

A LITERATURE REVIEW AND  
BIBLIOGRAPHY OF RESEARCH  
AND PRACTICE IN PEDESTRIAN SAFETY

Linda Shapiro  
and  
Rudolf G. Mortimer

HuF-3

HIGHWAY SAFETY RESEARCH INSTITUTE  
Institute of Science and Technology  
The University of Michigan  
Ann Arbor 48105

## Table of Contents

	Page
1. Introduction	1
2. A General Look at Pedestrian Accident Statistics	1
3. The Highest Accident Risks	4
3.1 School-Aged Pedestrians	4
3.1.1 The Role of the Child, His Family and His Physical Environment	5
3.1.2 The Role of Education in Accident Prevention	7
3.1.3 The Role of Traffic Control and Engineering	9
3.2 Middle-Aged Pedestrians Who Have Been Drinking	12
3.3 The Elderly Pedestrian	13
4. Other Factors Which Influence Pedestrian Accidents	15
4.1 Blindness -- A Human Factor	15
4.2 Night and Winter Walking	16
4.3 Injury Descriptions	19
5. Pedestrian Traffic Safety -- The Practical Aspects	21
5.1 Safety Plans and Campaigns	21
5.1.1 General Safety Plans	21
5.1.2 Specific Traffic Safety Plans	23
5.2 Engineering: Intersections and Control Devices	24
5.2.1 The Pedestrian Bridge	25
5.2.2 Traffic Lights -- The Phasing Problem	25
5.2.3 Traffic Lights -- New Designs	28
5.2.4 Radio Signals	29
5.2.5 The Zebra-Striped Crossing	30
5.2.6 The Rumble Strip and Other Innovations	32
5.2.7 The Effectiveness of Marked Cross- walks	33
5.3 Pedestrian Risk-Taking Behavior	34
5.3.1 The Jaywalking Controversy	34
5.3.2 Studies of Risk-Taking	36

Table of Contents cont.	Page
5.3.3 Street Crossing Time	36
5.4 City Planning	38
6. Conclusion	40
7. Bibliography	

## 1. INTRODUCTION

An extensive review of the literature dealing with pedestrian safety yields two basic types of information. One category is comprised of statistical descriptions of accident victims and theories covering human factors in the causes of accidents. The other, closely related, information category is concerned with various methods of accident prevention, from the points of view of safety education, law enforcement, and traffic engineering. The articles read, published between 1941 and 1968, are mainly from periodicals and technical journals.

The statistical analyses of accident victims concentrate on three main groups--young (school) children, elderly adults, and middle-aged adults under the influence of alcohol. Probable factors contributing to accidents in these groups are discussed. Articles on the pedestrian hazards associated with night and winter driving and other environmental effects are also discussed. Devices for accident prevention applicable to specific groups of pedestrians are described, as are more general methods, such as town safety campaigns, town engineering plans, and intersection control. The question of where to place the responsibility for accidents comes up constantly and is discussed from various points of view.

The American Automobile Association (1964) has published a booklet providing a general look at many of the topics discussed in this paper.

## 2. A GENERAL LOOK AT PEDESTRIAN ACCIDENT STATISTICS

In 1967, there were 9400 fatal pedestrian collisions on U.S. streets and highways. Thus, 17.7 percent of all traffic fatalities were pedestrians (Jensen and Ruby, 1968). Most of these collisions occurred when the vehicle was going straight ahead, rather than turning; and of the former type only 25 percent occurred at an intersection while 75 percent were noninter-

section collisions (National Safety Council, 1968).

Although pedestrians constitute a large portion of traffic fatalities they were involved in only 2.2 percent of urban and 0.9 percent of rural collisions. This combination of relatively low involvement and high fatality frequency indicates that pedestrian collisions are severe, producing a higher fatality-collision ratio than any other type of traffic collision. As would be expected, the probability that a rural pedestrian-vehicle collision would be fatal to the pedestrian is three times higher than for urban collisions of this type because of greater vehicle speed; however, because of the greater density of pedestrians and vehicles in urban settings, urban pedestrian fatalities are twice as frequent as rural pedestrian fatalities. The percent of travel on urban and rural roads was about the same.

When accident statistics from various cities are studied, certain patterns consistently emerge. Three groups of pedestrians, characterized by age and alcohol consumption, clearly run the highest risks of being injured or killed in a traffic accident. These groups are young children, the elderly, and adults who have been drinking.

A study in England by Jeffcoate (1957) shows the highest risk among pedestrians to be for those under 10 years of age and those over 70 years. The relative risk to pedestrians for different classes of vehicles on major and minor roads was also shown. Motorcycles were involved in pedestrian collisions three times as frequently as private cars. Figure 1 shows relative accident rates with pedestrians for various classes of vehicle on Class II roads and streets.

A study of 50 pedestrians over 18 years of age who were fatally injured in Manhattan (Haddon, 1966) reveals that the cases comprised two discrete high-risk groups: the elderly who had been drinking little or not at all, and the middle-aged who had been drinking heavily. A study of 448 pedestrian fatalities occurring from 1948 to 1957 in Washington, D.C., (Yaksich, 1957) yields similar data. Pedestrians represented two-thirds of all motor vehicle fatalities in the city during the ten-year period. Pedestrians 75 years or older had the highest population death rate (36.7 per 100,000). Pedestrians 65-74 years old had the second highest rate (23.2 per 100,000). The lowest death rate was for pedestrians aged 11-19 years, who had

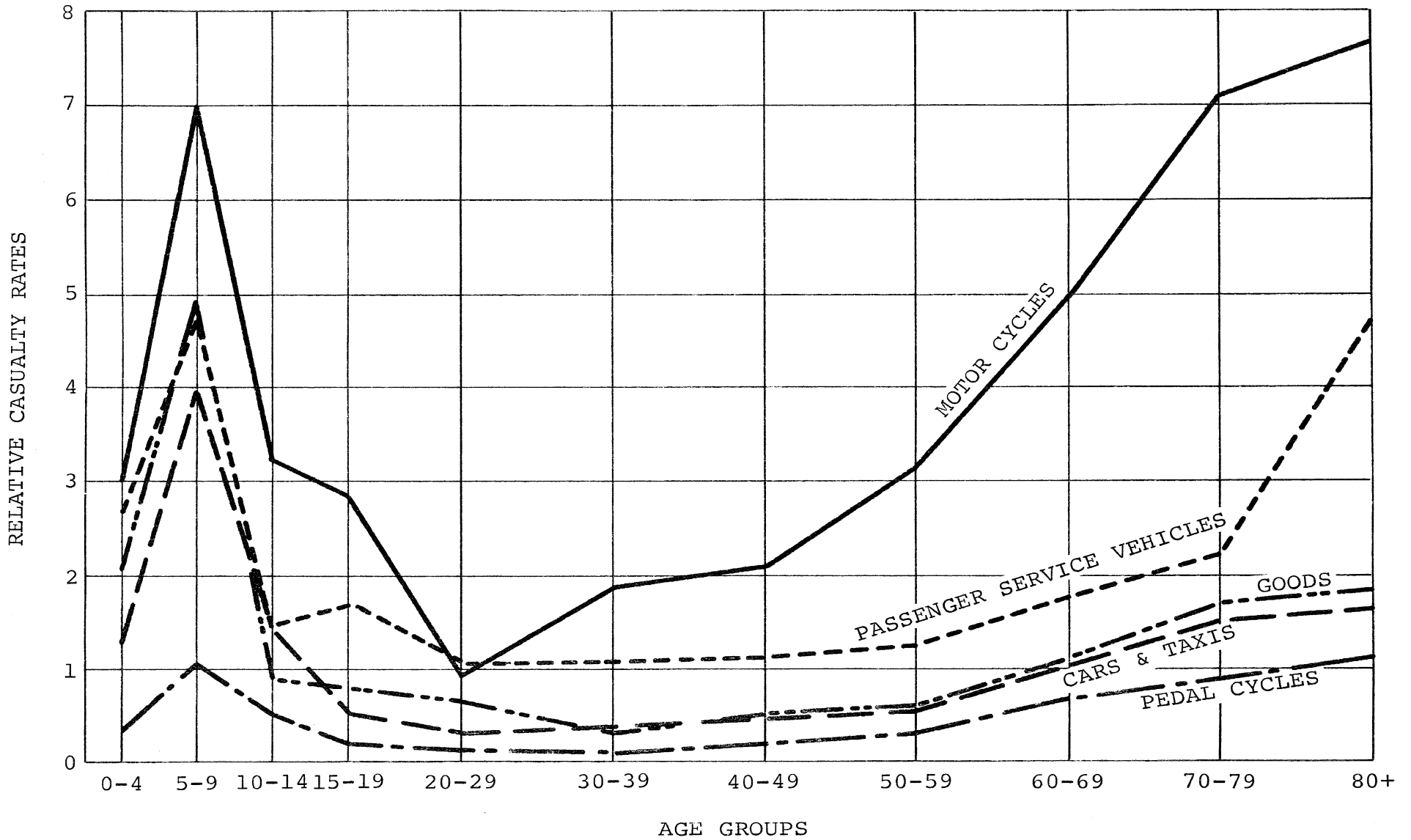


Figure 1. Comparison of Pedestrian Accident Rates on Class II Roads (1954) for Various Types of Vehicle. Reproduced from Jeffcoate, (1957), by Permission of the Director of Road Research, England. British Crown Copyright. Reproduced by Permission of the Controller HMSO.

0.5 deaths per 100,000 population. The population death rate of all the male population (7.9 deaths per 100,000) was 2.5 times the rate for females. Alcohol was found to be an increasingly important factor in pedestrian deaths.

A report on accident statistics from many countries prepared by the World Health Organization (1958) is in general agreement with the statistics cited. Sullivan (1964) also found that both very young and elderly pedestrians, as well as drunken pedestrians, are most likely to be involved in an accident. The same findings are reported in an article in Public Health Reports (September 1963).

Many articles stress the role of the pedestrian in traffic safety. Traffic Digest and Review (1961) points out that many pedestrians are injured or killed while performing dangerous acts such as crossing against traffic signals, crossing between intersections and/or parked cars, and walking while intoxicated. Yaksich (1957) states: "Pedestrians were in violation or committed an unsafe act in 70 percent of all fatal pedestrian accidents." An article in Public Health Reports (September 1963) states that more than 75 percent of all fatally injured pedestrians were violating a traffic or safety law, especially those laws concerning jay-walking. Siegel (1961) discusses specific characteristics of the pedestrian which contribute to pedestrian traffic hazards. These include their slow pace relative to vehicle speeds, their unpredictable behavior, and their resistance to inconvenience. Another factor, which will be more fully explored later, is that nine-tenths of the pedestrians killed were non-drivers.

### 3. THE HIGHEST ACCIDENT RISKS

#### 3.1. SCHOOL-AGED PEDESTRIANS

Some of the most disturbing injury and fatality statistics are those concerning children. Research has generated varying conclusions and suggestions. Everyone agrees that something must be done to ensure a higher degree of safety for children. However, writers differ as to whether the responsibility must lie with the child or the driver, and which type of engineering and education has the best effect on both children and drivers. Much of the

research concerns the child en route to and from school; most traffic safety problems arise when the children walk, although riding a school bus creates certain other problems. Much of the debate is over which crossing safety measures--patrol boys, crossing guards, or automatic lights--are most effective.

The first step in improving traffic safety for school children is understanding exactly who is most in danger, and when. Chicago Traffic Safety Review (March, April, 1962) states that "One out of every 27 Chicago children now five years old will be struck while crossing a street and injured by an automobile before reaching his tenth birthday." The article pinpoints the years between five and nine as the pedestrian's most dangerous period in life with respect to automobile accidents. The casualty rate of this age group is 4.5 times that of all other ages. However, the American Automobile Association (1965) states that ages four through seven are the most critical in terms of young pedestrian accidents. The article suggests that most children are hit after school hours during the warm months, crossing in mid-block. Chicago Traffic Safety Review (March, April, 1966) states that more child pedestrians were hurt in Chicago in 1965 than in any other year on record. Traffic statistics at the national level are also disturbing. In 1962 about 2,500 children aged fourteen and younger were killed in the United States, and another 78,000 were injured (Journal of American Insurance, 1963). It is emphasized that the large majority of children are struck when darting into the streets. The hours of darkness are most dangerous, and young boys have many more accidents than young girls.

3.1.1. THE ROLE OF THE CHILD, HIS FAMILY, AND HIS PHYSICAL ENVIRONMENT. Although carelessness on the part of motorists is undoubtedly a factor in child-pedestrian accidents, certain unsafe acts on the part of the children are frequently commented upon. The American Automobile Association (1965) states that



"in the majority of cases, accidents are caused not by the driver, but by unsafe acts of the child." The article suggests that the larger number of accidents to boys than to girls may be partially a result of our cultural value of male daring and aggressiveness. The young pedestrian, unlike others, is most often struck while crossing between intersections, after running into the road from between parked cars.

Marks (1957) notes that children are often injured while playing in the street. The American Automobile Association (No. 3, 1965) suggests that one way to keep children from playing in streets is to provide adequate and interesting play equipment, either public or private. Bartholomew (1967) investigated the effect of such play equipment on accident rates of pedestrians aged five to 14 years. The frequency and location of pedestrian street accidents in the service areas of selected recreation facilities, both before and after the dedication of the facilities, were compared. The study revealed that the development of a public playground or recreation center in a congested, high-accident area was followed by a significant decrease in accidents. The decrease was more pronounced in the quarter-mile zone around the facility than beyond it, and very few pedestrian accidents happened in an area immediately adjacent to the recreation facility.

Many studies have been made of the physical acts of children and motorists, and of the engineering practices used in constructing roads and traffic controls which affect accident rates. However, not too much information is available on the social and psychological factors which influence accident rates. One article by Backett and Johnston (1959) discusses a study of 101 families in which a healthy child has survived a road accident; these families were compared to a control group of families with healthy children who had not had accidents. The study suggests that a child's vulnerability was associated with one or more of the following characteristics: (1) more than an average amount of serious illness in the family; (2) some kind of maternal pre-

occupation (work, pregnancy, other children); (3) family crowding and lack of protected play facilities. Crowding seems to be less important than the other factors. Intelligence was not correlated with vulnerability to accidents. The correlations described are higher among younger children. A rating of local schools suggested that accidents to children are found in schools where parental standards of safety are rather low. Thus, although many writers warn that overprotection causes the child to be more vulnerable to accidents by making him unrealistically secure and incautious (Marks, 1957), it appears that the child who is not given enough protection is also accident prone.

3.1.2. THE ROLE OF EDUCATION IN ACCIDENT PREVENTION. Many articles stress the role of education in the protection of school-aged pedestrians. They emphasize that the solution to the problem lies not in strict control of traffic, but rather in the education of the child as to proper walking habits and the hazards which exist on every street and highway (State of Indiana, 1964). Lindquist (1955) states strongly that children can never be completely safe around cars and that the best protection for them is education, not traffic gimmicks. The educational procedures discussed are essentially of two types: The "Safety Town," in which the children learn traffic rules by participating in simulated traffic situations; and the classroom situation, in which the children read and memorize rules.

The "Safety Town" type of educational device should be more effective, because it involves the child more completely. He learns actively, by reacting within situations, rather than passively, by reading rules and regulations. A general description of the "Safety Town" concept appears in American Motorist (1961). The miniature towns are used for kindergarten-aged children throughout the country. The towns include miniature houses, churches, buildings, and realistically painted streets and traffic signals. The children use miniature automobiles and trucks. They also learn pedestrian safety. Counting equipment costs,

number of sessions held, and salaries, the expenses for the first year were reported at \$5,000-\$10,000. The expenses for succeeding years have been much lower. Another article (Journal of American Insurance, March, April, 1966) describes "Safety Town" in Mansfield, Ohio. Since the establishment of the town in 1937 there has not been an injury or death among Mansfield school children going to or from school on foot. Various methods, aside from the outdoor traffic simulation, are used at this school. They include games, songs, art work, and indoor classroom instruction. A modified safety town program is used in the school safety-education program in Nevada (Sale, 1960). Children hold various traffic signs and operate signals, while other children walk through the course. Each sign is carefully explained. The elementary schools in Battle Creek, Michigan, attempt to integrate the safety town idea into the total learning experience of the school day (Carper, 1959). The police department supplies scaled-down devices such as traffic lights, a railroad signal crossing, a stop sign, etc., which are set up within the halls of the schools. All children and school personnel obey the signals. This technique should be fairly effective in teaching traffic safety. Furthermore, Yaksich (1964) suggests that a good way for children to develop safety habits is to walk to school.

Traffic safety education in the classroom is also stressed, although several authors realize that this type of education is most valuable as a phase of a wider program of traffic safety education. The Procedure Manual prepared by the State of Indiana (1964) states that the solution to the problem of school-crossing protection does not rest entirely on strict control of vehicular traffic, but rather on the development of proper walking habits. Thus, in the author's opinion, a sound safety-education program in the home and school will contribute much more toward the protection of school children than dependence on protective mechanical devices. Lindquist (1955) agrees strongly

that the human factor is the most important in accident prevention and that children must be thoroughly educated in traffic safety.

Batts (1964) suggests that both protection and education for the child must be age-graded, with the emphasis on protection for younger children and education for older children. The National Safety Council (1960) provides two sets of age-graded safety lessons for junior and senior high school students. Each one gives an analysis of the accident rates for various areas in and outside the school. The lessons include a short quiz to test the pupils' comprehension of the data, as well as some discussion questions. While the lessons appear to be designed for classroom use, they seem too dry to spark lively discussions. Another, more imaginative classroom device is described by Coffey (1957). Elementary school children in Pittsfield, Massachusetts learned about Wandering Willy (a cartoon character in the local newspaper), who disregarded the most elementary traffic rules. The children discussed Willy's incorrect antics and the correct behavior appropriate to the situation. Ladd (1954) provides a pamphlet designed to aid traffic safety, which categorizes various pedestrians as "stupid, silly," etc, but its effectiveness is doubtful.

A list of traffic safety rules for children is provided by Mills (1960). Family Safety (1962) also provides a list, as well as suggestions for parents on arranging safe transportation for their children to and from school.

3.1.3. THE ROLE OF TRAFFIC CONTROL AND ENGINEERING. Several methods of traffic control and engineering are discussed and compared in the literature studied. A full list of pertinent references is contained in a recent bibliography by Cleveland (1969). Many writers agree that it is difficult to decide which measures to use (patrol boys, pedestrian-operated stop lights, crossing guards, or school crossing signs), and in what combination. Obviously school-aged children need some protection,

but several authors agree that overprotection, which may make the children irresponsible, is as dangerous as underprotection (National Safety Council, 1957).

Both Louisville and Chicago report the successful use of women as crossing guards for protecting school children (Heustis, 1950; O'Regan, 1965). Peoria reports using a school traffic safety plan which includes school boundaries based on major traffic-flow patterns, as well as patrol boys and adult crossing guards (Davis, 1964). Patrol boys, widely used in the United States and other countries, seem to be effective in reducing accidents among school-aged pedestrians according to the International Road Safety and Traffic Review (Summer, 1955).

Several authors feel that automatic traffic signals are more effective than crossing guards. May (1964) states that traffic signals are cheaper and more reliable than guards. She describes a program in which signals were installed midblock, at major pedestrian crossings. Dunivan (1964) describes the traffic safety system directed at school children in Miami. In this program school zones were replaced with signalized school crossings. Traffic was stopped only when necessary to allow pedestrians to cross the street. At all other times motorists faced a constant green signal, thus allowing them to maintain a realistic overall speed. The accident record attests to the effectiveness of this system. A committee studying the school crossing problem in Fort Wayne, Indiana, also recommends that adult guards gradually be replaced by school crossing signals operated by the pedestrian (White, 1960).

The effectiveness of special school zones, marked by signs, has also been studied, and several cities, including Miami, have done away with such zones. At least three authors are concerned with the relative effectiveness of various types of signs marking these zones. Dodds (1964) makes a plea for standardized traffic signs near school crossings, on the theory that motorists are more likely to obey familiar signs. Hartman and Rankin (1962) describe

a study testing this theory. Driver response to various school signs was measured to determine whether new signs could be developed with a stronger impact. The experimenters concluded that there is no radically different response to one sign or another, but that there is a significant discrepancy between a driver's response to a sign when he is behind the wheel and his response when he is questioned away from his vehicle. Away from the wheel the driver predicted greater sign effectiveness than was observed when he was behind the wheel. A broader study by Miller and Michael (1964) revealed that difference in the combination of signs, direction of automobile travel, time of day, and presence of children, significantly affected the 85th-percentile speed at the school crossing. The presence of children at the edge of the roadway significantly lowered the 85th-percentile speed under each sign condition. It was also found that the use of any of the traffic sign combinations selected had a rather small effect on the 85th-percentile speed. This study concludes that the most effective crossing protection combines a pedestrian-operated signal with an adult school guard. One study, reported by the Portland Traffic Safety Commission's Engineering Committee, concludes that "School Boy Sammy" signs are a good warning sign (Kalinowski, 1964). Another study by Dier (1955) was conducted to determine the theoretically safe traffic gap for the critical street width and the average sized pedestrian group. Actual gaps in traffic at specific locations can be measured to determine if the locations were "safe" or not. Proper traffic controls could then be prescribed.

Other aspects of school traffic safety are discussed in various articles. Harris (1955) considered whether or not children should cross the street in front of a school bus. This problem, along with methods for teaching children to handle it safely, is also discussed by Kralovec (1954). Reaction to actual accident and traffic situations has proven effective as a learning experience. For example, students of Baltimore elementary school investigated an accident involving a first-grader (Horst,

1961). Although the accident was partially the child's fault, the students discovered that all the crossings in the area were unsafe. They convinced the city of Baltimore to correct the situation. Also, they suggested that the school set up a traffic safety education program. Eventually, the students spurred the mayor into promoting a city-wide pedestrian safety campaign.

In Carlsbad, New Mexico, students worked with the aid of police to determine the speed of cars in their school zones. They sent a form letter to speed-limit violators, and car speeds in the zones did drop (McCloskey, 1959). A similar program was carried out in Salinas, California, (McIntyre, 1957) where the men's club felt that children did not remember safety rules once out of the classroom. To motivate them to follow the rules, the men observed the children near schools and noted traffic safety violations. The group of children with the least number of violations won a prize.

### 3.2. MIDDLE-AGED PEDESTRIANS WHO HAVE BEEN DRINKING

Adults who have been drinking form another of the three groups having the highest accident rates. Waller (1966) describes the application of the epidemiological method to a study of traffic accidents. Several patterns of nonuniform accident distribution can be identified in which greater than average risk is associated with personal (human) factors, as well as environmental factors. For example, greater than average traffic-accident risk can be identified in certain groups of middle-aged drivers having chronic medical conditions and in drivers and pedestrians who have been drinking, many of whom are unidentified alcoholics. Excessive risk is also associated with environmental factors such as poor roads, vehicle construction or design, and rural environment. It is suggested that safety programs place the greatest emphasis on early identification and treatment of alcoholism among drivers and pedestrians and on improvement of crash protection in the vehicle. Gonzales

and Alexander (1941) also stress that the effects of alcohol on pedestrians should not be ignored in evaluating the public health implications of highway accidents. Emphasizing the importance of this observation is the relatively large number of pedestrian fatalities compared with driver deaths, and the results of tests indicating that 30.7 percent of the pedestrian fatalities were sustained by persons under the influence of alcohol and that 26.2 percent of these had a blood alcohol content of 0.20 percent or more.

Negligence on the part of the intoxicated pedestrian is also an important factor. Decreased inhibitions tending to create a disregard for safety and impaired perceptual and motor response sensitivity increased the hazard. Kowalski et al. (1967) discuss the blood alcohol levels (BAL) of individuals killed by or in a vehicle involved in a pedestrian accident in Illinois during 1966, and describe a simple, workable method for obtaining blood specimens, which is particularly suited to quasi-professional personnel. All of the statistics quoted are for people over 15 years of age. Of the 2,206 fatalities, 1,562 blood specimens were submitted for alcohol content analysis. Approximately 42 percent of the pedestrians had measureable amounts of alcohol in their blood; 32 percent of these had BAL's over 0.10 percent. The number of drivers killed having appreciable amounts of alcohol in their blood also indicates that the legal limit for "driving while under the influence" should not be more than 0.10 percent. Education and law enforcement might reduce fatalities in the under-21 age group.

### 3.3. THE ELDERLY PEDESTRIAN

The third group of pedestrians having one of the highest accident rates is composed of pedestrians over 65. The American Automobile Association (No. 1, 1965) reports that persons 65 or older account for 40 percent of all pedestrian deaths in the United States. This AAA publication gives guidelines to local communities working to improve the safety



record among older pedestrians. The AAA stresses that safety programs must convey a realistic image of the elderly, many of whom are quite active and healthy. However, these pedestrians tend to suffer greater injury from an accident than younger people. According to the AAA, intersections pose the biggest problem for older pedestrians who become accident victims despite the fact that usually they are not violating any law. Nighttime is particularly hazardous for older pedestrians because of their often impaired vision. On the other hand, alcohol is not a significant factor in their accidents. The AAA recommends that certain changes be made in road design and that older people be consulted as to their needs.

Other writers take slightly different views of elderly pedestrians. Two articles in Traffic Safety (1957, 1960) maintain the elderly pedestrian's increased vulnerability is due largely to perception and motor failings of which he may not be aware. The articles also stress that many people over 65 may have never driven a car and thus may have unrealistic expectations about traffic and accidents, as well as about the drivers' limitations. Both articles recommend special traffic education for elderly people. Lashley (1960) disagrees with the AAA's contention that most elderly pedestrians are not in violation of any law. Lashley states that two-thirds of all pedestrians, including the elderly, are in violation of some traffic law. He agrees that two explanations for the high rate of fatalities among elderly pedestrians are their unfamiliarity with modern traffic hazards, and physical failings occurring with advancing age. Lashley also stresses traffic education for older people. McLellan (1963) describes an actual safety program for senior citizens conducted in Ontario. The program utilizes instruction, entertainment, posters, manuals, and pamphlets.

Wiener (1968), while discussing the problems of the elderly pedestrian in great detail, cautioned that there is little empirical evidence to substantiate the value of either education programs or judicial sanctions in reducing accident rates for the

elderly pedestrian. Wiener describes a study of these pedestrians in which the dependent variables were measures of pedestrian behavior, principally the percentage of legal and illegal street crossings. He states: "The relationship between conformity to walking regulations and pedestrian accidents is unknown. However, case studies of pedestrian accidents and police accident reports indicate, at least tentatively, what enforcement authorities may tend to take definitively, that pedestrian accidents generally result from unsafe and illegal walking behavior. . . . Therefore, it seemed reasonable in the conduct of this study and its interpretation to assume that since one cannot directly reduce pedestrian injuries, he can approach the problem as a suboptimization by attempting to increase obedience to pedestrian traffic laws. But again the reader is cautioned that the correlation between behavioral conformity and accident frequency is far from obvious."

Wiener (1968) observed the percentage of legal and illegal crossings made by elderly pedestrians at selected corners in Miami Beach, Florida, before, during, and after a heavily publicized anti-jaywalking campaign. The results show that in the target area there was a dramatic increase in legal crossings during the campaign, but four months after the campaign the percentage of legal crossings was the same as before the campaign, unless a police officer was present on the corner. After the campaign, the percentage of legal crossings was 50 percent higher when a policeman was present than when he was not, but it was still below the during-campaign level. Interviews revealed that elderly pedestrians are often confused about traffic control and base their judgments when to cross on the movement of automobiles rather than on traffic signals. The interviews also indicated a favorable attitude among the pedestrians toward anti-jaywalking law enforcement.

#### 4. OTHER FACTORS WHICH INFLUENCE PEDESTRIAN ACCIDENTS

##### 4.1. BLINDNESS - A HUMAN FACTOR

The problems of the blind present special considerations for traffic safety. "White-cane" laws were considered by

Rodgers and Voorhees (1961) and the editor of New Outlook for the Blind (1961). The Rodgers article reviews the existing white-cane laws and the philosophy behind them. This philosophy includes the assumptions that: (1) the white cane makes the individual visible to the motorist and therefore safe; (2) all motorists are aware of white-cane laws; and (3) blind persons cannot take even limited responsibility for their own safety. The authors advise that white-cane laws be discontinued, as they are not really useful and tend to encourage the classification of the blind as a helpless group. Instead, blind persons should be given thorough safety training, and the most practical, easily distinguishable canes possible. The editorial in New Outlook for the Blind (1961) stressed that white-cane laws vary widely from state to state. The author suggested that these laws should be reviewed, and that better training be given blind pedestrians. Special engineering for the blind in Israel is described by Zahavi (1963); the blind person activates a traffic signal by inserting a key into a control box. He is then given a go signal by a bell which rings for 20 seconds. This signal has proven successful.

#### 4.2. NIGHT AND WINTER WALKING

The two main topics relevant to night walking deal with reflective clothing and adequate street lighting. The magazine School Safety (1965) discusses elementary safety rules for school children, especially those relating to night walking, and factors affecting visibility in darkness and twilight. Yaksich (1964) reports that 54 percent of all pedestrian fatalities occurred during hours of darkness. More women were killed during the day, and more men were killed at night. Several articles discuss various protective devices that pedestrians can wear at night. International Road Safety and Traffic Review (1963) discusses nighttime protection of pedestrians on country or other

unlit roads. The article reports on a study conducted in Ansbach, Germany, in which various protective devices were worn by pedestrians. It concludes that special apparel is essential, and that the pedestrian is quite receptive to this type of protection. Until legislation is effected, a large-scale educational program must be implemented to acquaint the pedestrian with the dangers involved in walking on country roads at night. Reflectorized warning markers should be made to seem fashionable so that people will buy them. Eventually, the article states, legislation must be passed requiring all pedestrians to purchase an effective protective or warning device to be worn when walking on country roads, or other dark roads, at night.

Thorsen (1958) discusses night traffic accidents and protection in Sweden. Almost one-third of all traffic accidents in Sweden occur during the hours of darkness. One reason for this is that from October to April there is an average of more than 12 hours of darkness each day. Since about 1950 the pedestrian population has been using such protecters as "Scotch-Lite," a reflective material. In 1952 the Swedish National Traffic Society carried out nighttime demonstrations of reflective materials in all Swedish provinces. Also, the road authorities increased the use of reflective materials for road delineation, traffic signs, and railway crossings. A government report issued in Sweden in 1955 clearly shows that pedestrians equipped with reflective material on their outer clothing are considerably easier to see than those wearing normal clothes. The importance of reflectorization is particularly significant when motorists drive with dipped lights. Police Chief (1948) describes the use of Scotch-Lite in Columbus, Ohio. A five-year old boy was struck by a car at night, and this incident started a campaign to protect children from the hazards of twilight and darkness. In "Operation Nite-Ray," over 15,000 youngsters were provided with strips of Scotch-Lite tape to be sewn on their jackets and coats. The article gives no statistics on the effectiveness of the campaign. Safety Maintenance and Production (1955) describes another reflec-

tive material. This is a new kind of yarn that looks like normal grey yarn, but which "lights up" at night when headlights illuminate it. Clothing made of this yarn has improved pedestrian visibility.

Hazlett and Allen (1968) describe an experiment investigating the effects of ethyl alcohol on the brightness difference threshold of eight male graduate students, ages 22 to 39. One phase of the investigation consisted of a series of road tests in which two of the original eight and two other students served as observers. The tests were designed to investigate the observers' ability to detect simulations of variously clothed pedestrians at night, and to study the effects of ethyl alcohol on this detection task. Pedestrians are difficult to see at night even under the best of viewing conditions. Alcohol is indicated as further interfering with the visual mechanism. Pedestrian-visibility distances could be increased and some of the losses of perception due to alcohol counteracted by increasing either the roadway illumination or the positive contrast of the pedestrian. In the tests, even a small amount of reflectorization was detected within sufficient stopping time by significantly intoxicated drivers.

Increased traffic lighting is also helpful to night drivers. Blythe (1956) describes the traffic lighting problem in Indiana. A five-point program for traffic safety is given, including various types of law enforcement, education, and engineering practices, especially highway lighting. International Road Safety and Traffic Review (1956) describes the need for adequate lighting, both by means of street lights and headlights. Controversy exists as to which types of lighting are most effective. Floodlighting pedestrian crossings does not seem to be effective, as such lighting is not necessary on a dry night and does not work on a wet night. This article quotes J. M. Waldham, who says: "On a dry night it [floodlighting] increases the conspicuousness of the crossing to both driver and pedestrian, but on a dry night good street lighting is adequate. On a wet night, owing to the reflecting properties of wet surfaces, it makes the crossing very clear and inviting to pedestrians, but far less effective in

revealing it to the driver. This is not a safe situation." The lighting problem is extremely important, because the accident rate is about three times higher during hours of darkness than during daylight for fatal and serious accidents.

Another traffic safety problem, discussed by the National Safety Council (1965) concerns winter walking. The Council advises slippery surfaces be eliminated by salting, etc. Also, care and proper personal conduct afford protection against slips and falls. About one-ninth of all pedestrian fatalities occur in December, particularly in the cities.

#### 4.3. INJURY DESCRIPTIONS

Another group of articles containing more technical descriptions of pedestrian injury has been studied. These articles discuss various types of injuries, and investigate the relationship between specific cars and types of injuries. McDougall (1960) describes a 12-month study on morbidity due to traffic accidents carried out at the Montreal Children's Hospital. Of 389 children involved, four-fifths were pedestrians and more than one-third of them were admitted to the hospital. There were two deaths, and two children sustained permanent disabilities. Head injuries, the most frequent cause of admission to the hospital, resulted in the two fatalities and one permanent disability. Most of the injured pedestrians admitted were boys. Traffic accidents accounted for about one-tenth of all the traumatic cases treated at the Montreal Children's Hospital.

Alexander, Myers, and Davis (1961) discuss a review of the English, German, French, Dutch, and Italian literature on "run-over" cases. Eleven cases are presented with illustrations. They maintain that in some instances the head, even of a small child, may be run over by a slowly moving wheel of a modern automobile, leaving tire tread marks, but causing only relatively minor permanent damage. When the thorax or abdomen is similarly compressed, congestion of the small vessels of the head and neck may

result. The brain in such cases is usually spared. Solheim (1964) discusses a 10-year study of 168 pedestrians fatally injured in traffic accidents. Only one-fourth of the victims were women. Multiple injuries were common. On the average, each patient had 2.4 body areas seriously injured. Head injuries were the principal cause of death, but thorax-abdominal injuries were frequent and their importance is stressed. Aspiration of blood or gastric contents or both into the airways was common. Also, a thorough examination of the victim is considered necessary to exclude serious internal injuries. In this study, 20 percent of the injured pedestrians were found to be intoxicated, and 60 percent had initiated the chain of events that led to the accident.

Callahan (1966) reviews a study of pedestrian impact and injury sites conducted by Severy and Brink (1966) using experimental dummies. The study explores the relationships between the parts of the automobile causing an injury and types of injuries sustained. It is found that the size of the vehicle is not an important factor; rather, the relationship of the pedestrian's height to the car's profile largely determines the pedestrian's kinematics and injury. Ryan and McLean (1966) analyzed cases of pedestrian-automobile collisions collected in an on-the-spot survey of accidents in Adelaide, South Australia. They report that cars having conventional frontal shape have a different injury potential than cars having a sloping front, e.g., Volkswagens. The sites and patterns of fracture of the ribs, pelvis, and femur are related to the direction of the impact forces. Furthermore, they show how the shapes of fractures of the shaft of the tibia can be used to determine the pedestrian's orientation relative to the car at the time of impact. McCarroll (1962) discusses a similar, intensive, multidisciplinary investigation of 200 fatal pedestrian accidents, which indicates that the pedestrian, in most cases, bore much of the responsibility for the accident in which he was killed. Although multiple injuries were common, many serious lesions were not recognized before death and were discovered only at autopsy. Correlations of these occult

injuries with more easily recognized lesions are presented, and the importance of certain diagnostic signs is stressed.

More recently a study of 286 fatal accidents that occurred in Wayne County, Michigan, which includes the city of Detroit, was completed by Huelke and Davis (1969). The study includes descriptions of the sites of the collisions, reports of the medical examiner's office, police accident reports, and all available photographs. An analysis of the factors related to these fatalities is presented including the pedestrian actions and characteristics, physical factors, drug involvement, and injury pattern. In these victims 55 percent suffered fatal head injuries probably caused when the pedestrian struck the road, rather than directly by impact with the structure of the vehicle. The neck, thorax, abdomen, and pelvis were other principal injury sites, with the latter two much less frequent than the former. Vehicle front-end form was not considered an important area for potential reduction of pedestrian fatalities. However, this may not be true of non fatal injury accidents, which were not studied by these authors.

The analysis also reveals that in many instances the striking vehicle was traveling on a straight road, in clear weather conditions, at night, at less than 40 mph. Under such conditions, with headlights on, an alert driver should be able to see a pedestrian in time to stop. Furthermore many of the pedestrians struck were crossing with the signal. At night pedestrians should be made more conspicuous to arouse the inattentive driver. This could be accomplished through better vehicle and fixed lighting, reflective clothing, pedestrian and pedestrian-crossing alerting devices, and other appropriate means.

## 5. PEDESTRIAN TRAFFIC SAFETY--THE PRACTICAL ASPECTS

### 5.1. SAFETY PLANS AND CAMPAIGNS

5.1.1. GENERAL SAFETY PLANS. Cities have dealt with their pedestrian safety problems in various ways. Many safety campaigns rely on a combination of publicity and stricter law enforcement



aimed at making the pedestrian and the driver each more aware of the potential dangers facing him, and of the proper methods for dealing with these dangers. Controversy exists over the best kind of jaywalking laws. Some cities have established safety schools that are mandatory for traffic-law violators.

One method of education is through safety magazines. For example, Traffic Safety (1957) provides an article which serves as a warning and an educational service to pedestrians. It states traffic regulations and common-sense pointers for both pedestrians and drivers, as well as accident statistics. Other articles discuss various safety programs. Traffic Safety (1958) outlines the AAA's six-point program to reduce pedestrian deaths by 50 percent. The program includes a comprehensive study of accident locations leading to engineering improvements and better education, publicity, and lighting. In a similar article discussing the AAA's plan, Automotive News (1958) lists the following as major needs outlined by the AAA's program: engineering changes; public education; better street lighting; better education for the age extremes; a review of local pedestrian ordinances; impartial enforcement of pedestrian regulations; cooperation of press, radio, and TV; wider use of adult crossing guards; and school safety patrols.

Sielski (1964) discusses a longer range AAA safety campaign, which recognizes that most traffic laws and legislation have dealt with the motorist, not the pedestrian. For example, in 1935, when 40 percent of all traffic fatalities were pedestrians, the AAA took the initiative in trying to reduce the growing pedestrian fatality rate. Following widespread efforts, pedestrian deaths in 1963 decreased by 47 percent, to 8,200 in comparison with 15,500 in 1937. However, during the same period all other traffic fatalities increased 47 percent, which might indicate that although the higher fatality rate had shifted from pedestrians to drivers, the overall picture did not improve. Also, the shift may have been correlated with other factors, such as a decrease in the number of pedestrians and an increase in the num-

ber of drivers, and may not have resulted from the AAA campaign. In recent years the trend toward reduced pedestrian deaths has leveled off and now the rate seems to be rising again. Sielski recommends more work on pedestrian safety, especially in the areas of protection and law enforcement. Gleason (1954) reiterates many points about pedestrian safety. He advises communities to establish councils composed of representatives from various local groups to set safety standards and policies. He also advises use of the public media, as well as patrols organized by the schools. His main point is that people must be kept aware of pedestrian and traffic safety.

5.1.2. SPECIFIC TRAFFIC SAFETY PLANS. Davin (1952) describes the 1952 Citizen Traffic Safety Board's public education program in Chicago, which emphasized newspaper publicity, a "Watch it on Western Street" program, billboards, T.V. and radio spots, etc. Trumble (1959) describes traffic safety programs in various cities. Generally they combine education with law enforcement. Todhunter (1958) discusses pedestrian safety programs in Norfolk, Virginia, where the main concern was for school children, and in Sacramento, California, where transient laborers, who were frequently drunk on weekends, resulted in a pedestrian safety problem. The former problem was solved by a combination of education, enforcement, and engineering. The latter was controlled by having a special squad car take protective custody of drunks.

Kretchmar (1965) describes a very comprehensive traffic safety program in Seattle, using Pedestrian Traffic Regulation (limited jaywalking) that allows pedestrians to cross against the light if they judge such action to be safe. A mandatory pedestrian safety school for violators, a large program of public safety education, and a school patrol were also used.

An article in Traffic Safety (1957) describes a pedestrian campaign in Oakland, California, and contends that those charged with pedestrian education are not succeeding. Gwin (1955) de-

scribes the J. C. Penney Company's efforts to promote safety consciousness through various programs in several different towns. The basic program, a "Back to School" safety campaign, was quite widespread. It used the "Stop and Go" twins, publicized by every medium, a motion picture film, posters, car cards, outdoor ads, safety badges, and store window and counter displays. The article states that the project helped decrease accidents among school-aged youngsters throughout the country; however, no statistics were given supporting this statement. McInerney (1959) describes the 1957 New York City Pedestrian Safety Campaign, which included an antijaywalking ordinance (violation of which resulted in a \$2.00 fine) and a great deal of publicity, such as safety rallies and pamphlet distributions. This program was necessitated by New York's high pedestrian death rate in previous years, due, in part, to the fact that many people were too ready to accept stop lights as the sole solution to the problem. Lashley (1965) describes a pedestrian safety campaign started by the AAA in Washington, D. C. In 1964, the upward trend in pedestrian deaths was checked, so that only about half the predicted number were killed. The safety program included enforcement and revision of pedestrian regulations, and a pedestrian traffic school for violators.

## 5.2. ENGINEERING: INTERSECTIONS AND CONTROL DEVICES

Much of the literature deals with the problems of intersections. Most writers agree that the only perfect safety plan is one that completely separates the pedestrian and the automobile in either space or time. Several authors describe and discuss subways and overhead bridges, which serve to separate pedestrians and automobiles in space, but often are impractical. Because complete separation in space is usually impossible, we must use devices to separate the two in time (Howie, 1954).

A general discussion of various types of crossings is provided by Duff (1963). The discussion includes zebra crossings, signalled crossings, pedestrian control, subways and foot-bridges,

and pedestrian precincts and walkways. The article also contains a good discussion of the Panda crossing. This crossing is essentially the same as the five-phased intersection signal system discussed later.

5.2.1. THE PEDESTRIAN BRIDGE. Moore (1956) discusses some psychological factors important in pedestrian traffic engineering. He stresses the traffic engineer's need to have a fuller understanding of human abilities and limitations. Pedestrian use of subways and bridges, and the information required to plan these safe facilities so that they are sure to be used are also discussed. Some pedestrian bridges have already been installed, and Ramos and Travel (1949) describe one over Quezon Boulevard in Manila, Philippines. The bridge was successful on both financial and practical traffic levels probably because of its advantageous location and heavy pedestrian and traffic volumes. Elliott (1962) describes California's unsuccessful attempts to build pedestrian overcrossings from which children cannot fall or throw things. The railings were most problematic because they needed to be constructed so that children will not be able to crawl through the openings or over the top. [Elliott appears to have been upset about the failure of these projects, and in his article stated several times that the children must be severely punished in order to build their characters.]

American City (1966) reports the success of a pre-engineered, prefabricated bridge erected across a dangerously busy crossing used by most of the students in Mattleson, Illinois. In Metropolitan Transportation (1962), Donald Stephenson shows a more comprehensive traffic plan involving the use of walkways over intersections.

5.2.2. TRAFFIC LIGHTS--THE PHASING PROBLEM. Usually it is impossible or impractical to use pedestrian bridges at intersections, and other methods of intersection control must be discovered and employed. Duff (1963) discusses the several ways of arranging

priorities between pedestrians and motorists. At many intersections the pedestrian crosses with the signal, and cars are expected to defer to him before they turn. However, as traffic becomes heavier, more intricate arrangements must be made, including different phases and signals.

Rudden (1959) points out the confusion concerning different intersection signals. His article is an attempt to classify and designate different systems of control, which are described as follows:

(a) Concurrent Pedestrian Phase. Pedestrian signals display a "walk" indication separately for each direction (i.e., north-south "walk" and east-west "wait"). For a given direction, the green indication for vehicle traffic and the "walk" indication for pedestrian traffic are displayed simultaneously during the first portion of the phase. During this green-signal display, vehicles are permitted to turn into the crosswalk at the same time that pedestrians are permitted to walk.

(b) Exclusive Pedestrian Phase (Scramble). At a given intersection, pedestrian signals display a "walk" only after all vehicle signals display a "red." "Walk" is indicated for all crosswalks simultaneously, and during this phase pedestrians may cross in any direction.

(c) Clear Pedestrian Interval. At a given intersection, vehicles are restricted from turning into a parallel crosswalk by means of straight-through green arrows displayed during that portion of the phase when the crosswalk is assigned to pedestrians.

In a similar article, Gove (1958) defines and discusses the same systems of pedestrian signals. After discussing various problems the author suggests that information on how the cities actually use these signals be gathered, and that warrants or guidelines be established.

Some controversy exists concerning the "scramble system," which provides a completely separate interval for pedestrian movement across the street in any direction. Shoaf (1955) describes the scramble system as it was used in San Francisco.

The results of a study released on 7 May 1954 show that, for the test area, the average travel time for all motorists using the system increased an average of 48.4 percent. Furthermore, Shoaf concludes that only about 25 percent of pedestrians cross diagonally at corners where scramble is in effect, and it is doubtful that pedestrians save any time. He maintains that the 75 percent who cross the street at right angles actually lose time. From a pure traffic-oriented viewpoint, scramble does not make better use of existing streets. Also, the traffic congestion caused by scramble can be expected to result in losses to the businessmen of the area. Marconi (1959) also discusses the failure of the scramble system in San Francisco. The removal of the system resulted in a 24 percent increase in traffic speed. Ilgner (1954) discusses the discontinuation of scramble in downtown Milwaukee. During this time, nine pedestrian accidents occurred, as contrasted with 17 accidents at these four intersections during the same period the previous year. However, rear end collisions increased from eight in 1952 to 17 in 1953.

Bruening (1957) describes four intersections in Milwaukee, using the share-the-phase system. To avoid conflict between right-turning traffic and pedestrians, each has its own phase. This system, Bruening claims, has none of the disrupting effects of the scramble system. Pedestrians receive 15 percent more crossing time free of vehicular interference than with scramble. Traffic Engineering and Control (1961) discusses another intersection-signal system which is five-phased. The crossing is marked with a white cross.

The phases are:

(1) With no pedestrian demand for right-of-way, all signal lights are extinguished.

(2) As soon as a pedestrian depresses the button, a pulsating amber signal is shown to road traffic and the "wait" indicator on the push button unit is illuminated.

(3) After a preset period (three to seven seconds) the amber and "wait" signals are extinguished; vehicular traffic now

receives the pulsating red signal and must stop. At the same time pedestrians receive the white "cross" signal, and they may cross.

(4) After a preset period (three to seven seconds), the pulsating red signal is extinguished and vehicular traffic receives a flashing amber signal. At the same time, the white "cross" signal commences to flash at the rate of 90 flashes per minute. During this period pedestrians on the crossings still have right-of-way but motorists may proceed if the crossing is clear.

(5) After a preset period (three to 13 seconds), the rate of flashing is increased to 180 per minute to indicate that the pedestrian right-of-way is nearly ended. This increased rate of flashing continues for five seconds.

All signals are now extinguished for a preset period (20 to 65 seconds). This is known as the vehicle-precedence period, during which vehicles have the right-of-way and any pedestrian demand is stored until the end of the period. This ensures that during heavy pedestrian traffic the vehicles will be allowed to clear. Operation of the pedestrian push button during the vehicle precedence period causes the "wait" indicator to be illuminated. At the expiration of this period, the cycle of operation described above begins again if there has been any pedestrian demand. The five-phase signal may seem unnecessarily complicated, but the author feels that motorists and pedestrians could quickly learn to distinguish the cycles.

Another variation on the intersection signal is described in Roads and Road Construction (1956). Pedestrians signal their wish to cross by pushing a button, and get a "cross" or "wait" sign. Drivers, once obtaining the green light, would not have to stop again before leaving the system, which extends for 650 yards. Two separate plans have been devised, one for heavy and one for light traffic.

5.2.3. TRAFFIC LIGHTS - NEW DESIGNS. Another frequently discussed traffic problem is that of designing the most effective

automatic traffic signal. Hoffman (1958) discusses Hammond, Indiana's change from "walk/don't walk" signs to "leave curb/don't leave curb" signs. The following reasons for the change are given: (1) The new sign controls the pedestrian before he enters the street; (2) it eliminates gutter-standing; (3) it does not say anything to pedestrians who have already left the curb; (4) it can be incorporated into any existing system. Wiley (1953) describes New York City's new "walk/don't walk" signals, which flash white and amber instead of green. Fowler (1949) discusses the problem arising from the conflict between the driver's need to use the vehicular red-amber-green lights for guidance and his desire to make the same signals invisible to the pedestrian when "walk/don't walk" signs are installed. A highly developed "walk/wait" signal, which increased pedestrian observation of signals by at least 50 percent, was installed in Portland and in other cities in Oregon.

Mackie and Jacobs (1965) compare the behavior of drivers shown the steady amber signal at traffic signal-controlled crossings, and the pulsating amber light at panda crossings. According to law, drivers must stop when these signals appear unless they are too close to the crossing to do so. An attempt was made to discover whether there was any difference between the two types of crossings in the proportions of drivers beginning to stop at various distances from the intersections. The proportion of drivers who did not obey the red signal was also considered. The results indicated poorer driver behavior at panda crossings than at light-controlled crossings.

5.2.4. RADIO SIGNALS. A more novel approach to intersection signals developed by Ford Motor Company and similarly by General Motors Corporation (Hanysz, 1960) appears in Better Homes and Gardens (1965). This article describes the radio road alert system, which serves to replace road signs with sound. The



system consists of two small units, one of which ties into any transistorized auto radio, the other of which is buried underground or mounted on a road sign, utility pole, or building. The receiver in the car contains an end-loop magnetic tape which can hold up to 100 prerecorded messages. The transmitter unit is mounted along the roadway, and when a car containing a receiver approaches an area requiring special attention, the signal from the transmitter triggers the receiver. The receiver selects the proper message, turns the radio on, and delivers the voice message three times. If the radio is on already, the program is interrupted. The author believes that the system could be in effect within a few years.

Another "talking" signal was described in American City (1960). The signal, which was demonstrated at 5th Avenue and 42nd Street, New York city, activates a message interpreting the visual "walk" and "don't walk" signs.

5.2.5. THE ZEBRA-STRIPED CROSSING. Many authors discuss the pros and cons of zebra-striped crossings. In an article by Mackie (1962) an attempt was made to discover whether the risk of crossing on and off the stripings, but within 50 yards of them. Data secured from the 21 available crossing sites indicated that the risk of injury to a pedestrian who uses the striped crossing is significantly less than the risk he runs crossing within 50 yards of it. Moore (1953), reviewing a study of pedestrian judgment in crossing streets and of the effects of zebra crossing, reports that the proportion of pedestrians using the crossings was greater after zebra-striping was employed. The Surveyor and Municipal and County Engineer (1950) reviews two aspects of a National Safety Week held in England in April 1949. It was directed towards the behavior of road-users at pedestrian crossings, as influenced by zebra markings and propaganda. The experimenters conclude that the propaganda influenced pedestrians and drivers

to pay attention at crossings, especially at zebra crossings. Garwood and Moore (1962) reported a study, conducted in London from 1952 to 1962, in which the pedestrian casualty rate dropped by 7 percent following the installation of zebra crossings, combined with a public information program.

Another article in Surveyor and Municipal and County Engineer (1949) also reviews studies of the relative effectiveness of zebra crossings, and concludes that zebra markings are superior to either raised crossings or steel studs. In another edition of the same magazine, Jacobs (1965) gives a more detailed account of studies of zebra crossings. His conclusions are as follows: (1) There was a slight reduction in the delay to pedestrians wishing to cross the road in the immediate vicinity of the crossing, while on the crossing itself there was a slight increase. (2) The time taken by pedestrians to walk across the road on or near the crossing did not change significantly. (3) The crossing attracted 70 percent of the pedestrians from a length of road about 200 yards long to the vicinity of the crossing. Within 50 yards of the site, about 90 percent of the pedestrians used the crossing. (4) After the installation of the crossing, there was a reduction in vehicle speeds which can be partly explained by an increase in pedestrian and traffic flows.

One of the problems of zebra crossings involves the materials used for the markings. Roads and Road Construction (1949) notes the markings of nearly 1000 zebra crossings with white plastic strips, which had worn well after four months of wear. Another article in Roads and Road Construction (1953) describes the use of white, or white and black, ceramic blocks to mark the crossings. The surface of each block was studded

to eliminate skidding, and the sides of each were glazed to reflect overhead light toward oncoming traffic. Hayward and Peters (1954) describe the four materials most commonly used for zebra crossings: white plastic, white mastic asphalt, white bituminous macadam, and white concrete. White mastic asphalt seems to have the longest life, at least five years. Peters and Francis (1954) discuss the techniques adopted for laying two types of zebra crossings, white concrete stripes cast in situ with black stripes of mastic asphalt, and white and black stripes formed with precast concrete blocks. Both were quite effective. Street Engineering (March 1957) describes a new compound, "Perma-line," which is used instead of the older, short-lived type of street marking material. Perma-line showed only slight evidence of wear when examined after 18 months of use.

5.2.6. THE RUMBLE STRIP, AND OTHER INNOVATIONS. One innovation, seemingly quite practical, is the rumble strip. Both MacDonald (1964) and Mortimer (1965) discuss this device, which consists of a rock-and-plastic strip that sends sounds and vibration warnings through the frame of an automobile as it passes over patches of the material placed ahead of danger spots in the road. Mortimer (1965) discusses the effectiveness of the strips as used in approaches to intersection stop signs. At some intersections stop sign violations were as high as 62 percent; county-wide, the figure was 20 percent. With a rumble strip placed 100 yards from the stop sign, the car receives a slight jolt, followed by a gentle rocking motion and an audible rumble. After installation of the rumble strip there were, at some check points, no instances of complete disobedience. Every driver either completely stopped or reduced his speed to a rolling stop.

Storey (1954) described a Michigan City, Indiana, program in which crosswalks were painted green to discourage jaywalking

and keep drivers from stopping on the crosswalk; this system, which seemed successful, was tied in with green lights and the slogan "walk on the green." Another unusual device was described in American City (February 1966). A 1600-square-foot crosswalk installed in the heart of a Boston shopping district serves to remind pedestrians of the anti-jaywalking law. Only within the huge crosswalk can persons cross diagonally.

Another, quite different viewpoint is expressed by Roer (1961). He comments on the pedestrian in metropolitan Toronto, taking the position that pedestrians are not helped by heavily marked crossovers but, on the contrary, are given a false sense of security. The pedestrian and the motorist both seem uncertain about their rights when crossovers are present. To make pedestrian crossovers safer, he maintains, strict parking and stopping prohibitions should be applied and enforced.

Finch and Howard (1958) describe a unique study pertaining to an important, but little-discussed, problem of advertising signs in close proximity to traffic signals, of similar colors, creating confusion between signals and signs. An instrument designed to compare the colors of distracting lights with established color limits is discussed. Confusion of sign colors with traffic signal colors can be a real problem in city driving, and requires further study so that practical limits can be established to avoid the distractions that now exist without undue restriction on commercial signs.

5.2.7. THE EFFECTIVENESS OF MARKED CROSSWALKS. Marvin (1951) discusses the effect of marked crosswalks and stoplines on where a car will stop. No pedestrians were crossing during these studies. The studies show that during the day, at unmarked signalized intersections, the vehicles' mean stopping distance from the near curbline can be expressed as two-thirds of the street width minus nine feet. At night, motorists tend to stop three feet farther back. The width of the stopline was varied for the study and a 9-inch width recommended.

In a more recent article Mortimer and Nagamachi (1969) show that fewer vehicles stop on the pedestrian crosswalk when the road is marked with a stop line in front of the crosswalk than when it is marked with a crosswalk only or by the end of the center line. Such a marking can, therefore, be used to advantage in keeping the crosswalk relatively free of vehicles at traffic-signal-controlled intersections and thus permits improved pedestrian flow on the crosswalk.

The Pedestrian and School Safety Division (April 1964) of the AAA provides a fact sheet entitled, How To Obtain Orderly Movement of Pedestrian Traffic at Intersections Through Channelization by Means of Painted-Lines with the measurements and a diagram of various traffic lines.

### 5.3. PEDESTRIAN RISK-TAKING BEHAVIOR

5.3.1. THE JAYWALKING CONTROVERSY. Many traffic safety programs place their heaviest emphasis on enforcement or revision of jaywalking laws. Hayes (1961) describes a traffic safety program in Lansing, Michigan. The author feels that pedestrians should be controlled at least as much as motorists; he discusses the enforcement of pedestrian laws, pedestrian signals, pedestrian crossings, and education in the schools. Denham (1957) describes a traffic-law enforcement program which started in Miami on January 2, 1957. This program enforced the law requiring pedestrians to cross at crosswalks. Traffic accidents involving pedestrians decreased 19 percent within the following four-month period. Griffin (1959) describes the strict enforcement of pedestrian traffic laws in Detroit, and the drop in the pedestrian accident rates which seemed to be connected with this enforcement. Other factors contributing to the lower accident rate were a vigorous policy of law enforcement against all other traffic law violators, a sound engineering program, and an intensive educational effort. In the

early 1940's, Detroit pedestrian deaths annually accounted for 70 percent of traffic deaths; in 1958, they accounted for 52 percent of all traffic deaths. Also in the early 1940's, injuries to pedestrians accounted for 35.5 percent of the total traffic injuries. In 1958, pedestrian injuries were 17 percent of the total. The principal method of enforcing pedestrian traffic laws is by issuing \$2.00 tickets to violators. Essentially the law demands caution in crossing the street; crossing is permitted both at corners and in the middle of the block, and in the latter case is known as limited jaywalking. George Edwards, one of Detroit's councilmen at the time, insisted upon a legal clause to help protect the pedestrian against careless, reckless, and speeding drivers. While the clause made it a violation for a pedestrian "while crossing the street at a point other than a crosswalk to step suddenly, run or jump into the path of a moving motor vehicle...when [it] is so close as to constitute a hazard," it also stated that "the foregoing provision does not relieve the motorist of his responsibility to drive carefully," Griffin (1959) believed the reduction in pedestrian deaths and injuries showed that the anti-jaywalking campaign had been quite effective. Clearly this conclusion would require substantiation.

Traffic Safety (April 1959) describes a section of New Jersey's Public Opinion Poll on Traffic Safety entitled "The Driver Looks at the Pedestrian." One question was, "How do you feel about the enforcement of pedestrian regulations?" The drivers' answers varied as follows:

1. Pedestrians should be ticketed for violation: 49%
2. Pedestrians should be educated, not arrested: 27%
3. Pedestrians should be left alone: 2%
4. The law requiring drivers to yield to pedestrians at crosswalks should be enforced: 20%
5. No opinion: 2%

Traffic Safety (Sept. 1959) also describes a mandatory traffic safety session for jaywalkers in Elmira, New York. The effectiveness of the program may be reflected in the town's accident record for 1957 and 1958, although the statistical significance of this record is questionable. During this two-year period there were no pedestrian fatalities in Elmira, although four had occurred in 1956.

5.3.2. STUDIES OF RISK-TAKING. Several studies have been made of the risk involved in crossing at various corners. Mackie and Older (1965) discuss a study of seven streets in London, England, which found that more women (60 percent) than men (56 percent), aged 16-60, cross on the crossings; children have the best crossing behavior; the areas of high risk are the sections within 50 yards of the crossing facilities, especially if they were also near intersections. Sections within 50 yards of light-controlled crossings are more dangerous than those near zebra crossings, and the highest risk of all is within 50 yards of light-controlled crossings which are within 20 yards of junctions. The safest place to cross appears to be at pedestrian crossings. The peak danger zone is adjacent to the crossing itself. The article also gives more detailed information on risk. Jacobs and Wilson (1967) discuss a study which reaches basically the same conclusions as the previous study. The emphasis is on pedestrian risk near intersections, especially within 50 yards of a crossing. The risk is lowest, but not significantly so, on the crossings. Both on and off crossings, risk is greater near intersections.

5.3.3. STREET CROSSING TIME. A great deal of research has been done on the subject of pedestrian street-crossing time. How, for example, does the pedestrian judge when it is safe to cross the road? How does the traffic engineer help ensure that the pedestrian will have ample time to cross?

Hollich (1968) describes a situation in Chicago in which pedestrians did not have enough time to cross the street entirely. The problem was solved by the installation of a center refuge. Moore (1953) says that pedestrian decisions to cross a road are based on the distance and speed of an approaching vehicle, i.e., it is a calculation of how long it will take the automobile to reach the pedestrian. Cohen, Dearnaley, and Hansel (1955) report on road-crossing behavior against one-way, moderately heavy traffic. The speed and distance of the oncoming vehicle were calculated in seconds from the time the person stepped to the edge of the road and looked toward the oncoming traffic to the moment when the vehicle reached the crossing site. When the vehicle was 4.5 seconds away, 50 percent of the people who could cross did so. No one crossed when the vehicle was less than 1.5 seconds away, and everyone crossed when the vehicle was more than 10.5 seconds away. Road Research Laboratory devoted a chapter of Research on Road Traffic (1965) to the methods and results of studying pedestrian movements and behavior. Methods of measuring pedestrian speeds, delays, and density of groupings are discussed and consideration is given to the effect of various factors on these measures. An analysis is made of the factors likely to affect pedestrians in judging when it is safe to cross the road. Moore (1956) discusses the importance, from the traffic engineer's point of view, of obtaining a fuller understanding of human abilities and limitations. As an example of the sort of basic data which are useful, the results of an investigation into the time allowances required by pedestrians when crossing a traffic stream are given. Tanner (1951) carried out an analysis to determine the delay time incurred by the pedestrian in crossing a street and found a reasonable agreement with some empirical data.

A subsequent analysis by Weiss (1963) re-examined the



theory of pedestrian queuing, when freed from the restriction of a negative exponential gap distribution, and utilizes a continuous function, rather than a step function, distribution of gap acceptance probability.

Vuchic (1967) discussed the same problem from another angle. He showed that pedestrian crossing time may be an important factor limiting vehicular capacity at signalized crossings on undivided, multilane traffic arterials.

Garwood and Moore (1962) summarized the traffic safety situation as it exists at pedestrian crossings. They concluded the following:

- (1) Most pedestrians will use a subway or bridge only if it affords a quicker crossing than the ground-level route.
- (2) It is much safer to cross at a zebra crossing or traffic light, than outside but near to them.

An important goal of the research discussed in this section is to use the most effective equipment at specific intersections. Traffic Engineering (April 1962) has developed a tentative standard for the use of such equipment. The purpose of this three-part standard is to provide a guide for the preparation of minimum purchase specifications for pedestrian control signal heads. The standard represents the minimum requirements for the equipment described and is not intended to impose restrictions upon design of materials which conform to the purposes and intent of this standard.

#### 5.4. CITY PLANNING

The most effective approach to traffic safety is one which includes all of the approaches discussed. City planning, although it does not usually reach this ultimate goal, is the most comprehensive approach now considered in the literature. Many authors have suggested radically new types of city design, bringing to bear the results of much traffic research and

engineering knowhow. Backhouse (1959) discussed what people desire in a town, and how they can get what they desire. People want well-planned, safe, economic towns. Backhouse outlined the conditions in existing towns, emphasizing the intermixing of unrelated building uses, narrow streets and traffic congestion, lack of parking, poorly placed parking, etc. Backhouse suggested, as do most modern city planners, a town built on various levels. The ground level of the block is devoted to parking, loading zones, and lift shafts. Shops and offices are one or more stories above the ground-floor parking area. The block is surrounded by traffic-collecting roads, with pedestrian footpaths separated entirely from vehicular traffic. Backhouse also suggested a plan for an area in the transition stage between residential development and shopping zones and urban renewal schemes, and a plan for routing a new expressway through the second level of buildings. Both Dark (1962) and Holloch (1959) agreed that pedestrian and auto traffic must be on two separate levels.

International Road Safety and Traffic Review (1960) has an excellent article covering the general question of engineering and town planning for pedestrians. The urban pedestrian-vehicle problem must be eliminated so that the pedestrian can be safe. The author discussed Alker Triff, who first questioned our present city structure and made the first clear statement of the "precinct principle," whereby certain areas are set aside for pedestrian traffic only. Stuart (1968) also discussed the engineering phase of pedestrian planning.

Several cities have incorporated various facets of modern city planning into their own structure. Butler (1953) described a system in Denver consisting of: (1) restricted parking in the downtown area during peak hours, (2) a one-way street system, and (3) exclusive pedestrian signals at 31 intersections. Vehicle-pedestrian accidents were down from 48 in 1951 to 29 in

1952, perhaps partly due to these measures.

More recently some new towns (e.g., Columbia, Md.) had incorporated into their plans many of the ideas suggested by Backhouse (1959) and others, which eliminate the mixing of pedestrians and vehicles.

Various other considerations essential to road and town development have been discussed. Holford (1961) believes that roads should be developed to bypass outstanding (historic) villages and town centers before they are ruined by heavy traffic. He stresses that land use and economics, social and real estate values, and the design of landscape and utilities, are all important factors to consider if structural forms are to have meaning and purpose.

Faithfull (1959) has discussed ribbon, or roadside, developments as one of the serious problems of urban growth. Motor vehicular traffic and ribbon development have become almost independent because commercial developers wish to locate where traffic is thickest, and because traffic is generated by commercial land uses. Faithfull argues that to ensure traffic safety ribbon development must be controlled; certain areas must be only residential, others commercial. The roads must be developed to meet the needs of the surrounding property. An extremely comprehensive discussion of the past, present, and future relationships between the pedestrian and the city is to be found in Lewis (1966). The architecture of many cultures is discussed in detail to acquaint the reader with the philosophies and life-styles which determine the physical structures of various cities.

## 6. CONCLUSIONS

Much research has been done in all areas of pedestrian safety; more practical application of the conclusions of this research is necessary. Also, more research of a comprehensive

nature must be done which leads to total city plans instead of patchwork readjustments. A total city plan would consider the interests of both the driver and the pedestrian from several different aspects, as those of safety, practicality, and aesthetics.

## BIBLIOGRAPHY

- ' Alexander, E., Jr.; Myers, R.T.; and Davis, C.H., Jr.:  
Run-over (uberfahren) accidents. N. Carolina Med. J. 22  
(1961), 47-54.  
Eleven "run-over" cases are presented with illustrations.  
Head injuries in small children are discussed, as well as  
thorax and abdominal injuries.
- ' American Automobile Association: Manual on pedestrian safety.  
Washington, D.C. (1964).  
A general look at the pedestrian safety problem with discus-  
sions of pedestrian hazards, accident statistics, engineer-  
ing aids, legislation, education, etc.
- ' American Automobile Association: Older adult pedestrian  
safety. Pedestrian Safety Program Series No.1 (1965).  
A general look at the specific safety problems of the  
elderly pedestrian.
- ' American Automobile Association, Pedestrian and School Safety  
Division: How to obtain orderly movement of pedestrian  
traffic at intersections through channelization by means  
of painted lines. American Automobile Association,  
Washington, D.C. (April 22, 1964).  
A study of the measurement of various intersection lines.
- ' American Automobile Association: The young pedestrian.  
Pedestrian Safety Program Series No.3 (1965).  
A discussion of the many pedestrian accidents among young  
children, especially boys.
- ' American City 75, New York's walk--don't walk signs are learn-  
ing to talk. No.1 (1960), 107.  
A talking signal runs a message interpreting the visual  
walk and don't walk signs.
- ' American City 81, Huge crosswalk stresses pedestrian safety.  
No.2 (1966), 122.  
Description of a 1600-foot crosswalk which was installed in  
the heart of a Boston shopping district.
- ' American City 81, Street construction and maintenance. No.6  
(1966), 37.  
A prefabricated bridge erected across a dangerous crossing is  
used by a majority of students at a certain elementary school.

- ' American Motorist 30, It's the early training that counts.  
No.8 (1961), 15.  
General description of Safety Towns for kindergarten aged children.
- ' Automotive News 32, AAA opens campaign on pedestrian deaths.  
No.366 (1958), 23.  
A description of a campaign to cut pedestrian deaths in half within five years.
- ' Backhouse, W.O.: Grade separation of pedestrian and vehicular traffic in town centers. International Road Safety and Traffic Review 7, No.3 (1959), 5-8, 10.  
Discussion of grade separation of pedestrian and vehicular traffic in town centers.
- ' Bartholomew, W.M.: Pedestrian accidents in service areas of selected city recreation facilities. Traffic Safety Research Review 11, No.4 (1967), 117-120.  
A study of accidents of 5- to 14-year-old pedestrians in the vicinity of recreational facilities, with a comparison of frequency and location of accidents before and after the dedication of the facilities.
- ' Batts, H.M.: Is present school crossing protection adequate? Institute of Traffic Engineers, Proceedings (1964).  
Paper No.3, 167-168.  
School controls are neither adequate nor uniform, and education must be age-graded.
- ' Better Homes and Gardens 43, Special report on a new safety concept. No.10 (1965), 40, 130, 139.  
Description of talking road signs.
- ' Brackette, E.M.; and Johnston, A.M.: Social patterns of road accidents to children: Some characteristics of vulnerable families. British Med. J. 1, No.5119 (1959), 409-413.  
A study of 101 families in which a healthy child has survived a road accident.
- ' Blythe, J.D.: Highway lighting and accidents in Indiana. HRB Bulletin No.146 (1956).  
Traffic lighting problems in Indiana.
- ' Bruening, M.E.: Share-the-phase pedestrian control. Traffic Digest and Review 5, No.9 (1957), 12-16.

Replacement of the "scramble" system with the "share-the-phase" system, in which pedestrians and right-turning cars share the same phase.

- ' Butler, E.L.: Denver's new traffic control system includes pedestrian separation period. Traffic Digest and Review 1, No.1 (1953), 16-18.

Description of town plan used in part of Denver which includes restricted parking during peak hours, a one-way street system in the area and an exclusive pedestrian phase at 31 intersections.

- ' Callahan, J.M.: Car-design guide sought....pedestrian accidents topic of safety study. Automotive News 40, No.4060 (1966), 8, 54.

A discussion of the parts of the car that cause injury to the pedestrian. It was stated that it is not the size of the car which is important, but the relationship between the pedestrian's height and the car's profile that determines injury.

- ' Carper, J.: They stop at corridor traffic signals. Safety Education 38, No.7 (Mar. 1959), 2-3.

Scaled-down traffic signals are used in school hallways.

- ' Chicago Traffic Safety Review, Children 5-9 in most danger. (Mar./Apr. 1962).

- ' Chicago Traffic Safety Review, Children pedestrian victims increase--other age groups down. (Mar./Apr. 1966).

- ' Cleveland, D.E.: Selected bibliography on traffic control for pedestrian safety. Highway Safety Research Institute, The University of Michigan (1969).

- ' Coffey, A.V.: Pittsfield meets Wandering Willy. Safety Education for September 37, No.1 (1957), 2-3.

A safety education program for elementary school children through a cartoon character in the local newspapers.

- ' Cohen, J.; Dearnaley, E.J.; and Hansel, C.E.M.: The risk taken in crossing a road. Operational Research Quarterly 6, No.2 (1955), 120-128.

A report on road-crossing behavior against one-way, moderately heavy traffic.

- ' Dark, J.W.: Raised footways in urban central areas. Traffic Engineering and Control 3, No.9 (1962), 553-556.

A description of the technical aspects of the development of a two-tier system having vehicles at the ground level, and pedestrian traffic only at a higher level.

- Davin, F.: Crusade for traffic safety. Public Safety 42, No.35 (1952), 4-6.  
A description of a safety campaign in Chicago carried on mainly through the mass media.
- Davis, L., Jr.: Is present school crossing protection adequate? Institute of Traffic Engineers, Proceedings (1964), Paper No.2, 166-167.  
A description of school traffic safety in Peoria. School boundaries are based on traffic flow, and both patrol boys and adult crossing guards are used.
- Denham, P.M.: Miami's pedestrian control program. Traffic Digest and Review 5, No.11 (1957), 1-3.  
A description of enforcement of the law requiring pedestrians to cross at crosswalks.
- Dier, R.D.: Determining the degree of hazard at school crossings. Traffic Engineering 25, No.4 (1955), 137-139, 153.  
An attempt to determine a safe gap in traffic for the purpose of crossing.
- Dodds, T.: We might as well print our school warnings in Japanese. Safety Education 44, No.3 (1964), 8-10.  
A plea for standardized traffic signs near the school crossing based on the theory that motorists are more likely to obey familiar signs.
- Duff, J.T.: Mutual obligations of turning traffic and pedestrians at signal controlled intersections and appropriate indication thereof. International Road Safety and Traffic Review 11, No.2 (1963), 9-10, 12, 14, 17, 48.  
Papers submitted by 18 countries concerning the problem of the mutual obligations of turning traffic and pedestrians at signal controlled intersections.
- Dunivan, R.E.: Is present school crossing protection adequate? Institute of Traffic Engineers, Proceedings (1964), Paper No.1, 162-166.  
What happens when school zones are replaced with signalized school crossings.
- Elliot, A.L.: Kidproof railings: Safety offers challenge on pedestrian crossings. California Highways and Public Works 41, No.9-10 (1962), 19-23.  
An attempt to develop safe pedestrian over-crossings off of which children cannot fall or throw things.



- Faithfull, W.G.: Ribbon development in Australia. Traffic Quarterly 13, No.1 (1959), 34-54.

A discussion of roadside development as one of the serious problems of urban growth.
- Family Safety, Back to School. (Fall 1962), 14-15.

A discussion of safety rules for children.
- Finch, D.M.; and Howard, J.H.: A color comparator for lights in the vicinity of traffic signals. HRB Bulletin No. 191 (1958), 1-6.

Discusses the problem of advertising signs and lights which are close in color to traffic signals and describes an instrument which compares light colors.
- Ford Motor Co.: Radio Road Alert System. Automotive Safety Center, Dearborn, Michigan.
- Fowler, F.T.: Pedestrians observe these signals. American City 64, No.3 (1949), 135, 137.

A discussion of the necessity for making red, amber, and green signals visible to the driver but invisible to pedestrians when wait and walk signals are present.
- Garwood, F.; and Moore, R.L.: Pedestrian accidents. Medicine, Science and the Law, (Oct. 1962), 439-447.
- Garwood, F.; and Moore, R.L.: Pedestrian accidents. Traffic Engineering and Control 4, No.5 (Sept. 1962, 274-276, 279.

A survey of accidents at various types of traffic crossings is presented.
- Gleason, E.M.: A blueprint for community action on pedestrian safety. National Safety Council Transactions 28 (1954), 80-81.

Setting up a community safety program.
- Gonzales, T.A.; and Gettler, A.O.: Alcohol and the pedestrian in traffic accidents. J. Amer. Med Assoc. 117, No.18 (Nov. 1, 1941) 1523-1525.

Discussion of the influence of alcohol on pedestrian deaths.
- Gove, A.W.: Pedestrian signal warrants. Institute of Traffic Engineers, Proceedings (1958), 97-99.

A description of three different types of intersections: clear, mixed, and scramble.
- Griffin, G.M.: Walkers win in car capital. Traffic Safety 54, No.4 (April 1959), 6-10, 42-43.

Descriptions of a safety campaign in Detroit which included law enforcement and safety education.

- Gwin, J.: Penney's for safety. Public Safety for February 47, No.2 (1955), 4-6.  
A description of Penney's safety campaign.
- Haddon, W., Jr.: Prevention of accidents. Textbook of Preventive Medicine. Boston: Little, Brown (1966).  
This chapter discusses the proportion of accidents which happen to children, and whether this number is disproportionate to the number of children in the population. It also discussed the backgrounds of children injured in traffic accidents.
- Hanysz, E.A.: Highway Alert Radio. IRE Trans. 9, No.2 (1960).
- Harris, L.S.: Where should they cross? Safety Education for March 34, No.7 (1955), 8-12.  
The advisability of children crossing in front of a school bus is discussed.
- Hartman, J.F.; and Rankin, W.: How effective are school signs? Safety Education 41, No.6 (Feb. 1962), 20-21.  
A discussion of various types of school signs.
- Hayes, A.T.: Pedestrian control. Institute of Traffic Engineers, Proceedings (1961), 87-92.  
Pedestrian control in Lansing, Michigan, using pedestrian laws, signals, crossings, and education in the schools.
- Hayward, A.T.J.; and Peters, C.H.: Materials for marking striped pedestrian crossings. Surveyor and Municipal and County Engineer, London 113, No.3230 (1954), 87-91.  
A description of long-lasting material used for constructing zebra crossings.
- Hazlett, R.D.; and Allen, M.J.: The ability to see a pedestrian at night: The effects of clothing, reflectorization and driver intoxication. HRB Reprint (1968).  
A description of the effect of alcohol on a subject's ability to detect simulated pedestrians wearing various types of clothing at night. The effects of alcohol are somewhat counteracted by raising lighting and by wearing reflectorized clothing .
- Heustic, C.E.: Louisville's ladies in blue. Public Safety 37, No.6 (1950), 14-15, 32.  
A description of Louisville's system for protecting school children.
- Hoffman, L.: Hammond curbs pedestrians. Traffic Safety 52, No.3

(March 1958), 16-7

Discusses Hammond traffic safety techniques.

- ' Holford, W.: A question of priorities. Traffic Engineering and Control 3, No.1 (May 1961), 30-32.

Several points of view to be considered when planning a road.

- ' Hollich, G.F.: Intersection solution--center refuge gives pedestrians a better chance. Street Engineering 3, No.5 (May 1968), 20-22.

A description of a center refuge built on a wide street in Chicago to facilitate crossing.

- ' Hollich, G.: Why not a pedescalator system? Street Engineering 4, No.1 (Jan. 1959), 28-31.

Description of a plan of second story sidewalks, using escalators and ramps, as a means of doubling the traffic capacity of streets and sidewalks.

- ' Horst, J.: Accident sparks safe crossing drive. Safety Education 41, No.3 (Nov. 1961), 13.

Students improve an unsafe intersection.

- ' Howie, G.W.: Design for walking. National Safety Congress Transactions 28 (1954), 84-86.

Describes safety programs in various parts of the country.

- ' Illgner, H.F.: "All-way" pedestrian walks. Municipality 49, No.7 (July 1954), 153, 162.

Description of an all-way walk interval system at four intersections which resulted in a slight decrease in accidents.

- ' International Road Safety and Traffic Review, School safety patrols around the world. (Summer, 1955), 16-20.

School patrols seem to be an effective means of reducing accidents.

- ' International Road Safety and Traffic Review 4, Danger in the dark. No.1 (Winter, 1956), 5-9, 17.

This article describes the need for adequate lighting, by both street and headlights.

- ' International Road Safety and Traffic Review 8, Pedestrian segregation. No.1 (Winter, 1960), 7-8, 10-12, 14.

Discussion of the precinct principle, under which certain areas are used only for pedestrians.

- ' International Road Safety and Traffic Review 11, Protection of pedestrians at night. No.4 (Autumn, 1963), 38-43.

This article advises that reflective garments be made compulsory for pedestrians at night.

- ' Jacobs, G.D.: Effect of zebra crossing installations on pedestrians and vehicles. No.1: Yiewsley High Street. Surveyor and Municipal and County Engineers 126, No.3816. (July 24, 1965), 23-24, 27.

According to this article, zebra crossings seem successful, resulting in an increase in pedestrian and traffic flows, and a reduction in vehicle speeds.

- ' Jacobs, G.D.; and Wilson, D.G.: Study of pedestrian risk in crossing busy roads in four towns. Road Research Laboratory Report LR 106, (1967).

A comparative study of pedestrian risk at four intersections.

- ' Jeffcoate, G.O.: Relative accident rates for different types of vehicles involved in pedestrian accidents in built-up areas on weekdays. Road Research Lab. Note RN/3065, 1957.

- ' Jensen, L.L.; and Ruby, W.J.: Motor Vehicle Accident Data, Automotive Safety Research Office, Ford Motor Company (1968).

- ' J. of Amer. Insurance 39, Heaven help the child pedestrian! No.11 (Nov. 1963), 22-23.

Discusses statistics on child pedestrian accidents and various causes of and remedies for such accidents.

- ' J. of Amer. Insurance 42, Tiny town--great teacher. No.2 (Mar./Apr. 1966), 29-32.

A discussion of a traffic education system for children.

- ' Kalinoski, J.R.: Evaluation of school crossing warning signs. Portland Traffic Safety Commission, Engineering Committee (1964).

A study of vehicle speed at school crossings exhibiting various school crossing warning signs.

- ' Kowalski, J.M.; Rose, N.; and Fiorese, F.F.: Blood alcohol levels in vehicular and pedestrian fatalities in Illinois. Illinois Med. J. 131, No.5 (1967), 659-661.

Forty-two percent of the pedestrians studied had a measurable amount of alcohol in their blood. Thirty-two percent had blood alcohol levels of over 0.10 percent.

- ' Kralovec, D.W.: Coordinating transit safety with public schools. Transactions, National Safety Congress 26, (1954), 71-76.

A discussion of various aspects of school traffic safety.

- ' Kretchmar, A.A. Seattle promotes pedestrian safety. Traffic Digest and Review 13, No.6 (1965), 15-17.

A description of pedestrian safety regulations in Seattle, Washington, including limited jaywalking and a mandatory pedestrian safety school for traffic violators.

- Ladd, W.: You are an AP. Public Safety 46, No.3 (Sept. 1954), 16-17.

Categorization of various pedestrian faults.
- Lashley, G.T.: The aging pedestrian. Traffic Safety 57, No.2 (August 1960), 10-13.

A discussion of the problems of the elderly pedestrian.
- Lashley, G.T.(ed.): Remembering the forgotten man. American Motorist 34, No.1 (May 1965), 11-24.

A description of a pedestrian safety campaign in Washington, D.C. Existing pedestrian regulations were enforced by a pedestrian traffic school.
- Lewis, David: The pedestrian in the city. Princeton: D.Van Nostrand Company, Inc. (1966).

A compilation of reports on pedestrian-traffic segregation.
- Lindquist, G.C.: School crossing protection. National Safety Council 27 (1955), 116-120.

No traffic gimmick can completely protect a child. He must be educated to traffic safety.
- MacDonald, K.R.: Talking road warns of hazardous curve. Better Roads 31, No.4 (April 1964), 40.

A description of a rumble strip in Richmond, California.
- Mackie, A.M.: Accident risk to pedestrians on and within 50 yards of zebra crossings. Traffic Engineering and Control 4 No.8 (Dec. 1962), 448-450.

Risk to the pedestrian who uses the zebra crossing is significantly less than the risk to those who cross within 50 yards of it.
- Mackie, A.M.; and Jacobs, G.D.: Comparison of road user behavior at panda, zebra, and light controlled crossings. Traffic Engineering and Control 6, No.12 (1965), 714-718, 732.

Poorer driver behavior was found at panda than at light controlled crossings.
- Mackie, A.M.; and Older, J.J.: Study of pedestrian risk in crossing busy roads in London inner suburbs. Traffic Engineering and Control 7 (Oct. 1965), 376-380.

Statistics on pedestrians who used certain crossings in London are presented along with a description of the crossing areas of relative risk.
- Marconi, W.: Exit "scramble" in San Francisco. Traffic Engineering 29, No.4 (Jan. 1959), 20-24, 35.

A description of the shortcomings of the scramble system resulting in its discontinuation in San Francisco.
- Marks, H.: Child pedestrian safety: A realistic approach. Traffic Engineering 28, No.1 (Oct. 1957), 13-19, 25.

An analysis of 1,008 accidents involving child pedestrians.

- ' May, F.E.: Student pedestrian traffic signals vs. crossing guards. National Safety Council Transactions 23 (1964), 25-28.

The effectiveness of traffic signals as opposed to human crossing guards is discussed.

- ' Marvin, W.L.: Driver observance of crosswalk and stop lines. Traffic Engineering 21, No.5 (Feb. 1951), 157-159.

A description of the effect of marked crosswalks and stop lines on the point at which a car stops at the corner.

- ' McCarroll, J.R., et al.: Fatal pedestrian automotive accidents. J. Amer. Med. Assoc. 180, No.2 (April 14, 1962), 127-133.

A description of the injuries sustained in 200 fatal pedestrian accidents.

- ' McClosky, R.I.: Patrols slow down traffic. Safety Education 39, No.4 (Dec. 1959), 2-3.

A student project to alert school speed zone violators.

- ' McDougall, R.: Traffic accidents to children II. J. Canad. Med. Assoc. 82, No.2 (Jan. 9, 1960), 61-65.

A discussion of a study on child pedestrian deaths in Montreal.

- ' McInerney, T.J.: Pedestrian safety campaign in New York City. Traffic Quarterly 32, (April 1959), 283-293.

Description of a New York Safety campaign which publicized anti-jaywalking ordinance.

- ' McIntyre, R.J.: A description of a safety campaign for the protection of school children in Salinas, California. Safety Education 36, No.7 (March 1957).

- ' McLellan, E.M.: The lost art of walking. Traffic Safety 63, No.1 (July 1963), 20-21.

Discussion of an educational program for elderly pedestrians in Ontario.

- ' Metropolitan Transportation 58, Get rid of red lights. No.6 (July 1962), 30.

Discusses use of overpasses and one-way streets.

- ' Miller, E.D.; and Michael, H.L.: A study of school crossing protection. Traffic Safety Research Review 8, No.2 (June 1964), 51-56.

Evaluation of the effect of various types of school crossing protection.

- Mills, J.B.: Parents--play it safe--safeguard your child. California Parent Teachers 37, No.2 (Oct. 1960), 23.

A list of traffic safety rules for children.
- Moore, R.L.: Man and machines in transport systems. Operational Research Quarterly 4, No.1 (1953), 3-10.

A discussion of the pros and cons of various crossing devices such as subways and bridges, with consideration of the role of pedestrian judgment in crossing a street.
- Moore, R.L.: Psychological Factors of Importance in Traffic Engineering. International Study Week in Traffic Engineering, Stresa, Italy (Oct. 1-5, 1956), 1-3.

A study of the importance of human factors in traffic allowance used by the pedestrian in crossing the subways and bridges.
- Mortimer, R.G.; and Nagamachi, M.: Effects of roadway markings on vehicle stopping in pedestrian crosswalks. Rept. HuF-2, Highway Safety Research Institute, University of Michigan (1969).
- Mortimer, W.J.: New materials used at rumbler stops. Cook County Highways 12, No.7 (July 1965).

A discussion of warning rumble strips.
- National Safety Council: Accident Facts. Chicago, Ill (1968).
- National Safety Council: Safety lessons for junior high and senior high school students. Safety Education 40, No.1 (Sept. 1960), 29-32.

Classroom materials on traffic safety.
- National Safety Council: School crossing protection. Public Safety Memo No.71 (April 1957).

A discussion of school crossing protection. Underprotection is dangerous, but overprotection may make the children irresponsible.
- National Safety Council: Winter walking. Safety Education Data Sheet No.58 (1965).

Discussed are various explanations of the fact that 1/9 of all pedestrian fatalities occur in December.
- O'Regan, M.: Ladies take over at school crossing. Traffic Safety 65, No.9 (Sept. 1965), 26-27, 38.

The use of women crossing guards in Chicago has proven effective.
- Peters, C.H.; and Francis, E.: Concrete markings for pedestrian crossings. Surveyor and Municipal and County Engineer 113 (Jan.9, 1954), 21-23.

A description of different materials used for zebra crossings.

- ' Police Chief 21, Columbus protects its youngsters from winter's low visibility hazards. (Feb. 1954), 41.

This article describes "operation nite-ray," in which over 15,000 children were given reflective strips.

- ' Public Health Reports, Pedestrian automotive fatalities. No.9 (Sept. 1963), 772-773.

Discusses the factors contributing to pedestrian fatalities in New York City.

- ' Ramos, I.; and Fravel, H.D., Jr.: Pedestrian overpass. Traffic Engineering 19, No.5 (Feb. 1949), 215-219.

A description of a pedestrian crossing bridge in Manila which was both practically and financially successful.

- ' Road Research Laboratory, Pedestrians. Research on Road Traffic, London (1965), 390-405.

Description of methods of measuring pedestrian movement.

- ' Roads and Road Construction 27, Zebra pedestrian crossings. No.317 (1949), 186-187.

A description of materials used to mark zebra crossings.

- ' Roads and Road Construction 31, Ceramic pedestrian crossing markings.. No.362 (Feb. 1953), 58.

A discussion of ways of marking zebra crossings.

- ' Roads and Road Construction 34, A progressive pedestrian traffic control system. No.399 (1956), 79-80.

A description of a pedestrian-activated traffic light.

- ' Rodgers, C.T.; and Voorhees, A.L.: Some thoughts on white cane philosophy and problems. New Outlook for the Blind 55, No.5 (Mar. 1961), 173-177.

The author advises that white cane laws be discontinued, because they are not useful.

- ' Roer, P.: Pedestrian crossovers. Traffic Engineering 13 Aug. 1961), 21-22.

Pedestrians are given a false sense of security by heavily marked crossroads.

- ' Rudden, J.B.: Warrants for and experiences with pedestrian intervals at signalized intersections. Institute of Traffic Engineers, Proceedings (1959), 181-182.

The designation and classification of three different systems of intersection control.



- ' Ryan, G.A.; and McLean, A.J.: Pedestrian survival. Proceedings of the 9th Stapp Car Crash Conference, University of Minnesota, Minneapolis (1966), 321-334.

A discussion of the relationship between the shape of a car and various pedestrian injuries. From the fracture site, the relative position of the pedestrian and car can be determined.

- ' Safety Maintenance and Production 110, The "normal" look by day becomes the "safe" look at night. No.4 (Oct. 1955), 80-81.

This article describes a grey yarn which reflects light at night.

- ' Sale, J.: Nevada's "Walk-thru." Traffic Safety 57, No.1 (1960), 27, 44.

Children learn how to operate traffic signals.

- ' Severy, D.; and Brink, H.: Auto-pedestrian collision experiments. Society of Automotive Engineers, Report 660080 (Jan. 1966).

Reports of the findings of auto-pedestrian collision experiments.

- ' School Safety 1, Stand out for safety. No.1 (Oct. 1965), 15-18. Elementary safety rules.

- ' Shoaf, R.T.: A discussion of warrants for scramble signals. Traffic Engineering 25, No.7 (April 1955), 261-263.

A description of the limits of the scramble system in San Francisco.

- ' Siegel, S.T.: The role of pedestrian control in traffic regulation. Institute of Traffic Engineers Proceedings (1961), 72-80.

A description of pedestrian characteristics which make them vulnerable to injury, such as slow pace, unpredictable behavior and age.

- ' Sielski, M.C.: The pedestrian: Traffic safety's fall guy. National Safety Council Transactions 24, (1964), 36-37.

More work is needed on pedestrian safety including more protection and more enforcement.

- ' Solheim, K.: Pedestrian deaths in Oslo traffic accidents. Brit. Med. J. 1, (Jan. 1964), 81-83.

A 10-year study of 168 pedestrians fatally injured.

- ' State of Indiana, Office of the Governor, Indiana school crossing protection. Procedure Manual, (Mar. 19, 1964).

This study concludes that education is the most important factor in traffic safety for children.

- ' Storey, L.H.: Walk on the green. Public Safety 46, No.3  
(Sept. 1954), 8-9.  
In Michigan City, crosswalks were painted green to discourage jaywalking.
- ' Street Engineering 2, More effective markings for "hot" crosswalks. No.3 (Mar. 1957), 30, 46.  
Description of a new long-lasting compound for painting streets.
- ' Stuart, D.: Planning for pedestrians. J. American Institute of Planners 34, No.1 (Jan. 1968), 37-41.  
Description of the engineering phase of pedestrian planning.
- ' Sullivan, H.W.: On the care and preservation of pedestrians. National Safety Council Transactions 24 (1964), 40-43.  
The young, the elderly, and those who have been drinking are most likely to be in an accident.
- ' Surveyor and Municipal and County Engineers 108, Experiments in the marking of pedestrian crossings. (July 8, 1949), 407-409.  
An investigation of the effectiveness of zebra crossings.
- ' Survey and Municipal and County Engineers 109, Influence of the "Zebra" marking and of propaganda on behavior at pedestrian crossing. (June 23, 1950), 365-366.  
A discussion of two aspects of a National Road Safety Week held in April 1949.
- ' Tanner, J.C.: Delay to pedestrians crossing a road. Biometrika 38, No.3-4 (1951), 383-392.
- ' Thorson, A.: Personal protection in darkness. Experience concerning the use of retro-reflective materials in Sweden. International Road Safety and Traffic Review 6, No.1 (1958), 32-34.  
A description of the use of reflective material in Sweden.
- ' Todhunter, W.: A tale of two cities and their pedestrians. Traffic Safety 53, No.5 (Nov. 1958), 22-23.  
A description of the traffic safety campaigns in Norfolk, Virginia, and Sacramento, California.
- ' Traffic Digest and Review 9, Pedestrian violations. No.6 (June 1961), 10-15, 26-31.  
Some causes of pedestrian accidents, and some methods of law enforcement and accident prevention are dealt with.

- ' Traffic Engineering 32, A tentative standard for adjustable face pedestrian control signal head. No.7 (April 1962), 41-42, 44, 46, 48-49, 52.  
A standard guide for the preparation of the minimum purchase specifications for pedestrian control signal heads.
- ' Traffic Engineering and Control 3, New pedestrian crossing. No.8 (Dec. 1961), 502.  
A description of a 5-phase crossing system.
- ' Traffic Safety, Pedestrian control, key to city traffic problem. No. 3 (Sept. 1957), 40-43.  
A description of various types of pedestrian control.
- ' Traffic Safety 53, New AAA program aims to keep pedestrians alive. No.4 (Oct. 1958), 19.  
A description of the AAA traffic safety program.
- ' Traffic Safety 54, Drivers discuss walkers and safety persuaders. No.4 (April 1959), 18-19.  
This article is a questionnaire, "The driver looks at a pedestrian."
- ' Traffic Safety 51, Helpful hints for pedestrian protection. No.3 (Sept. 1957), 42-43.  
A look at the pedestrian accident picture and safety suggestions for walker and drivers.
- ' Traffic Safety 51, Pedestrian control: Key to city traffic problem. No.3 (Sept. 1957), 40-42.  
Oakland's pedestrian safety campaign.
- ' Traffic Safety 55, School bells ring out for Elmira jaywalkers. No.3 (Sept. 1959), 23, 48.  
Traffic safety school is mandatory for jaywalkers in Elmira.
- ' Traffic Safety 57, The senior citizen in traffic. No.2 (August 1960), 18-19.  
Statistics about elderly pedestrians.
- ' Traffic Safety 54, Trimble, J.: Hope for the battered urban pedestrian. No.2 (Feb. 1959), 22-25, 47-48.  
Several programs in various cities, which are mostly combinations of safety education and law enforcement.
- ' Vuchic, V.R.: Pedestrian crossing time in determining widths of signalized traffic arterials. Transportation Science 1, No.3 (August 1967), 224-231.

Pedestrian crossing time may limit vehicular capacity. All two-way arterials of more than four lanes should have either median dividers or a special refuge island.

- Waller, J.A.: High accident risk among middle-aged drivers and pedestrians. Geriatrics 21 (Dec. 1966), 125-137.  
A discussion of the high accident risk among middle-aged drivers and pedestrians, especially those who have been drinking.
- Wiener, E.L.: The elderly pedestrian: Response to an enforcement campaign. Traffic Safety Research Review 12, No.4 (Dec. 1968), 100-111.

- Weiss, G.H.: Analysis of pedestrian queuing. J. of Research, Sec B, Math and Math Physics, 67 B, No.4 (Oct.-Dec. 1963), 229-243.

A formula for determining when pedestrians will cross.

- White, J.D.: School crossing problems. Proceedings, 46th Annual Road School (April 18-21, 1960), 165-173.  
A discussion of a study of the school crossing problem in Wayne, Indiana, with a recommendation that patrol boys be replaced by pedestrian-activated signals.
- Wiley, T.T.: New York City's pedestrian signals. American City 68, No.2 (1953), 139.  
A discussion of the replacement of the "scramble" system with the "share-the-phase" system in which pedestrians and right-turning cars share the same phase.
- World Health Organization: Epidemiological and vital statistics. Report prepared by the World Health Organization, 11 No.1(1958).  
A discussion of the statistical data which demonstrate the effects of the increase in motor traffic on pedestrian mortality.
- Yaksich, S.: A Study of Pedestrian Fatalities in Washington, D.C. (1948-1957). Prepared for the American Automobile Association (1957).

The statistics of Washington's traffic fatalities.

- Zahavi, Y.: Traffic signals for the blind in Israel. Traffic Engineering 34, No.2 (Nov. 1963), 51-52.  
Description of a special traffic signal for the blind in Tel-Aviv, Israel when the signal is activated by a blind pedestrian, a bell sounds when it is safe to cross.

