use (*3*).

Speed humps in Montgomery County, Maryland, typically reduced 85th percentile speeds by 6 to 11 km/h (4 to 7 mph). The installation of the humps reduced accident frequency. The humps did not have a consistent effect on traffic volumes, however (*4*). The speed-reducing effect was stronger in adjacent Howard County, Maryland, where the use of speed humps on a number of streets lowered the 85th percentile speeds by 14 to 37 km/h (9 to 23 mph) (*5*).

Five speed humps were built along a 0.8-km (0.5-mi) stretch of Grey Rock Road in Agoura Hills, California. Instead of the customary 76-mm (3-in) height, these humps were 70 mm (2.75 in.) high. The 85th percentile traffic speeds fell by 10 to 15 km/h (6 to 9 mph) after the humps were installed. Traffic volumes remained constant and motorists did not divert to other residential streets (*6*).

FIGURE 1 **Two vehicles slow down as they pass over speed hump.**

The speed humps placed in Westlake Village, California, were 67 mm (2.625 in.) high. The humps reduced the 85th percentile speeds by 15 to 23 km/h (9 to 14 mph), so that they fell to 39 to 47 km/h (24 to 29 mph). Several demonstration projects in Los Angeles used speed humps 67 mm (2.625 in.) high, with results similar to those in Agoura Hills and Westlake Village (*6*).

In three Australian cities (Corio and Croydon in Victoria, and Stirling in Western Australia), the 85th percentile speeds at speed humps dropped by half or more after installation. Mid-hump speeds fell by about one-fourth to one-third. Daily traffic volumes fell by one-fourth to roughly one-half (*7–9*).

Previous Studies on Effects of Bulbouts and Street Narrowing

The purpose of a bulbout (also known as a choker, curb bulb, neck-down, nub, or gateway) is reduction of the width of vehicle travel way at an intersection or a mid-block pedestrian crossing. Bulbouts shorten the street crossing distance for pedestrians, may slow vehicle speeds, and provide pedestrians and motorists with an improved view of one another, thereby reducing the risk of a motor vehicle–pedestrian collision (Figure 3).

FIGURE 2 **Two pedestrians using raised crosswalk.**

FIGURE 3 **Bulbouts shorten crossing distances for pedestrians, improve sight distances, and may slow vehicle speeds.**

Anne Arundel County, Maryland, has used a combination of medians and bulbouts near intersections. The medians narrow the traveled way and provide a sheltered storage area, whereas the bulbouts force drivers to make a lateral deflection as they enter the narrowed area. Medians with lateral deflection reduced the 85th percentile speeds by 3 to 8 km/h (2 to 5 mph) (*5*).

In Ontario, Canada, Macbeth (*10*) reported speed reductions on five raised and narrowed intersections and seven mid-block bulbouts, in conjunction with lowering the speed limit to 30 km/h. The proportion of motorists who exceeded 30 km/h was 86 percent before the devices were built, but only 20 percent afterwards.

The Dutch towns of Oosterhout and De Meern have both installed street-narrowing variations. The Oosterhout project consisted of installing two bulbouts so as to require motorists to deviate from a straight path. Both the 85th percentile vehicle speed and the degree of pedestrian-motor vehicle conflict fell after the bulbouts were installed. In De Meern, two bulbouts were placed opposite one another to narrow the width of the traveled way. A significant reduction in the 85th percentile vehicle speed was observed (*11*).

In two Australian cities, Keilor (Queensland) and Eltham (Victoria), bulbouts had little effect toward reducing vehicle speeds. However, in Concord, New South Wales, a comparison of a street with both bulbouts and marked parking lanes versus an untreated street showed that the crash rate on the treated street was only one-third that of the untreated street. It was not stated how many of these crashes involved pedestrians, nor how the streets compared prior to treatment (*9*).

The Australian “wombat” crossing usually consists of a raised crosswalk and bulbouts. It is designed to slow motorists, shorten pedestrian exposure to motor vehicles, and increase pedestrian visibility to motorists. Wombat crossings have generally reduced 85th percentile vehicle speeds by about 40 percent (*9*).

DATA COLLECTION

A before-and-after data collection approach was used. Table 1 lists the cities, treatments, and street types where the treatments were installed. The sites in Cambridge were on one-way streets. All other sites were on two-way streets.

Data were collected with a video camera prior to and following the installation of each treatment. The video camera was set up on

TABLE 1 Cities and Types of Treatments Evaluated

LOCATION	TREATMENTS AND STREET TYPES
Cambridge, MA	2 BULBOUTS #1: Berkshire at Marney (residential collector) #2: Berkshire at York (residential collector) 1 RAISED INTERSECTION Berkshire at Marcella (residential collector)
Corvallis, OR	1 REFUGE ISLAND WITH PAVEMENT MARKINGS Circle Boulevard (suburban arterial near a shopping mall)
Seattle, WA	2 BULBOUTS #1: Alki at 59th (urban arterial along the waterfront) #2: Pike at 11th (downtown arterial in a shopping and office district)
Sacramento, CA	4 SITES WITH REFUGE ISLANDS PLUS ZEBRA CROSSWALKS (all four sites were in residential areas)

the sidewalk, approximately 61 m (200 ft) upstream from the crossing location. The camera faced in the same direction as traffic on that half of the roadway. This position allowed the camera to videotape-record pedestrians in the crosswalk and in the queuing areas on either side of the roadway. The camera also recorded whether approaching motorists stopped or slowed down for pedestrians.

RESULTS

The treatments were evaluated according to three measures of effectiveness (MOEs):

1. Average pedestrian wait time,
2. Pedestrians crossing in the crosswalk, and
3. Pedestrians for whom motorists yielded.

Each MOE is described in more detail in the following sections. The reader is advised that the MOEs had different sample sizes because of how the MOEs were defined. In some observations, individual data items were not recorded, and these observations were not included in the analysis.

Average Pedestrian Wait Time

Pedestrian wait time refers to the time that a pedestrian waits after arriving at the curb before he or she starts to cross the roadway. When no vehicles are present, pedestrians can cross immediately after they arrive at the curb. When vehicles are present, pedestrians typically either wait for a gap that they perceive to be adequate, or until an approaching motorist stops or slows down, before they start crossing. Bulbouts, raised intersections, and raised crosswalks may slow vehicle speeds, thus increasing the number of adequate gaps and also increasing the likelihood that an approaching motorist will yield to a pedestrian. Because refuge islands allow pedestrians to cross one direction of traffic at a time, pedestrians may choose shorter gaps than they would if they had to cross both directions of traffic. Therefore, it is expected that all of these devices will shorten the time that pedestrians must wait to cross the street. In this study, wait times were recorded for all pedestrians who crossed the street, regardless of whether motor vehicles were approaching.

The *t*-test for difference in means was used to compare average pedestrian wait times in the before and after periods. The effect of the bulbouts in Seattle was statistically significant, but in the undesired direction—that is, the wait times at the bulbouts were longer in the after period than in the before period. None of the other treatments had a significant effect on pedestrian wait time, not even at the 0.10 level (Table 2).

Where Do Pedestrians Cross?

All of the traffic calming treatments that were evaluated were implemented at sites that already had marked crosswalks in the before period. It was not clear whether these treatments would motivate pedestrians who otherwise might not have done so to cross in the crosswalk, in order that they might benefit from these treatments. The benefits include a shorter crossing distance resulting from bulbouts, a delineated crossing zone created by raised crosswalks and raised intersections, and an island in the middle of traffic providing a place of refuge.

The chi-square statistic was used to compare the percentages of pedestrians who crossed in the crosswalk (Figure 4) in the before and after periods. As Table 3 shows, the raised intersection in Cambridge and the refuge islands in Sacramento had statistically significant effects: that is, more pedestrians crossed in the crosswalk in the after period than in the before period. The effects of the Cambridge bulbouts and the refuge island in Corvallis were in the desired direction but were not statistically significant, not even at the 0.10 level. The results for the bulbouts in Seattle were statistically significant, but in the undesired direction—more pedestrians crossed in the crosswalk before the bulbouts were installed than after they were installed.

Motorist Yielding

Constricting the roadway or creating vertical displacement, bulbouts, raised crosswalks and intersections, and refuge islands is intended to

TABLE 2 Average Pedestrian Wait Time, Before and After Treatment

LOCATION	TREATMENT	BEFORE	AFTER	SIGNIFICANCE
Cambridge, MA	Bulbouts 2 locations	0.16 sec N = 85	0.11 sec N = 99	Not significant
Seattle, WA	Bulbouts 2 locations	1.19 sec N = 1086	1.76 sec N = 1233	0.0033 Undesired direction
Cambridge, MA Berkshire at Marcella	Raised intersection	0.04 sec N = 104	0.00 sec N = 47	Not significant
Corvallis, OR	Refuge island and pavement markings	8.59 sec N = 75	6.68 sec N = 110	Not significant
Sacramento, CA	Refuge islands and zebra crosswalks 4 locations	1.59 sec N = 289	1.54 sec N = 214	Not significant

slow vehicles down and increase the likelihood that motorists will see pedestrians sooner than they would otherwise. This study examined whether these treatments increased the likelihood that a motorist would stop or at least slow down for a pedestrian waiting to cross or already in the roadway.

The chi-square statistic was used to compare the percentages of pedestrians for whom motorists yielded in the before and after periods. None of the treatments had a statistically significant effect on the percentage of pedestrians for whom motorists yielded, not even at the 0.10 level (Table 4). In the after period, motorists yielded to 66.7 percent of the pedestrians in the best case, and to only 7.5 percent in the worst case. Two bulbouts in Cambridge and the refuge island in Corvallis had small sample sizes.

DISCUSSION OF RESULTS

Table 5 summarizes the effect of traffic calming devices by site and MOE. For example, there was no change in pedestrian wait time or the number of pedestrians using the crosswalk for the two bulbout locations in Cambridge, Massachusetts. The sample size was too small to allow researchers to evaluate the likelihood of a driver yielding to pedestrians after the bulbouts were installed.

FIGURE 4 Pedestrian in crosswalk with refuge island, Sacramento, California.

Average pedestrian wait times were usually under 2 seconds (Table 2). The short wait times indicate that most pedestrians started crossing as soon as they reached the curb, or within a few seconds thereafter. Motor vehicle traffic volumes were usually not high, so adequate gaps for pedestrians to cross the roadway came frequently, without a long wait. The wait times did not change much between the "before" and "after" periods. However, the wait times in the "before" period were close to zero and could not get much shorter, nor did they get much longer. In fact, the change in wait times at four of the sites turned out to be not statistically significant.

It is likely that wait times will fluctuate from one day to the next in response to vehicle and pedestrian volumes and vehicle speeds. The significant effect in the wrong direction at the other two sites in Seattle may be partly the result of these fluctuations in pedestrian and motor vehicle volumes.

CONCLUSIONS

Raised intersections and refuge islands are likely to direct more pedestrians to cross within the crosswalk. At most other sites, traffic calming devices did not appear to have significant effects on pedestrians. In fact, the bulbouts in Seattle were associated with increased wait times and a lower percentage of those who crossed in the crosswalk, both undesirable effects from a pedestrian standpoint. These findings may result from a fluctuation in traffic conditions at the site.

The reader is cautioned that traffic calming devices are not guaranteed to improve conditions for pedestrians. These devices by themselves can ensure neither that motorists will slow down and yield to pedestrians nor that pedestrians will cross in the crosswalk. Moreover, traffic calming devices have their disadvantages. For example, these treatments can hinder activities such as street cleaning and snowplowing, may impede emergency vehicle access, and may affect drainage. In addition, the noise of vehicles going over speed humps, raised crosswalks, or raised intersections may disturb nearby residents.

The ultimate evaluation of traffic calming devices would consist of a safety-based analysis using 3 or more years of collision records

TABLE 3 Percent of Pedestrians Who Crossed in Crosswalk, Before and After Treatment

LOCATION	TREATMENT	BEFORE	AFTER	SIGNIFICANCE
Cambridge, MA	Bulbouts 2 locations	40 out of 60 (66.7%)	43 out of 64 (67.2%)	Not significant
Seattle, WA	Bulbouts 2 locations	772 out of 824 (93.7%)	696 out of 939 (74.1%)	0.000 Undesired direction
Cambridge, MA Berkshire at Marcella	Raised intersection	12 out of 104 (11.5%)	18 out of 47 (38.3%)	0.001
Corvallis, OR	Refuge island and pavement markings	41 out of 79 (51.9%)	88 out of 113 (78.0%)	Not significant
Sacramento, CA	Refuge islands with zebra crosswalks 4 locations	193 out of 314 (61.5%)	161 out of 224 (71.9%)	0.012

TABLE 4 Percent of Pedestrians for Whom Motorists Yielded, Before and After Treatment

LOCATION	TREATMENT	BEFORE	AFTER	SIGNIFICANCE
Cambridge, MA	Bulbouts 2 locations	1 out of 5 (20.0%)	4 out of 6 (66.7%)	Not significant Small sample size
Seattle, WA	Bulbouts 2 locations	198 out of 342 (57.9%)	246 out of 471 (52.2%)	Not significant
Corvallis, OR	Refuge island and pavement markings	2 out of 35 (5.7%)	4 out of 53 (7.5%)	Not significant Small sample size
Sacramento, CA	Refuge islands with zebra crosswalks 4 locations	15 out of 46 (32.6%)	16 out of 38 (42.1%)	Not significant

TABLE 5 Summary of Traffic Calming Devices by Site and MOE

TREATMENT AND CITY	VEHICLE YIELDING	PEDESTRIAN WAIT TIME	USING CROSSWALK
BULBOUTS (2 locations) Cambridge, MA	*	No Change	No Change
BULBOUTS (2 locations) Seattle, WA	No Change	Worse	Worse
RAISED INTERSECTION Cambridge, MA	N/A	No Change	Improve
REFUGE ISLAND & PAVEMENT MARKINGS Corvallis, OR	*	No Change	No Change
REFUGE ISLANDS & ZEBRA CROSSWALKS (4 locations) Sacramento, CA	No Change	No Change	Improve

N/A Data were not collected for this MOE
Improve Significant improvement at 0.10 level
Worse Conditions significantly worse at 0.10 level
* Small sample size

and more study sites. Other devices (such as traffic circles) were not examined in this study. Such an evaluation was beyond the scope of this study, but eventually should be conducted.

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