TRAFFIC ENGINEERING FOR PEDESTRIAN SAFETY: SOME NEW DATA AND SOLUTIONS

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This paper describes involvement patterns for a number of specific types of pedestrian accidents. It also describes traffic engineering actions designed to change the behavior of pedestrians and drivers to make them more likely to avoid these specific types of accidents. The patterns and solutions are drawn from a study of over 2,100 individual pedestrian accident cases.

•A GROWING awareness of the nature and extent of the pedestrian safety problem is likely to lead to greater requirements for action by traffic engineers and others to reduce pedestrian casualties. A few facts illustrate the magnitude and trend of the pedestrian problem: Each year there are about 400,000 pedestrian victims, and more than 10,000 of them die. Although the number of fatalities had been slowly decreasing until the late 1950's, the trend has reversed itself and has increased 36 percent since 1958. It has been estimated that there will be about 13,000 pedestrian fatalities in 1980. With improvements in vehicle occupant protection taking place, pedestrians could account for one-third to one-half of highway fatalities by 1980.

TRAFFIC ENGINEERING AND SOLUTION APPROACHES

There are three main approaches to reducing pedestrian casualties. First, we can physically separate the participants and reduce the opportunity for collisions. However, all conflicts cannot be avoided. The second approach is to develop safer behavior so that drivers and pedestrians can avoid accidents. Because this is not likely to be 100 percent effective in the near future, the third approach calls for modifying the impact dynamics, primarily through vehicle design, to reduce the severity of the injury.

This paper is concerned with the second approach. The underlying contention is that traffic engineering can contribute to the development of safe behavior by (a) restricting participants' action possibilities; (b) enhancing their capability to act safely; and (c) enhancing their predisposition or tendency to act safely.

A second underlying contention is that traffic engineering can be most effective when it is part of a comprehensive local pedestrian safety program. The particular focus of this paper is on some specific solutions supported by new data on pedestrian accidents.

METHODOLOGY AND DATA BASE

The methodology and data on which this work is based are reported in detail elsewhere (1). They are only summarized briefly as background for the conclusions.

Data were collected on over 2,100 cases of pedestrian accidents as they occurred during a 10-month period in 13 major cities in the United States. Data were secured by means of interviews with participants and witnesses, on-scene observations, and police records. The focus was on the sequence of events and behavior leading to the accident as well as on selected situational factors that might influence those events. Causal conclusions were drawn for each case individually, and cases were grouped into types primarily on the basis of similarity of causation. Other data were then tabulated for the cases in each type.

GENERAL CONCLUSIONS

Three general conclusions from the overall study are especially relevant. First, there are a number of distinct types of pedestrian accidents that need individual attention. These types may be differentiated on the basis of (a) the sequence of events and behavior leading to the collision; (b) the important factors that predispose that sequence to occur; and (c) the characteristics of the people, vehicles, and locations typically involved. Second, different accident types occur more frequently in different areas of the city. Third, pedestrian search and detection failures are frequent causal factors.

These three points will be clarified as selected specific accident types and solutions are summarized. The percentage given for each type indicates the percent of urban accidents studied that were definitely assigned to this category. One can multiply that percentage by 360,000 to get a rough idea of the estimated number of accidents in that category each year.

DART-OUT, FIRST HALF (24 PERCENT)

A pedestrian, not in an intersection crosswalk, appears suddenly from the roadside. His quick appearance and short exposure to the driver are the critical factors. The pedestrian often may be running, and parked cars often obstruct vision, but neither need be present if the basic condition of sudden appearance to the driver's view is met. The prime example of the dart-out is a school-aged child running out from between parked cars on his own block in a residential area in the center city in the afternoon after school. He heads straight across the relatively narrow street, looking where he is going, and is struck less than halfway across. The driver, traveling at a normal rate of speed, does not have enough time to stop after detecting the child.

Almost 90 percent of these dart-out pedestrians were under 14. About half of the incidents happened between 3:00 p.m. and 6:00 p.m., 78 percent were between 2:00 p.m. and 9:00 p.m., and 80 percent were in the daytime. The crashes took place in residential areas (72 percent) and did not involve high speeds (85 percent were below 30 mph). Most of the time the pedestrian was struck within 2 blocks of his home (65 percent) while crossing a street less than 40 ft wide (74 percent). Figure 1 shows the typical type 1 dart-out. The analysis of the problem has shown that the main items to be attacked and overcome are (a) a risky pedestrian course—exposing him to view briefly; (b) failure of the pedestrian to search and detect; and (c) parked cars that interfere with driver and pedestrian vision. An innovative potential countermeasure that is directed at this problem is parking redeployment. Two steps would be taken in selected residential locations. First, parking would be removed from one side of the street, probably the left. Second, head-in diagonal parking would replace parallel parking on the right (Fig. 2). In appropriate locations this would accomplish the following: Visual obstructions would be removed from the left side of the road giving the driver an increased view and more time to detect and react. The diagonal parking would provide a physical control that would tend to slow down the pedestrian as he ran across the street but, even more important, would angle him into traffic and direct his field of vision more in the direction of the threatening vehicles. Also, he would be able to execute evasive action more readily than when crossing directly across the street. Approaching on an angle would let him change course to avoid being struck, rather than having to stop. Finally, it appears that the average driver maintains a greater clearance from cars parked at an angle (2), and this improves his view of pedestrians entering from the parking side.

Because this is an innovative countermeasure, it offers greater potential as a solution to a stubborn problem but at the same time will evoke some resistance because it disturbs commonly accepted ways of handling on-street parking. Some legitimate questions can be raised that should be answered relative to traffic flow, parking accidents, and public acceptance. Previous reports about accidents and diagonal parking have dealt with its use in business areas rather than the kind of application suggested here. The data were gathered 20 to 35 years ago. (Changes in vehicle design and driving habits could change present-day results.) Although they showed a reduction in parking accidents when parallel parking replaced diagonal, most studies had no controls or insufficient baseline data for drawing firm conclusions about the cause. The effect of parking redeployment on parking accidents can and should be determined. However, even if this countermeasure were to increase auto-with-auto accidents, it still might be worth it. (A trade of personal-injury accidents for property-damage accidents appears to be generally acceptable.)

With respect to traffic flow, Johnston (2) has reported that for angle parking it takes the average driver 12 seconds to back out of a stall and proceed forward in the traffic lane; for parallel parking the average driver takes 32 seconds to back into a stall and clear the traffic lane. For the 85th percentile, maneuver time was 17.4 seconds for angle and 53.5 for parallel parking.

Another innovative potential countermeasure also deals with the problem of the child dart-out who runs into the street looking straight ahead and fails to detect the threatening vehicle. The measure requires the cooperative efforts of educators and engineers. It consists of special training and curb marking in high-incidence areas to condition children to look toward traffic as they approach the curb. This is different from education in the traditional sense, since the special training is aimed at conditioning an automatic physical response or habit—turning the head—rather than trying to get the child to think of what to do as he is running out into the street.

The special curbside markings would provide the trigger to set off this automatic response and help to maintain the habit. Alternating colored diagonal stripes facing at a 45-degree angle toward the traffic is a possible marking. The heavy incidence of child dart-outs in high-density center-city residential areas helps to localize this application. It is hoped that future research will permit an accurate pinpointing of the high-risk streets.

Other countermeasures that would be helpful for this type of accident are (a) prohibition of street parking, (b) off-street parking and play areas, and (c) sidewalk parks with fences.

DART-OUT, SECOND HALF (9 PERCENT)

The second-half dart-out is the same as the dart-out described for the first half except that the pedestrian covers half of a normal crossing before being struck. A third of these cases occurred in commercial areas. The basic characteristics of the situation were very similar to the first-half dart-out but not quite as extreme. For example, 77 percent of the pedestrians were under 14 (versus 87 percent); 69 percent of the cases had speeds below 25 mph (versus 85 percent); 52 percent were in residential areas (versus 72 percent); 74 percent were mid-block (versus 87 percent); and 72 percent were in the daytime (versus 80 percent). Differences were greater with respect to specific location: 34 percent of the streets were under 40 ft across (versus 74 percent for first-half dart-outs), and 17 percent of the pedestrians were 10 or more blocks from home (versus 5 percent for the first-half dart-outs). Thus the second-half dart-out is generally similar to the first-half dart-out, but his running and driver-detection failures as a result of traffic come into play more often, and the accidents happen on wider nonresidential streets as well as on the narrower residential streets. The pedestrian may be watching traffic, although he still does not detect danger in time. In commercial areas with on-street parking meters, small fences or railing extending out a few feet from either side of the meter post could combine with parked cars to form a barrier to prevent dart-outs.

INTERSECTION DASH (9 PERCENT)

The intersection dash category covers cases similar to dart-outs with regard to pedestrian exposure to view, but the incident occurs in or near a marked or unmarked crosswalk at an intersection. One of the predisposing factors identified for the intersection dash was the inducement to pedestrian risk-taking coming from the traffic signal. The pedestrian is wrong to cross against the light. He should wait until he has the proper signal, but it is apparent that some will become impatient when they must wait. In some locations, longer-than-usual waiting periods are involved in order to move heavy traffic volumes. However, it must now be recognized that this may induce pedestrians to take

Figure 1. Typical first-half dart-out type of accident.

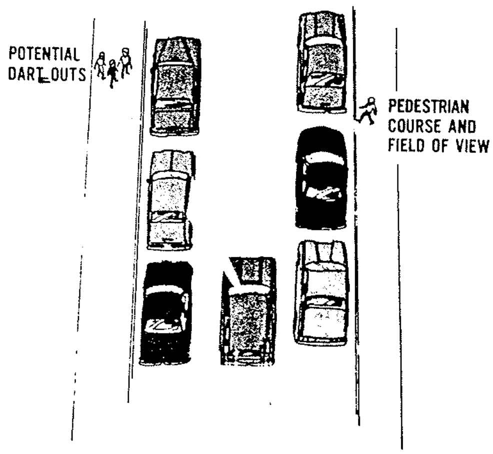


Figure 2. Redeployment of parking to counter dart-out accidents.

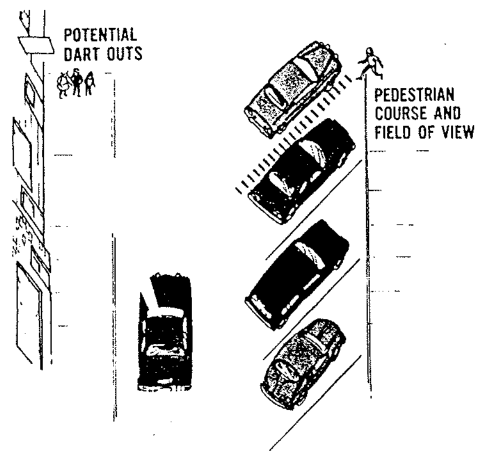
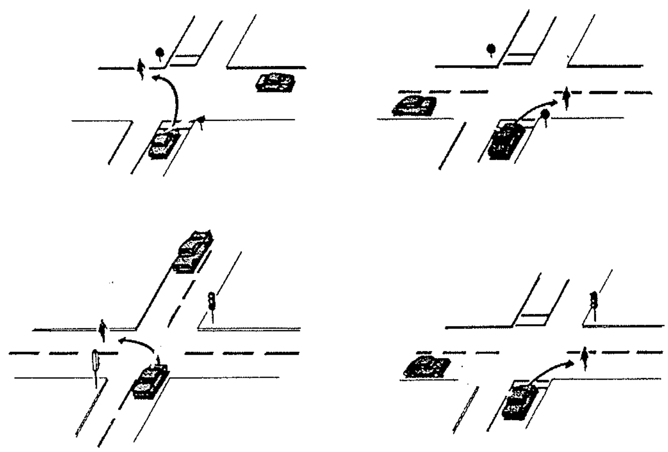


Figure 3. Examples of vehicle turn with attention conflict.



risks because they are impatient. Standard time periods cannot be recommended on the basis of this study. The best specific treatment will depend on the individual nature of the intersection and its vehicle and pedestrian volumes. It is recommended that local traffic engineers review intersections with the longer pedestrian waiting periods, especially in commercial and multifamily dwelling areas surrounding the central business district, and consider the following possibilities.

1. Reset cycles to bring pedestrian waiting time in line with the norm, or lower if other considerations permit.
2. If rush hour volumes do not permit complete retiming, reduce pedestrian waiting periods during nonpeak hours (two-thirds of intersection dashes occurred before or after the 4:00 p.m. to 6:00 p.m. rush period).
3. Provide a signal indicating the waiting time remaining to green. This could be a numeric countdown signal giving the seconds remaining, but need not be; color codes or 10-second intervals could be used. Such a signal could be integrated with the wait-walk type pedestrian signals.

MULTIPLE THREAT (3 PERCENT)

The pedestrian is struck by car x after other cars blocking the vision of car x stopped in other lanes going the same direction and avoided hitting the pedestrian. For example, cars in lanes one and two stop and permit the pedestrian to cross, but car x in lane three going in the same direction hits the pedestrian as he steps out in front of the car in lane two. This multiple-threat type also occurs with cars starting from a signal. Most pedestrians were watching traffic but not the collision vehicle; 42 percent were running, and 42 percent were walking normally. More than 60 percent of the pedestrians were in a crosswalk. More than half did not recognize the need for evasive action; 38 percent did just prior to impact. Most drivers were looking ahead (74 percent) and proceeding at sustained speed (58 percent) prior to the accident. However, 19 percent were slowing down, 14 percent were stopped or proceeding from a stop, and 11 percent were accelerating. Some 21 percent did not recognize the need for evasive action, and 63 percent did just prior to impact. Pedestrian age was spread out: 39 percent were under 15, 32 percent were between 15 and 35, and 20 percent were over 60. Most incidents occurred in daytime (84 percent), in commercial areas (65 percent), and at intersections (80 percent). As to the locations, 53 percent had no traffic control, 7 percent had a stop sign, and 38 percent had a traffic signal. Speeds were not high (88 percent under 30 mph).

Stop line modification is a countermeasure directed primarily at multiple-threat accidents occurring at signalized intersections in commercial areas. To reduce the incidents where cars stopped at the stop line obscure the view from the striking car, a wide stop or limit line should be placed a number of feet ahead of the crosswalk. Although specific design would depend on a number of factors at the particular location, the objective is to stop the cars far enough back so that a pedestrian in the walk is likely to be noticed by cars other than the ones facing him. The recommendation given by the Manual on Uniform Traffic Control Devices for a stop line about 4 ft in front of the nearest crosswalk may not go far enough. This countermeasure might also be used at nonsignalized intersections, but the specific location of the stop line would have to take into account the need for the driver to see cross traffic if it is not controlled.

VEHICLE TURN OR MERGE WITH ATTENTION CONFLICT (7 PERCENT)

The driver is turning into or merging with traffic; the situation is such that he attends to the traffic in one direction and hits the pedestrian who is in a different direction from his attention. A critical feature is that the attention conflict is built into the situation. Usually the driver directs his attention in a given direction to determine an acceptable gap into which he will enter. Figure 3 shows some of these situations. Pedestrian age was strikingly different from the typical pedestrian pattern, as were some other characteristics. Only 5 percent of the pedestrians were under 15 years, whereas more than half were 55 or over. Although 60 percent of the cases occurred between 1:00 p.m. and 8:00 p.m., they were spread much more evenly than usual over the normal waking hours; 71 percent were during daylight hours, 73 percent were in commercial areas, and practically all were at intersections. Of special interest is the finding that 55 percent of the cases occurred at locations with red, green, and amber signals, and an additional 23 percent occurred at signalized locations where right turn on red was permited. Pre-involvement speeds were quite low—83 percent were 15 mph or less.

Right-turn attention conflict reduction is one countermeasure aimed at reducing the numbers of this type of accident. It involves the review of intersections in commercial areas with the objective of removing the basic attention conflict situation for the driver by selecting one of several possible actions. Some of these actions are

1. Removal of right turn on red;
2. Signalization of intersection;
3. Controlling cross traffic by stop sign;
4. Effecting one-way traffic on street to right, coming from the right;
5. Erecting pedestrian barrier if right turn on red is needed; and
6. Introducing pedestrian-only signal phase.

The first two possibilities could remove the need for the driver to look to his left to identify an acceptable gap while turning right. The barrier in effect removes the crossing conflict, and pedestrian-only phase gives the pedestrian an opportunity to cross between the cars turning on the green and on the red. Once again the specific action requires location study.

The problems and actions for left-turn attention conflict reduction are the same as for the right turn with one difference. The left-turn problem also includes the situation in which a driver is proceeding on the green and must select a gap in oncoming traffic in order to make his left turn. Additional actions to be considered are

1. Prohibition of left turns;
2. Use of left-turn-only arrow (protected from oncoming traffic); and
3. Use of leading or lagging green with notice to driver.

There are two other general pedestrian accident countermeasures that apply to this type as well as to other types that occur at signalized intersections; they are (a) pedestrian threat information and (b) crossing simplification.

Pedestrian Threat Information Content

The use of pedestrian signals is growing, and the information provided by the common "walk-don't walk" signal is minimal. The fact that "don't walk" does not mean that at all is probably not serious because people can be expected to learn that it means "don't leave the curb." However, the signals give advice rather than information, and many people do not accept advice.

The red signal to a driver gives him advice and information. It not only tells him that he is legally advised not to go; it also tells him that someone else is being told to proceed across his path. For the pedestrian, however, "walk" is only advice. Vehicles may or may not be told to cross his path at the same time. Of the 13 cities in our data base, only in Denver was it noted that the removal of "don't walk" (followed by no pedestrian signal) meant it was permissible to cross, but one was subject to some legal vehicle threat. In Denver, "walk" means that no vehicles are permitted to cross the pedestrian path.

The pedestrian should be given better information about the threat he faces at a signal. He could be informed of the three basic conditions, (a) heavy, fast-moving, or direct traffic flow across the pedestrian path, (b) turning and/or lighter traffic across the pedestrian path, or (c) no legally permitted traffic across the pedestrian path.

These conditions are somewhat comparable to red, green, and amber (RGA). Perhaps the pedestrian should have a distinct RGA, obviously different enough not to be confused with the vehicle signal (e.g., a sign that flashes "pedestrian" in the appropriate color).

Crossing Simplification

Many of the countermeasures discussed have the effect of simplifying the crossing situation. It would be expected that the fewer directions from which threatening traffic can arrive, the more likely it is the pedestrian will be able to handle the situation. The positive effect of one-way streets in simplifying pedestrian crossings, reducing pedestrian accidents, and improving traffic flow is documented elsewhere (3) and is apparently not disputed. The existence of many two-way streets, however, makes it desirable to call attention to this measure once again.

Another approach to crossing simplification is the use of non-intersection pedestrian crossings. This would reduce the threat from turning vehicles. Mid-block signals and corner pedestrian barriers might be required. Difficulties with traffic flow might make mid-block signalization difficult, but it may be feasible in some locations. A crossing some feet in from the intersection would mean that a pedestrian only has traffic coming from his side rather than from behind on his side and in front on his side. Again, this approach is suggested for further analysis and testing rather than immediate implementation.

BUS-STOP RELATED (3 PERCENT)

Bus-stop-related accidents include cases in which the location or design of the stop appears to be a major factor in the causation; e.g., the pedestrian crosses in front of the bus standing at a stop on the corner, and the bus blocks the view of cars. It does not include those cases that may be considered as exiting from a vehicle, nor does it include cases in which the stop is only an attraction or distraction. Our data support those who have recommended "far side" bus stops. It is suggested that bus stops be located at the far side of the intersection to minimize visual interference. One city in the study had no bus-stop-related accidents. Upon investigation it was determined that over 90 percent of its bus stops had already been relocated to the far side.

CONCLUSION

Pedestrian accidents are a serious and growing problem. A study of the specific circumstances and events of pedestrian accidents has indicated some promising solutions. Those involved in traffic engineering in our cities can reduce pedestrian deaths and injuries by testing the application of these proposed solutions. Their efforts will be easier, and most effective, if they work with police, educators, and other members of a local team.

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