September 1981
NHTSA Technical Report

DOT HS-806-270

U.S. Department
of Transportation
**National Highway
Traffic Safety
Administration**

Pedestrian Accidents A State-of-the-Art 1970–1980

Research and Development
National Center for Statistics
and Analysis

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT HS 806 270		

4. Title and Subtitle	
Pedestrian Accidents A State-of-the-Art 1970-1980	5. Report Date September 1981
	6. Performing Organization Code NRD-32
7. Author(s) James C. Fell and Gary R. Toth	8. Performing Organization Report No.
9. Performing Organization Name and Address National Center for Statistics and Analysis National Highway Traffic Safety Administration 400 - 7th Street, SW Washington, DC 20590	10. Work Unit No. (TRAIS) 11. Contract or Grant No.
12. Sponsoring Agency Name and Address U. S. Department of Transportation 400 - 7th Street, SW Washington, DC 20590	13. Type of Report and Period Covered State-of-the-art in accident data since 1970. 14. Sponsoring Agency Code

15. Supplementary Notes

This report will appear as a chapter in a textbook edited by John H. Hughes, M.D., entitled "ROADWAY TRAUMA: A MULTIDISCIPLINARY UPDATE" and published by CHARLES THOMAS PUBLISHERS.

16. Abstract In 1979 in the United States, 8,090 pedestrians were killed in motor vehicle accidents out of a total of 51,093 total traffic fatalities. An estimated total of 150,000 police reported pedestrian accidents of all severities occurred during the same year with at least 128,000 of these resulting in injury. When one compares pedestrian accidents with total reported traffic accidents of all kinds in 1979 (7,330,000), it seems to be a very small segment of the problem--2 percent. However, pedestrian accidents account for a full 16 percent of the total traffic accident fatalities. This report discusses the pedestrian accident problem in this country by providing statistics on the basic characteristics of the accidents and summarizing the findings from four major research studies.

It appears that the age and sex of the pedestrian, the location of the accident, and the type of vehicle striking the pedestrian all play an important role in the problem. The pedestrian problem truly is most severe for the young (5-8 years old) and the old (≥64 years old) with males being overrepresented in all age groups but especially those pedestrians between 25-34 years of age. Three location factors are very significant in fatal accidents--rural roads, high-speed roads, including major arteries, and non-intersection areas. The size of the striking vehicle is also important: the heavier the vehicle, the more likely a fatality.

In the U.S. experience, there have been four major pedestrian accident research studies in the 1970s which have had important results. These four studies have provided

(continued on attached sheet)

17. Key Words	18. Distribution Statement
Pedestrians, accidents, age, sex, location, vehicle type, injury severity, vehicle contact surfaces, pedestrian trajectory, pedestrian action, accident types, countermeasures, alcohol, BAC levels, accident risk.	Document is available to the public through the National Technical Information Service; Springfield, Virginia 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	50	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

Abstract (Cont'd.)

further detail and new findings in the areas of injury causation and severity, pedestrian accident typologies and scenarios, and the role of alcohol involvement. Findings and recommendations emanating from these studies are reported and discussed. Future research using the National Accident Sampling System is recommended.

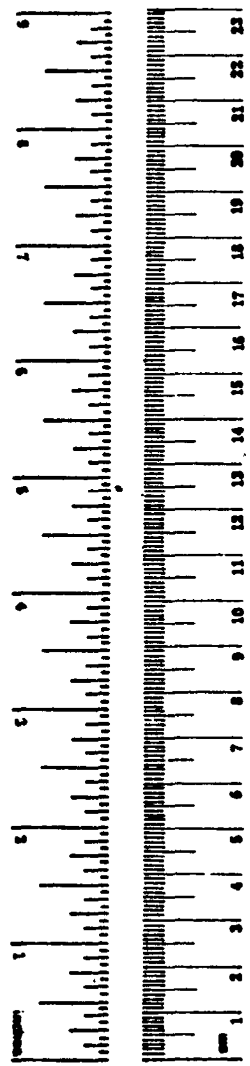
The report concludes that the pedestrian problem is unique and has no single, high impact solution. A concerted effort of several promising countermeasure approaches must be made to reduce that loss.

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F

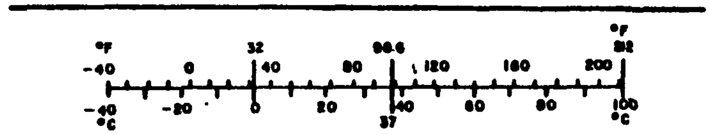


TABLE OF CONTENTS

TABLES

TABLE OF CONTENTS (Cont'd.)

FIGURES

PEDESTRIAN ACCIDENTS

by

James C. Fell

and

Gary R. Toth

National Highway Traffic Safety Administration*

THE PEDESTRIAN PROBLEM

In 1979 in the United States (U.S.), 8,090 pedestrians were killed in motor vehicle accidents out of a total of 51,093 total traffic fatalities [1]**. An estimated total of 150,000 police reported pedestrian accidents of all severities occurred during the same year with at least 128,000 of these resulting in some injury [2]. When one compares pedestrian accidents with total reported traffic accidents of all kinds in 1979 (7,330,000), it seems to be a very small segment of the problem--2 percent. However, pedestrian accidents account for a full 16 percent of the total traffic accident fatalities.

Pedestrian fatalities have been consistently accounting for 16-18 percent of the traffic fatalities throughout the 1970s. Actually, the situation has improved when compared to earlier years. In 1933, for example, there were 12,840 pedestrian deaths or <u>41 percent</u> of the traffic fatalities [3]. This

*The opinions expressed in this chapter are those of the authors and not necessarily those of the National Highway Traffic Safety Administration.

**Numbers in brackets [ ] indicate references listed at the end of the chapter.

trend continued until after World War II in 1946 when pedestrian deaths dropped to 34 percent of the fatal picture. In 1952 the proportion was 24 percent and by 1965 the proportion leveled off at 18 percent. There were even more striking reductions over those years when one considers various pedestrian fatality rates (per registered motor vehicle, per vehicle miles traveled, and per population). In 1936 there were 6.05 pedestrian fatalities for every 100 million vehicle miles traveled (VMT). In 1979 there were .62 pedestrian fatalities per 100 million VMT. Among other reasons for these drastic reductions were such factors as the development of limited access highways, improved traffic controls, and the extension of separate pedestrian walkways. As mentioned, however, these rates have leveled off in the 1970s and it is questionable whether significant reductions can occur without substantially new efforts in pedestrian safety.

Although this chapter will deal only with the U.S. situation, some brief comparisons of the pedestrian problem with other countries should be made. The U.S. clearly has the lowest pedestrian fatality rate per 1 trillion vehicle kilometers traveled (VKT) when compared to Canada, Japan, and several European countries; but it does not have the lowest rate per 100,000 population (see Table 1). In essence, there seems to be an inverse relationship between the socio-economic development of a country and its pedestrian death rate in terms of VKT [3].

To summarize, although pedestrian accidents as a whole only account for about 2 percent of the U.S. total traffic accidents, they are obviously severe when they do occur, accounting for 16-18 percent of the traffic fatalities. Pedestrian fatality rates have improved in the U.S. since 1933 but have leveled off in the 1970s.

Table 1

Some International Comparisons of Pedestrian Fatality Rates, Various Years 1972-1977

	Year of Data	Pedestrian Fatalities	All Traffic Fatalities	Pedestrian % of Total Fatalities	Pedestrian Fatalities per 1,000,000,000 VKT	Pedestrian Fatalities per 100,000 Population
United States	1976	8,600	47,038	18.3	3.8	4.0
Canada	1976	835	5,260	15.9	4.9	3.6
Netherlands	1977	384	2,583	14.9	5.7	2.8
Japan	1977	2,961	8,945	33.1	8.6	2.6
Norway	1977	147	442	33.3	8.7	3.6
United Kingdom	1976	2,335	6,570	35.5	9.3	4.2
Italy	1976	2,148	8,927	24.1	10.0	3.8
Denmark	1972	283	1,116	25.4	10.5	5.6
Finland	1975	264	910	29.0	12.1	5.6
West Germany	1977	3,748	14,978	25.0	12.4	6.1
France	1974	2,690	13,327	20.2	13.3	5.1
Austria	1977	447	1,867	23.9	15.1	5.9
Spain	1977	1,295	4,843	26.7	20.8	3.6
Hungary	1977	705	1,803	39.1	33.6	6.6
Greece	1972	340	1,181	28.8	52.3	3.7
Yugoslavia	1974	1,394	4,161	33.5	73.9	6.4
Poland	1974	1,760	3,936	44.7	79.3	5.1

Source: The Fatalities Data for All of the European Countries Come From the United Nation's Economic Commission for Europe Annual *Statistics of Road Traffic Accidents in Europe 1972-1977.* The Vehicle Kilometers Travelled Estimates Are Also Taken From This Series or From the International Road Federation's *World Road Statistics 1970-74.* The Japanese Data Are From the International Association of Traffic and Safety Sciences Annual *Statistics '78 Road Traffic Accidents in Japan.* The U.S. Fatalities Figures Are From the National Safety Council's *Accident Facts,* 1980 Edition. The Canadian Fatality Figures Are From Transport Canada's Road Safety Annual Report 1978. Except for Japan, the Population Figures Used Were the United Nation's Mid-1977 Estimates Published in *Statistics of Road Traffic Accidents in Europe 1977.*

Courtesy of Wolfe and O'Day [3]

BASIC CHARACTERISTICS

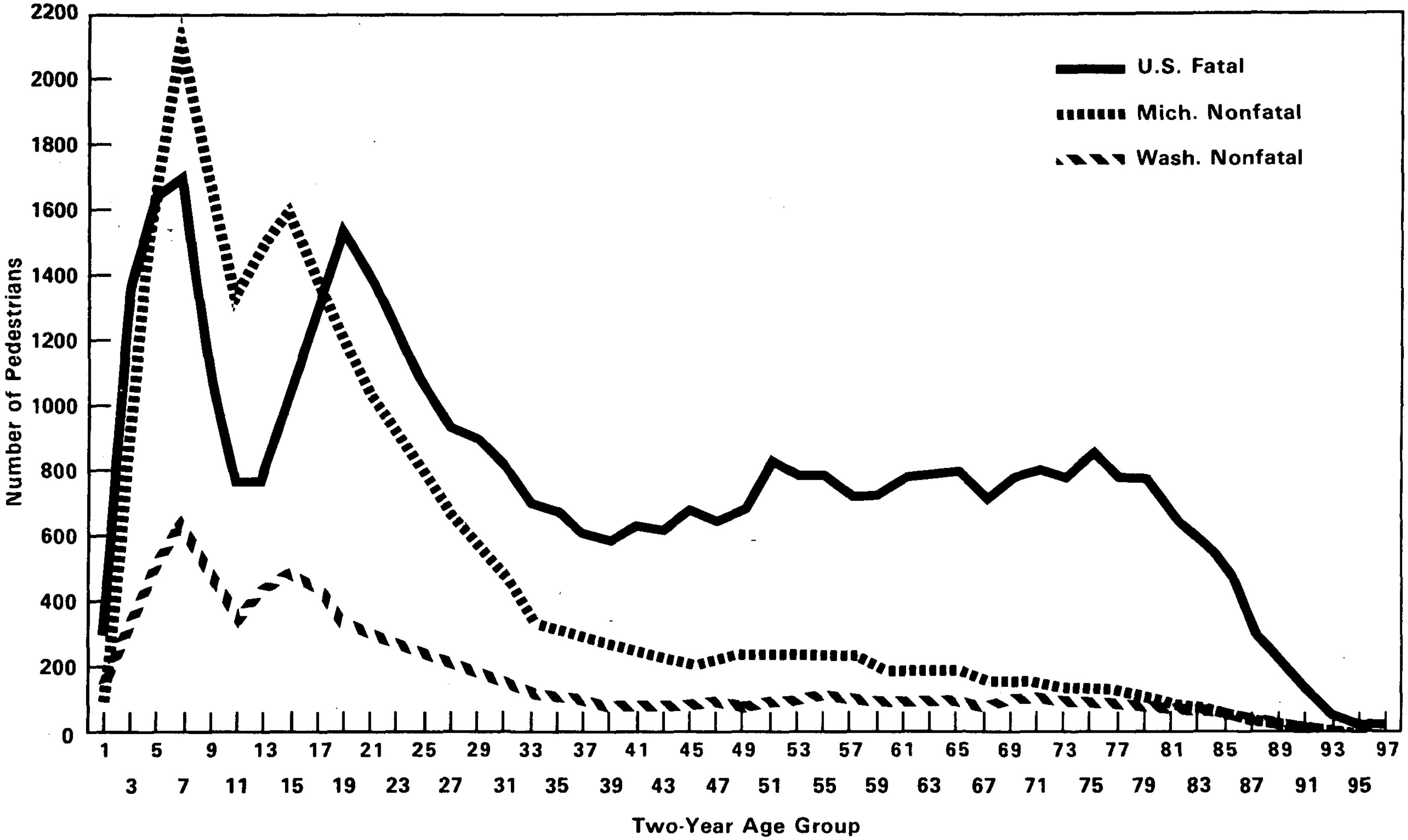
The age and sex of the pedestrian, the location of the accident, and the type of vehicle striking the pedestrian all play an important role in the problem. Statistics from the Fatal Accident Reporting System (FARS) [1], the National Safety Council [4] and the States of Michigan and Washington [3] all point out very interesting facts.

Concerning pedestrian age, there appear to be two age groups that peak in pedestrian accident involvements--young children (5-8 years old) and late teens (15-19 years old). There is also a mild increase at the end of the scale (> 64 years old) (see Figure 1). Also, while 21.5 percent of the pedestrian fatalities are under 15 years old, over 40 percent of the pedestrians in non-fatal accidents are under the age of 15. At the other end of the age scale, 22 percent of the fatalities are over the age of 64 while only 6-10 percent of the non-fatal pedestrian accidents involve these senior citizens (> 64 years old).

The data confirm that older people are much more likely to die when involved in a pedestrian accident. While approximately 3 percent of children between 5 and 14 years of age die when involved in a pedestrian accident, this increases to 12 percent for people over 64 years old and to 20 percent for pedestrians over 74 years of age. It should be pointed out, however, that while deaths from pedestrian accidents account for only a small fraction of overall senior citizen deaths, pedestrian accidents account for a full 10 percent of the deaths to children between 5 and 14 years of age.

Figure 1

U.S. Pedestrian Fatalities and Non-Fatalities by Two-Year Age Groups



Courtesy of Wolfe and O'Day [3]

As in other trauma areas, males are significantly overrepresented in pedestrian accidents when compared to their population figures. In fatalities, males account for 70 percent of the problem and have two to three times the death rate per 1 million population. Even at the young ages of 0-4, males are involved in 62 percent of the fatal pedestrian accidents. At the older ages (> 64) males are involved in 63 percent of the pedestrian fatalities, while the male involvement peaked at 78 percent for the ages 25-34. Apparently males take more risks, are at risk more often, and have a higher drinking rate than females; which, at least in part, explains their over-involvement in pedestrian fatalities (see Table 2).

The location of the pedestrian accident is also very important with regard to whether it is fatal or non-fatal. For example, approximately 38 percent of the fatal pedestrian accidents occur on rural roads compared to approximately 16 percent of all pedestrian accidents. Concerning road type, 8 percent of the pedestrian fatalities occur on limited access highways while only 2 percent of the pedestrian accidents overall occur on these highways. Close to 45 percent of the fatalities occur on other major roadways while only 20 percent of all pedestrian accidents occur on these roadways. Local roads account for at least 75 percent of all pedestrian accidents but less than 50 percent of the fatalities. The speed limit of the road also has an

Table 2

U.S. Pedestrian Fatalities and Total Deaths by Age and Sex, 1976

Ages		Pedestrian Traffic Deaths	Ped. Deaths Per 1,000,000 1976 Population	Total Deaths	Pedestrian % of Deaths
Under 1:	Male	6	4	27,320	0.02
	Female	6	4	20,945	0.03
	Subtotal	12	4	48,265	0.02
1-4:	Male	322	51	4,915	6.6
	Female	188	31	3,691	5.1
	Subtotal	510	41	8,606	5.9
5-14:	Male	776	41	8,068	9.6
	Female	457	25	4,833	9.5
	Subtotal	1,233	33	12,901	9.6
15-24:	Male	911	45	34,253	2.7
	Female	322	16	11,828	2.7
	Subtotal	1,233	30	46,081	2.7
25-34:	Male	579	36	30,162	1.9
	Female	177	11	13,267	1.3
	Subtotal	756	24	43,429	1.7
35-44:	Male	448	40	37,160	1.2
	Female	142	12	21,309	0.7
	Subtotal	590	26	58,469	1.0
45-54:	Male	587	51	95,324	0.6
	Female	201	16	54,712	0.4
	Subtotal	788	33	150,036	0.5
55-64:	Male	534	56	189,695	0.3
	Female	204	19	106,365	0.19
	Subtotal	738	37	296,060	0.25
65-74:	Male	509	83	267,466	0.19
	Female	282	35	176,461	0.16
	Subtotal	791	56	443,927	0.18
75+:	Male	572	179	375,312	0.15
	Female	348	63	443,879	0.08
	Subtotal	920	105	801,191	0.11
Total Males		5,312	51	1,051,983	0.50
Total Females		2,354	21	857,457	0.27
Grand Total		7,666	36	1,909,440	0.40

Courtesy of Wolfe and O'Day [3]

expected effect with almost one-third of the fatalities occurring on high speed roads. In the State of Washington, 23 percent of the pedestrians involved in accidents on roads with a speed limit of 55 mph were killed while only 3 percent of the pedestrians involved in accidents on roads with a speed limit $\leq$ 25 mph were killed.

Relationship to intersections is also important--only 19 percent of the fatalities occur at intersections (see Table 3). A higher proportion of non-fatal accidents occur at intersections (e.g., 27 percent in Michigan; 42 percent in Washington) where certainly most of the potential pedestrian/motor vehicle conflicts do occur. Lower speed impacts most likely account for this difference.

A final interesting point on basic characteristics deals with the size of the striking motor vehicle. There is quite a strong relationship between vehicle weight and involvement in fatal pedestrian accidents. For example, vehicles weighing over 3,500 lbs. are twice as likely to be involved in a fatal pedestrian accident than a vehicle weighing 1,500 - 2,500 lbs. Similar ratios hold true for trucks and buses--their involvement ratios in fatal pedestrian accidents are twice what they are in non-fatal pedestrian accidents.

Table 3

Accident Location Relative to the Roadway for Pedestrian Fatalities and Non-Fatalities

		1975-79 U.S. Fatal		1976-79 Mich. Non-Fatal*		1974-78 Wash. Non-Fatal	
		N	%	N	%	N	%
Intersection	Crosswalk, Sidewalk	2,637	7.1	—	—	2,398	35.1
	On Roadway	4,199	11.3	—	—	490	7.2
	Not Known	185	0.5	—	—	—	—
Non-Intersection	Crosswalk, Sidewalk	1,371	3.7	—	—	282	4.1
	Shoulder, Bike Path	2,070	5.6	—	—	414	6.1
	Outside Traffic-Way	586	1.6	—	—	99	1.4
	On Roadway	25,905	69.7	—	—	3,151	46.1
	Not Known	203	0.5	—	—	—	—
Total	Intersection	7,021	18.9	6,680	27.0	2,888	42.3
Total	Non-Intersection	30,135	81.1	17,431	73.0	3,946	57.7
Total		37,156	100.0	24,111	100.0	6,834	100.0
Missing		921	—	0	—	1,886	—

*Michigan Pedestrian Accident Data Do Not Contain Detailed Roadway Location Information

Courtesy of Wolfe and O'Day [3]

Summarizing these four selected characteristics, the pedestrian problem truly is most severe for the young (5-8 years old) and the old (> 64 years old). Males are very much overrepresented in all age groups but especially those pedestrians between 25-34 years of age. Three location factors are very significant in fatal accidents--rural roads, high speed roads, including major arteries, and non-intersection areas. The size of the striking vehicle is also important; the heavier the vehicle, the more likely a fatality.

The above all seem very logical and intuitive; however, they are now verified by factual data. It has only been recently that we have been able to measure the magnitude of these problems described above.

In the next section, four major pedestrian accident studies will be summarized pointing out more specific detailed information which should help counteract the pedestrian problem.

MAJOR PEDESTRIAN ACCIDENT STUDIES

In the U.S. experience, there have been four major pedestrian accident research studies in the 1970s which have had important results and are certainly worth summarizing in this chapter. These four studies have provided further detail and important new findings in the areas of injury causation and severity, pedestrian accident typologies and scenarios, and the role of alcohol involvement.

The Houston Study

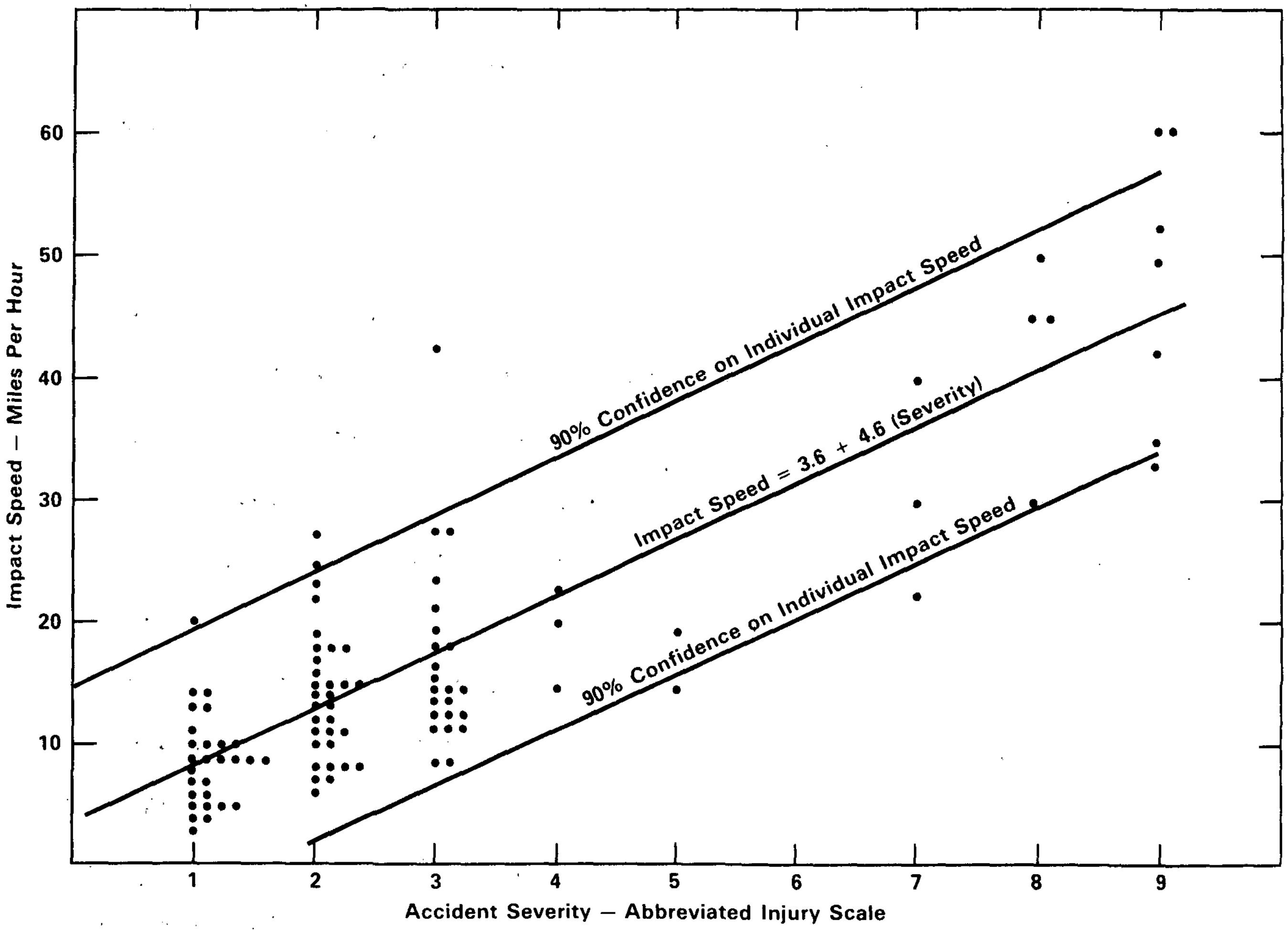
This first study to be described was a multidisciplinary accident investigation effort where 175 pedestrian accidents were investigated by an expert team in the city of Houston, Texas between June 1971 and May 1973 [5]. Full-scope in-depth investigations were conducted at the accident scene and on a follow-up basis in each case.

Evidence was collected and assessments were made on impact speeds, pedestrian contact points on the vehicle and ground, detailed injury severities, and probable contributing factors to the crash. Even though this was a sample biased toward more severe accidents (19 fatal, 156 injury producing), some very interesting and important results should be noted.

As mentioned, impact speeds were estimated via scene evidence, vehicle damage, etc., and these figures were correlated with pedestrian injury severity. A linear relationship resulted. This finding, although again intuitive, gave researchers some basis with which to estimate injury reduction from lower impact speeds. Proceeding a step further, the relationship was also calculated for the 135 collisions where the pedestrian was struck by the front of the vehicle. Finally, examining only "direct" frontals (eliminating glancing blows, etc.), the linear relationship was even further refined (see Figure 2 and Table 4).

Figure 2

Impact Speed Vs. Accident Severity for 103 Direct Frontal Impacts



Courtesy of Tharp [5]

*An earlier version of the present Abbreviated Injury Scale [6] was used in this study, thus the reason for scales 7, 8 and 9 (multiple fatal injuries) in this figure. The earlier version was "Rating the Severity of Tissue Damage: I. The Abbreviated Injury Scale," Committee on Medical Aspects of Automotive Safety, Journal of the American Medical Association, 215: 277-280 1971.

Table 4

Analysis of Variance

Source	Sum of Squares	Degree of Freedom	Mean Square
Linear Regression	12,641	1	12,641
Residuals From Regression	4,285	102	42
Corrected Total	16,926	103	

F-Ratio = 298 (With 1 and 102 Degrees of Freedom)
Significance Level = 0.0000
Coefficient of Determination = 0.75
Standard Error of Estimate = 6.51
Correlation of Coefficient = 0.86

Courtesy of Tharp [5]

Of primary interest also was the question of whether there was a difference in the severity of injuries associated with various contacted surfaces. Table 5 shows the pedestrian injury severity which resulted from the various contact surfaces in the 103 "direct" frontal collisions. The differences evidenced by the statistical testing indicates that:

- bumpers produced fewer fatal injuries but more severe injuries (AIS 3-5)[1] than the flat or folded vehicle surfaces.

- contacts with the vehicle are more severe than contacts with the environment.

The first finding is probably due to the fact that bumpers are low and tend to contact the legs and hips of pedestrians, while the flat and folded surfaces contact more critical body areas of the pedestrian - the head and chest.

[1]The Abbreviated Injury Scale (AIS) is an ordinal system for rating the severity of injuries that is utilized by medical and non-medical investigators [6].

Table 5

Vehicle Contact Surface — Injury Severity

Injury Severity	Vehicle Contact Surface: Bumper	Flat	Fold	Total Vehicle	Roadway Environment
1	22(23.1)*	17(15.2)	27(27.7)	66(42%)	51(33.6)
2	11(13.6)	10(8.9)	18(16.4)	39(25%)	19(20.0)
3	16(10.9)	5(7.1)	10(13.0)	31(20%)	3(16.0)
4-5	6(3.5)	0(2.3)	4(4.2)	10(6%)	2(4.8)
Fatal	0(3.9)	4(2.5)	7(4.6)	11(7%)	5(5.6)
Total	55(35%)	36(23%)	66(42%)	157(100%)	80
		$x^2 = 14.9$; 8 d.f.; p = 95%			$x^2 = 21.3$ 4 d.f. p = 99.9%

*Theoretical Frequencies Assuming No Relationship Between Contact Surface and Injury Severity in Parentheses ( ).

Courtesy of Tharp [5]

A very interesting finding in this study was the result of autopsy data on the fatalities. In 11 of the 19 fatalities resulting from direct frontal impact, a fractured neck was noted as either the only fatal injury (three cases) or one of several fatal injuries (eight cases). In ten of these 11 cases the neck area had not been impacted by any object. The author concluded that "when a pedestrian is struck directly by a moving vehicle, the laws of conservation of momentum show that the vehicle speed is reduced by only a small amount while the pedestrian is accelerated to a high speed in a fraction of a second . . . The head, representing a mass attached to the body by the neck, has to be accelerated to the speed of the body by forces applied through the neck. Thus, the neck is subjected to large forces because the mass of the head, some 12 to 13 pounds, is accelerated to the vehicle impact speed in a small fraction of a second (say .02 to .04 seconds in the shoulder high impact)" [5, page 102].

Among the recommendations emanating from the study were the following:

- If pedestrians could be convinced to delay one or two seconds at a signalized intersection and observe traffic before crossing, numerous accidents could be avoided.

- On the other hand, adjustment of traffic signals for a two-three second delay after stopping traffic prior to the pedestrian "walk" signal would reduce the risk of pedestrians stepping into the street prior to vehicles clearing the intersection.

- A low, rounded sloping hood would tend to deflect a pedestrian's body from the path of the vehicle and reduce the amount of energy the pedestrian would absorb during impact. This would both reduce the severity of the vehicle impact and, since non-vehicle contacts to the pedestrian tend to be less severe, reduce the overall injury severity to the pedestrian (also see Reference [7]).

The Pedestrian Injury Causation Study (PICS)

One of the largest and most comprehensive pedestrian accident studies to date was a multi-site study known as the Pedestrian Injury Causation Study (PICS) [8]. This study took place in five urban areas[2] during the years 1977-1980. A total of 1,997 pedestrian accidents were investigated involving 2,021 vehicles and 2,068 pedestrians which resulted in 2,092 distinct vehicle/pedestrian involvements or impacts. The urban areas were selected to obtain some geographic representation in the U.S. and to eliminate, as much as possible, any regional biases due to weather, roadway type, etc.

The primary objectives of the study were to identify factors causing pedestrian injury severity and, more specifically, to identify relationships among pedestrians, their injuries, and motor vehicle contact areas. The ultimate objective was to provide enough detailed, statistically valid data for safety engineers to use for redesign of vehicle structures such that injuries from pedestrian impacts can be reduced.

[2]The five areas were Buffalo, New York; Washington, D.C.; San Antonio, Texas; San Jose, California; and Los Angeles, California.

A probability sample of police reported pedestrian/motor vehicle accidents were investigated in each of the five urban areas with fatal accidents being oversampled (100 percent of the fatal accidents were sampled in four of the five areas). Only accidents involving automobiles and light trucks (pickups and vans) were collected. Excluded from the sample were non-fatal hit-and-run accidents, accidents in which the vehicle contacts another vehicle before impacting the pedestrian, accidents occurring in driveways and parking lots, and accidents in which the pedestrian was lying down or crawling in the road.

Five different trained teams investigated nearly 50 percent of the accidents at the scene of the crash while the vehicle or pedestrian remained at the accident site. Details were collected on vehicle contact points, vehicle damage, pedestrian injury descriptions from hospital and medical records, environmental characteristics, and situational factors in the accident.

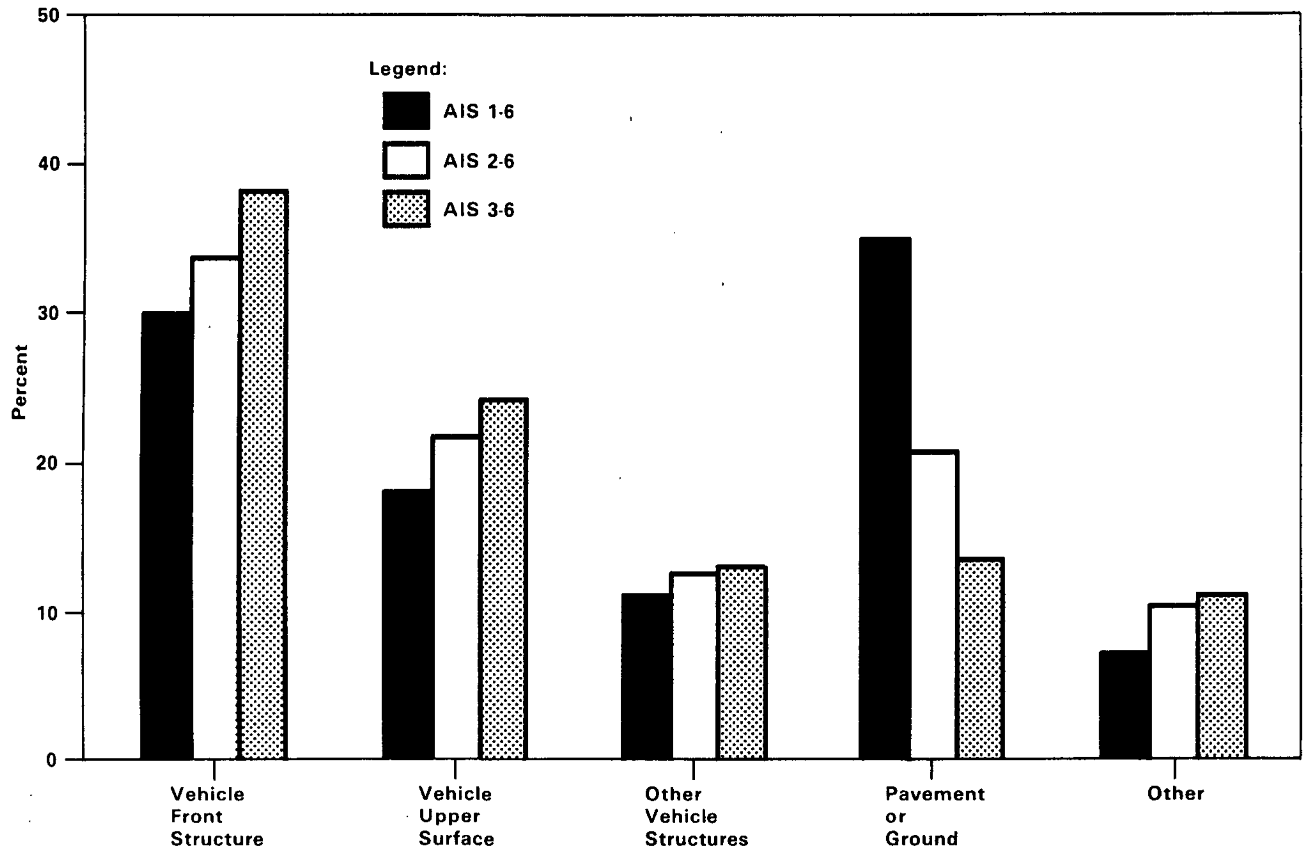
There is no statistical guarantee that the accidents occurring in these five areas are representative of accidents in the nation as a whole, but, if it is assumed that they are fairly representative of the urban pedestrian accident problem, then the following statistics are extremely informative.

Accidents were primarily a single vehicle/single pedestrian involvement (96 percent) and almost three-quarters of the accidents were frontal collisions. More than nine out of ten of the investigated collisions occurred at speeds below 30 mph (keep in mind, 71 percent of the vehicle impact speeds could not be determined because physical scene evidence was missing). In general, if any avoidance maneuver was attempted by the vehicle driver, it was braking (53 percent) rather than steering (2 percent) or a combination of the two (13 percent). In about one-fourth of the accidents, no avoidance maneuver was attempted.

Almost half of the pedestrians involved in the collisions were younger than 16 years old. Truly, a pedestrian rarely escapes injury when struck by a vehicle. Almost 99 percent of all pedestrians involved in the accidents sustained some kind of injury, even though a large proportion (60 percent) of those pedestrians injured had only a minor overall injury. The most prevalent single source of the most severe pedestrian injury was the pavement or ground (32 percent); however, when the entire front structure of the vehicle is treated as a single component, then this structure becomes the prevalent source of the pedestrian's most severe injury (34 percent). The distribution of injuries caused by vehicle contacts increased when minor and moderate injuries were excluded (see Figure 3); whereas, the pavement induced injuries decreased. Serious and life-threatening injuries are definitely more prevalent from the vehicle front structure (38 percent) and vehicle upper surfaces (24 percent) than the pavement or ground (14 percent). The front structure of the vehicle includes the front bumper assembly, grill, headlights, and hood face.

Figure 3

Distribution of the Most Severe Injury to a Pedestrian of Known Injury Severity and Injury Source



Courtesy of NHTSA

At higher impact speeds, pedestrians had a tendency to rotate onto the hood; whereas when the impact speed decreases, the tendency was to contact the hood/hood front area of the vehicle and then eventually be thrown to the pavement. At even lower speeds the pedestrian was knocked onto the pavement. Pedestrian kinematics were affected somewhat by the frontal geometry of the striking vehicle, but, it appears that impact speed was the most important factor influencing the resulting trajectory of the struck pedestrian. In an attempt to determine the effects of vehicle geometry in frontal impacts on producing injuries, such vehicle parameters as bumper height, hood length, hood height, and bumper lead were explored. It became apparent that the frontal geometry had relatively limited effect on pedestrian kinematics. This surprising fact may be a result of the large majority of minor injury accidents masking the effect of vehicle geometry which is thought to be associated with the relatively small number of serious and fatal accidents. At any rate, geometric variables generally do not cause direct injuries but do influence pedestrian kinematics and the area of the vehicle contacted which, in turn, is probably related to pedestrian injury. Therefore, it seems that vehicle geometry probably plays a secondary role to speed in the overall pedestrian injury generation process.

Adult pedestrians[3] experienced more serious injuries and sustained a larger proportion of these injuries from vehicle contacts rather than the pavement. The proportion of adult pedestrians sustaining life threatening

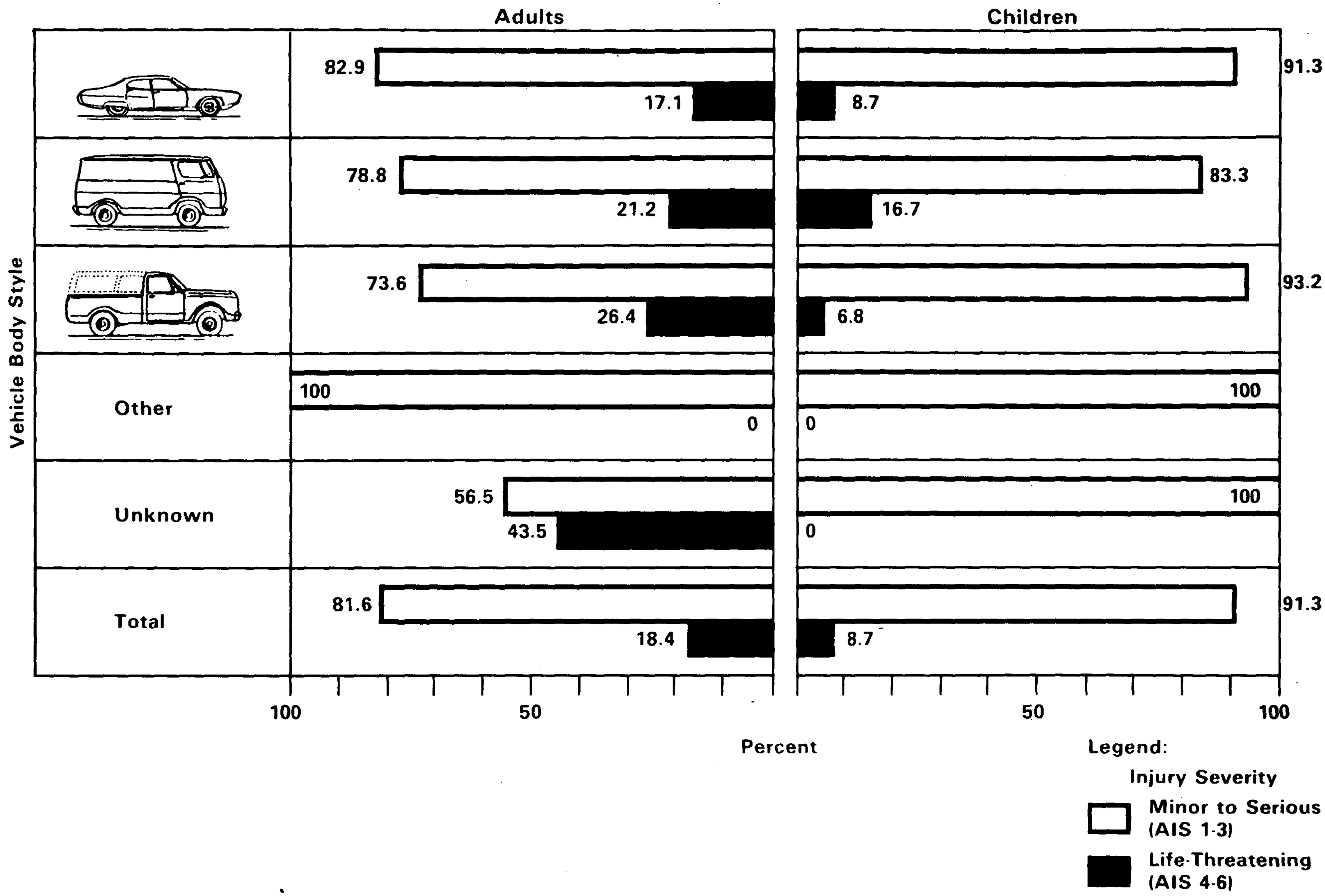
[3]For the purpose of analysis, two age categories were defined: adults (above 10 years old) and children (10 years old and younger).

injuries (18 percent) was double that for children (9 percent). The highest proportion of these life-threathening injuries to children were caused by vans (17 percent), whereas for adults it was pickup trucks (26 percent) (see Figure 4). When the severest injury to various body areas for children and adults was studied, it became very apparent that it was very much related to pedestrian size. Impacts to adults from the front of the vehicle (face area from bumper to hood top) generally resulted in injuries to the abdomen (44 percent), pelvic-hip (57 percent) and lower limbs (60 percent). For children, impacts from the front resulted in injuries to the entire torso (57 percent) and both lower (41 percent) and upper extremities (21 percent). Few children were able to contact the upper surfaces of the vehicle (12 percent) except with the head, neck, and face; whereas the hood top was a more frequent source (23 percent) of severe injury to the head, neck, torso, and upper extremities of adults (see Table 6). Injuries from contact with the windshield area were extremely rare for children (0.1 percent), but relatively frequent for adults (5 percent) [8].

Frontal pedestrian/motor vehicle collisions were not only the most frequent (73 percent), but also the most severe type of pedestrian accident (see Figure 5). Frontal impacts generally occurred at higher speeds than those of rear impacts and a frontal collision was more often a direct contact

Figure 4

Distribution of the Most Severe Injury to a Pedestrian by Vehicle Body Style



Courtesy of NHTSA

Table 6

Percentage Distribution of Severest Injury to Each Body Area by Known Injury Source For Adults and Children

Body Area

Injury Source	Head Neck		Face		Chest		Abdomen		Pelvic-Hip		Upper Extremities		Lower Extremities		Total	
	Adult	Child	Adult	Child	Adult	Child	Adult	Child	Adult	Child	Adult	Child	Adult	Child	Adult	Child
Vehicle Front Structure	0.6	9.3	1.0	6.1	11.0	46.2	43.6	58.9	57.1	63.2	8.3	21.1	59.9	41.4	28.8	28.0
Vehicle Upper Surfaces	29.9	18.3	31.9	17.5	42.9	14.2	29.5	6.3	17.2	11.8	30.6	9.7	7.6	5.2	23.3	11.8
Other Vehicle Structures	3.6	6.0	4.0	6.1	15.7	9.4	10.3	9.5	8.5	2.9	9.8	8.6	9.2	14.7	8.3	8.9
Pavement or Ground	51.4	61.5	59.7	69.2	24.3	29.2	10.9	21.0	16.3	19.9	49.4	59.4	17.4	34.7	33.9	48.6
Other	14.5	5.0	3.4	1.1	6.2	0.9	5.8	4.2	0.9	2.2	1.9	1.1	5.9	4.1	5.7	2.8
Total	100%		100%		100%		100%		100%		100%		100%		100%	
	16.5	16.8	10.4	19.5	7.5	6.1	5.6	5.5	11.7	7.6	19.9	19.4	28.3	25.1		

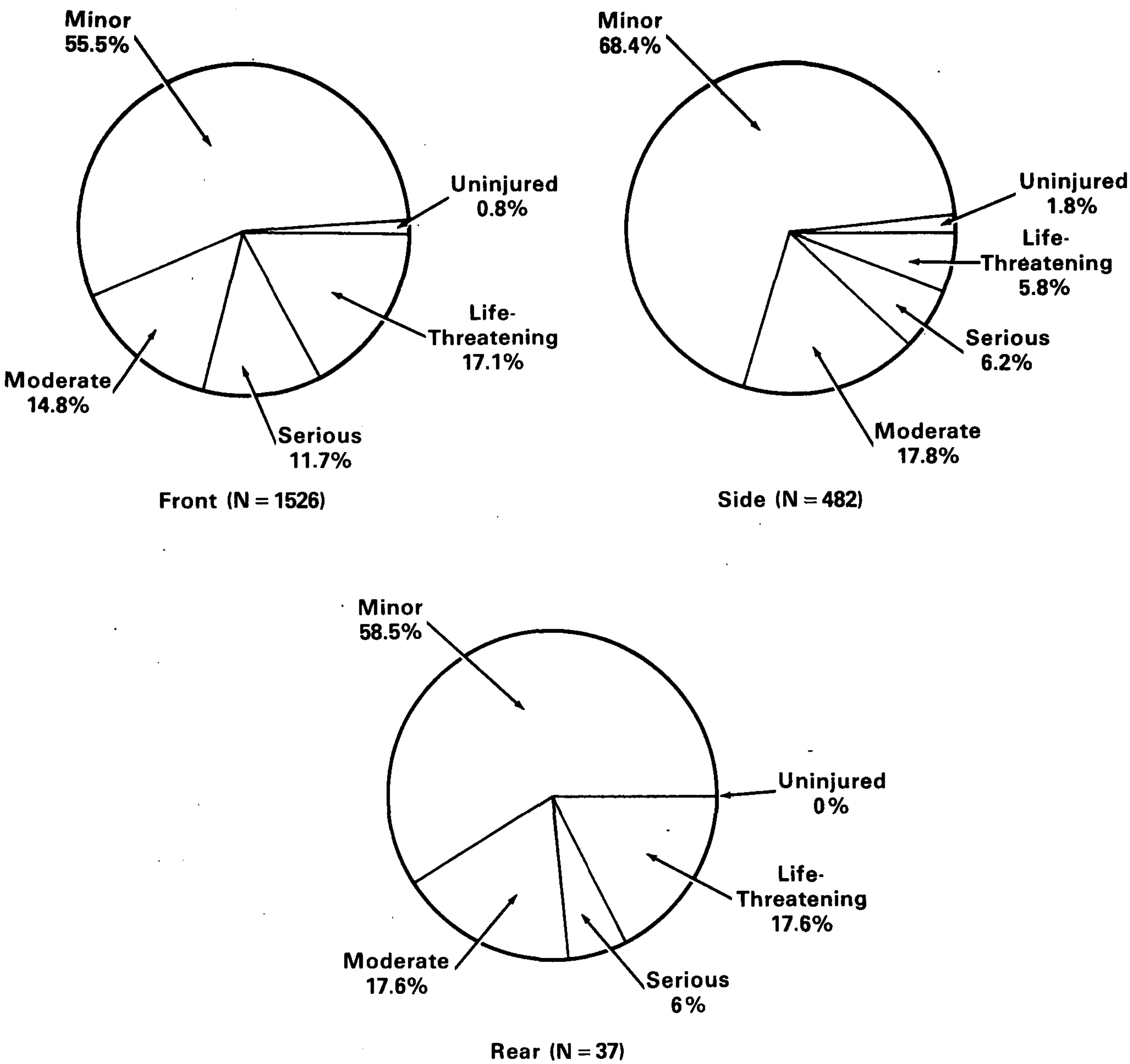
Courtesy of NHTSA

to the pedestrian, as compared to a side impact which frequently resulted in a glancing blow to the pedestrian (see Table 7). More than three-fourths of the side impact interactions resulted in the pedestrian either being knocked down or pushed aside; whereas, one-third of the frontal impact interactions resulted in the pedestrian being thrown/knocked to the right or left of the vehicle or shunted.

Data from PICS indicated that as the vehicle size increases, the proportion of fatalities also increases in frontal collisions (see Table 8). As expected from previous studies, the fatal accident was a higher speed event than the non-fatal accident. Based on impact speeds determined from physical evidence, all frontal fatal accidents occurred at 11 mph or higher compared with 38 percent for non-fatal accidents. Above 30 mph, less than one out of four pedestrians survived a frontal collision with a vehicle. Survival is rare above this speed except under the most unusual circumstances.

Figure 5

Vehicle-Pedestrian Involvements
Distribution of the Most Severe Injury by
Type of Impact for Known Injury Severity



Legend:

Minor	(AIS 1)
Moderate	(AIS 2)
Serious	(AIS 3)
Life-Threatening	(AIS 4-6)

COURTESY OF NHTSA

Table 7

Pedestrian Trajectory by Type of Impact

Vehicle-Pedestrian Interaction	Actual N	Actual %
Frontal Impact		
Carried by Vehicle	56	2.9
Carried by Vehicle, Wrapped Position	44	2.3
Carried by Vehicle, Slid to Windshield	87	4.5
Rotated Over Top	24	1.2
Thrown Straight Forward	226	11.7
Thrown Forward and Left of Vehicle	112	5.8
Thrown Forward and Right of Vehicle	154	8.0
Knocked to Pavement, Forward	424	22.0
Knocked to Pavement, Left of Vehicle	70	3.6
Knocked to Pavement, Right of Vehicle	121	6.3
Knocked to Pavement, Run Over or Dragged	43	2.2
Shunted to Left (Corner Impact)	12	0.6
Shunted to Right (Corner Impact)	32	1.7
Other	18	0.9
Unknown	103	–
Frontal Impact Total	1,526	–
Side Impact		
Knocked to Pavement	338	17.6
Bumped or Pushed Aside	47	2.4
Snagged, Rotated	24	1.2
Snagged, Dragged by Vehicle	3	0.2
Feet or Legs Run Over	46	2.4
Other	9	0.5
Unknown	15	–
Side Impact Total	482	–
Rear Impact		
Carried by Vehicle	0	0
Thrown Rearward, Straight, Right, or Left	1	0.1
Knocked to Pavement, Straight, Right, or Left	24	1.2
Knocked to Pavement, Run Over or Dragged	6	0.3
Shunted, Left or Right (Corner Impact)	0	0
Other	4	0.2
Unknown	2	–
Rear Impact Total	37	–
Unknown	47	–
Total	2,092	100.0

Note: Unknowns Have Been Excluded From Percentage Calculations.

Courtesy of NHTSA

Table 8
*Accidents by Vehicle Type for Frontal Impacts**

Vehicle Type	Fatal	Non-Fatal	Total Vehicles	Percent Fatal
Minicar	28	696	724	3.9
Compact	44	709	753	5.8
Intermediate	35	800	835	4.2
Full Size (Includes Luxury and Limousine Type Vehicles)	53	865	918	5.8
Small Van	12	102	114	10.5
Pickup Truck	36	266	302	11.9
Other/Unknown	10	107	117	8.5
Total	218	3,545	3,763	

*Weighted data (i.e., adjusted for fatal oversampling).

Courtesy of NHTSA

The role of the vehicle was far more prominent in fatal frontal impacts than in non-fatal accidents for the most severe injury. The source of the severest pedestrian injury in non-fatal frontal impacts was very similar for most vehicle types. The pavement ranked first for all vehicle types, except for minicars. The vehicle front structure ranked second except, again, for minicars. The source of the severest injury in fatal accidents dramatically changed. The pavement did not even appear as a primary or secondary injury source, except as a primary source for pickups. Hood top and energy transfer dominated the primary source while the vehicle front structure was prevalent as a secondary source.

To summarize the PICS study, the pedestrian becomes exposed to a significant threat of injury upon entering the roadway and rarely escapes injury during a collision from the gross mismatch between human and vehicle. It became very apparent that the pedestrian accident was a difficult phemomena to study because most of the physical evidence was extremely transient or totally absent altogether. The source of major injuries in fatal frontal accidents was often from the vehicle area rearward of the hood face. Hard vehicle surface areas such as the hood, fender edge, or the bumper was associated with the more severe injuries. In non-fatal accidents, the lower extremities sustained frequent injuries, primarily caused by contact with the bumper. Therefore, elimination, modification, or any improvement in these areas to the vehicle through redesign, energy absorption, or by other methods, should have an effect on life-threatening, minor, and disabling injuries.

The Rural Pedestrian Accident Study

The third major study concentrated on pedestrian accidents that occurred in rural or suburban areas [9]. It also concentrated on the causes of the accidents in terms of pedestrian and driver behavior, the roadway environment, and other relevant situational factors. Whereas the first two studies discussed had an emphasis on the causes of the pedestrian injuries, the next two will deal with the causes or contributing factors to the accidents.

Although most frequently described as "rural" accidents, the phrase "nonurban" is perhaps more appropriate. Research efforts before this study focused on urban pedestrian accidents, yet it should be recalled that 15 percent of the accidents and close to 40 percent of the pedestrian fatalities are in "nonurban" areas. This study, for the most part, followed the protocol and used a similar approach as a pioneering study in this area of pedestrian research by Snyder and Knoblauch in 1971 [10].

Care was taken in this study to permit statistical inferences to be drawn to the national rural picture by first selecting a stratified random sample of counties from six states[4] to sample the accidents. All of the 1974 rural pedestrian accidents in each of the counties were investigated, which totaled

[4]The six states were California, Michigan, Missouri, North Carolina, Pennsylvania and Texas

1,531 out of 6,399 which occurred during that time in the six states as a whole. This sample represented 3 percent of the national rural pedestrian accident picture.

No on-scene investigations were made in the data collection. However, trained local field investigators visited the accident sites on a follow-up basis, interviewed drivers and pedestrians, and filled out a detailed data collection form complete with a uniform coding and field procedures manual. Some of the descriptive findings follow:

- the rural accidents tend to occur more often during the late evening and early morning hours than the urban accidents.
- over twice as many 15-19 year olds were involved in the rural accidents (15 percent) as opposed to the urban accident (7 percent).
- most of the striking vehicles were going straight ahead (75 percent), although some were changing lanes (3 percent), backing up (3 percent), negotiating curves (2.4 percent), and turning left or right (4.5 percent).

With regard to pedestrian behaviors, most were attempting to cross the road, (61 percent) but a surprising percentage were not (39 percent). Table 9 indicates the major pedestrian activity at the time of the crash.

The "actions" of pedestrians observed at the accident site one week later at the same times of the accidents were compared with those involved in the accidents. A "hazard index" was calculated by dividing the percentage of the

Table 9

Pedestrian Activity

En Route, Going Somewhere	50.6%
At Play	13.3%
Standing, Waiting, Not Moving	5.7%
Going to or From School	4.8%
At Work	4.0%
Going to or From a Vehicle	4.0%
Working on or Pushing a Vehicle	3.5%
Going to or From a School Bus	2.1%

Courtesy of Knoblauch [9]

accident data base displaying a given behavior by the base-rate population (those pedestrians observed but not in an accident) sharing that behavior:

$$\text{HAZARD INDEX} = \frac{\text{\% of Accident Data Base}}{\text{\% of Base-Rate Data Base}}$$

Five pedestrian behaviors were found to have significantly high hazard indices (see Table 10): (1) standing in the roadway, (2) coming from behind a parked vehicle, (3) working in the roadway, (4) working on vehicle, and (5) crossing at a non-intersection.

Pedestrian, driver and environmental precipitating, predisposing and causal factors were assessed by the investigators based upon the evidence gathered, and with fairly strict coding guidelines. These are contained in Table 11. Keep in mind several factors can be associated with one accident case, thus the percentages do not add up to 100 percent.

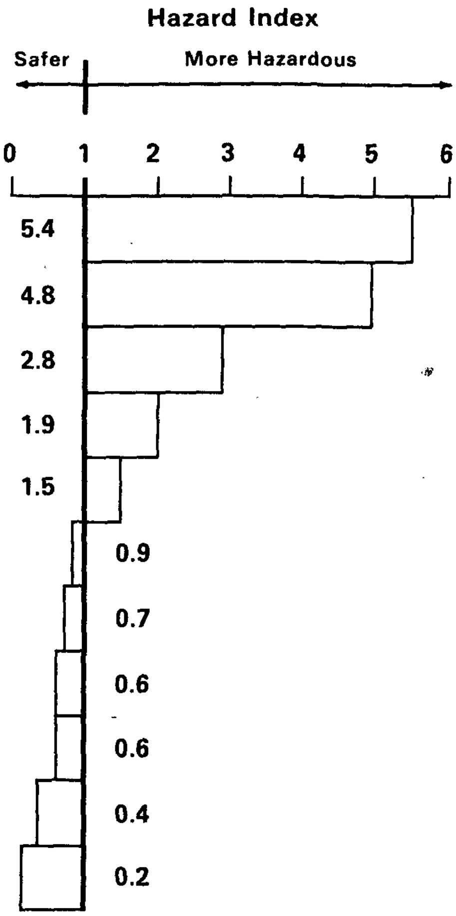
In order to better understand the problem and to attempt to identify countermeasures, a number of accident "types" were developed that shared common elements or critical descriptors. With the aid of the data in Table 10, 23 accident types were identified with 5 types accounting for over one-half the rural pedestrian accidents.

- walking along the roadway - 11.6%
- dart out, first half of the road - 10.8%

Table 10

Pedestrian Action
Accident and Baserate Data Compared

Pedestrian Action	Accident Data %	Baserate Data %	Hazard Index
Standing in Roadway	8.1	1.5	5.4
Coming From Behind Parked Vehicle	5.3	1.1	4.8
Working in Roadway	2.2	0.8	2.8
Working on Vehicle	3.5	1.8	1.9
Crossing, Not at Intersection	39.4	27.0	1.5
Walking in Road, With Traffic	10.8	12.3	0.9
Playing in Road	3.6	4.9	0.7
Walking in Road, Against Traffic	4.8	8.0	0.6
Crossing, at Intersection	18.3	29.0	0.6
Getting On/Off School Bus	1.6	3.6	0.4
Getting On/Off Other Vehicle	2.4	9.9	0.2



Courtesy of Knoblauch [9]

- dart-out, second half of the road - 10.3%
- middle of the block dash - 9.9%
- intersection dash - 9.9%

Each accident type was examined to determine if a "countermeasure concept" could be applied. A countermeasure concept pinpointed the basic characteristics of an accident "type" that must be eliminated or modified in order to prevent the occurrence of the accident. Potential countermeasures were then identified to achieve this desired effect. For example, the countermeasure associated with the "mail box-related" accident type would be to relocate mail boxes so that pedestrians do not have to cross the roadway to get their mail. Table 11 summarizes the engineering, enforcement, and regulation oriented countermeasures which emanated from these assessments (pedestrian and driver education programs are not included). The "percent of accidents" in Table 12 was derived by considering the percentage of each accident type that would be impacted upon by a particular countermeasure and projecting that percentage to the entire sample.

In conclusion, this approach of accident investigation, analysis, typology and countermeasure application has had some success in the urban accident types [11] and there is good reason to believe it can be successful in the rural picture.

Table 11

Pedestrian Causal Factors

Factor	Percent of Accidents
No Contributory Pedestrian Factors	7.8
Running on or Into the Roadway	29.5
Risk-Taking: Pedestrian Action Was Dangerous	23.5
Short-Time Exposure: Pedestrian Appeared Suddenly	17.4
Inadequate Search and Detection	17.3
Misdirected Search or Detection Pattern	13.2
Distraction	11.5
Condition of the Pedestrian (Alcohol, Etc.)	10.3
Unexpected or Unusual Place for Pedestrian	8.9
Inattention	8.6
Poor Prediction of Vehicle/Pedestrian Path	6.2
Pedestrian Misinterpretation of Driver's Intent	5.8

Driver Causal Factors

Factor	Percent of Accidents
No Contributory Driver Factor	32.4
Driver Inadequate Search and Detection	18.2
Search and Detection Pattern Not Directed at Pedestrian	15.8
Vehicle Speed	11.5
Driver Misinterpretation of Pedestrian's Intent	10.1
Poor Prediction of Vehicle/Pedestrian Path	6.4
Driver Ran Off Traveled Way	6.4
Condition of the Driver (Alcohol, Etc.)	6.0

Environmental Causal Factors

Factor	Percent of Accidents
No Contributory Environmental Factors	40.7
Inadequate or No Roadway Lighting	16.1
Driver Vision Obscured by Parked Vehicles	8.8
Inadequate or No Shoulder, No Sidewalk	8.5
Driver Vision Obscured by Moving or Standing Traffic	8.3
Pedestrian Vision Obscured by Parked Vehicles	5.7
Driver Vision Obscured by Trees, Roadside Items	4.5

Courtesy of Knoblauch [9]

Table 12

Countermeasure Identified By Accident Typology Development

Countermeasures	% of Accidents
Improve Roadway Markings	11.7
Provide Sidewalks/Paths	11.6
Improve Roadway Lighting	11.5
Improve Pedestrian Safety at Nonsignalized Intersections	8.6
Provide Fenced Play Areas	8.1
Provide Crosswalks	8.1
Improve School Trip Walking Safety	6.5
Improve Vehicle Warning Systems	6.1
Provide Motorist Aid Services	5.9
Improve Vehicle Visibility	5.8
Parking Restrictions	5.7
Improve School/Playground Area Safety	5.4
Enforce Existing Vehicle Regulations	3.9
New Pedestrian Regulations	3.7
Reflectorized Clothing	3.5
Relocate School Bus Stops	3.0
Improve Shoulders	2.9
Control Drinking Drivers	2.5
Control Drinking Pedestrians	2.5
Provide New Signs/Signals	2.4
Improve Roadways in Bad Weather Conditions	2.0
Improve Vehicle Safety	2.0
Improve Existing Signs/Signals	1.8
Remove Trees, Bushes, Etc. as Visual Obstructions	1.8
New Vehicle Regulations	1.4
Relocate Mailboxes	1.3
Provide Pedestrian Barriers	1.2
Improve Parking Lot Design	0.8

Courtesy of Knoblauch [9]

The New Orleans Study

The final pedestrian study to be described here takes an in-depth look at a problem that heretofore has only been mentioned - alcohol. The alcohol problem is so great in adult pedestrian accidents that it justifiably deserved a separate study by itself.

A field accident research study was conducted in the city of New Orleans, Louisiana, in 1975-76 in order to (1) determine the percentage and relative risk of alcohol involvement in adult pedestrian fatal and injury crashes; (2) identify in the alcohol involved accidents any unique accident types or other characteristics which might distinguish these from non-alcohol involved accidents; and (3) study the alcohol use patterns and extent of drinking classifications of these pedestrians [12].

The study was based upon data collected on adult (age 14 or older) pedestrian fatal and non-fatal injury accident cases and the establishment of control groups based on accident and random site sampling. It is important to describe the groups and data sources in order to better understand the results of this effort:

- Fatal Accident Group - this consisted of all pedestrians aged 14 or older who died within 24 hours of a motor vehicle accident in New Orleans between March 1972 and March 1976, a total of 86 cases.

- Injury Accident Group - this consisted of pedestrians aged 14 or older taken to a very large hospital in New Orleans following a motor vehicle accident between March 1975 and March 1976 (excluding Mardi Gras) - 180 cases.

- Accident Site Control Groups - this consisted of similarly exposed but non-accident involved pedestrians aged 14 or older passing the site of the fatal and injury accidents within ±30 minutes of the time of the accident on the same day of the week as the original accident, and as soon as possible after their occurrences. For fatal accidents which occurred before the study period i.e., (pre-1975), sampling took place on the same day of the year (e.g., third Tuesday in June) as the accident. A total of 1,208 of the 1,469 eligible pedestrians provided an alcohol breath test specimen and a short interview.

- Random Site Control Group - this final group consisted of 112 street locations chosen at random and sampled for one hour periods with sampling evenly distributed insofar as possible by time of day and day of week. A total of 80 out of 94 eligible pedestrians provided an alcohol breath test specimen and an interview.

The alcohol results for the accident groups (fatal and non-fatal injury) are indicated in Table 13. Note that in both accident groups, alcohol was involved approximately one-half of the time. Alcohol involvement in adult pedestrian accidents (as opposed to non-pedestrian motor vehicle accidents) appears to be the same for fatal and non-fatal accidents. Alcohol involvement in drivers in motor vehicle accidents is estimated to be 50 percent in fatal accidents [13] and 25 percent in injury accidents [14].

Table 13

BAC Levels For Adult Fatal and Non-Fatal Crash Involved Pedestrians

BAC*	Fatal (N=80)	Non-Fatal (N=143)
.000	49%	51%
.001 - .049	2	9
.050 - .099	4	4
.100 - .149	11	6
.150 - .199	8	7
.200 - .249	9	10
.25+	18	13
	100%	100%

*BAC Data Throughout This Report Are Given as Percent Weight/Volume.

Courtesy of Blomberg, Et Al [12]

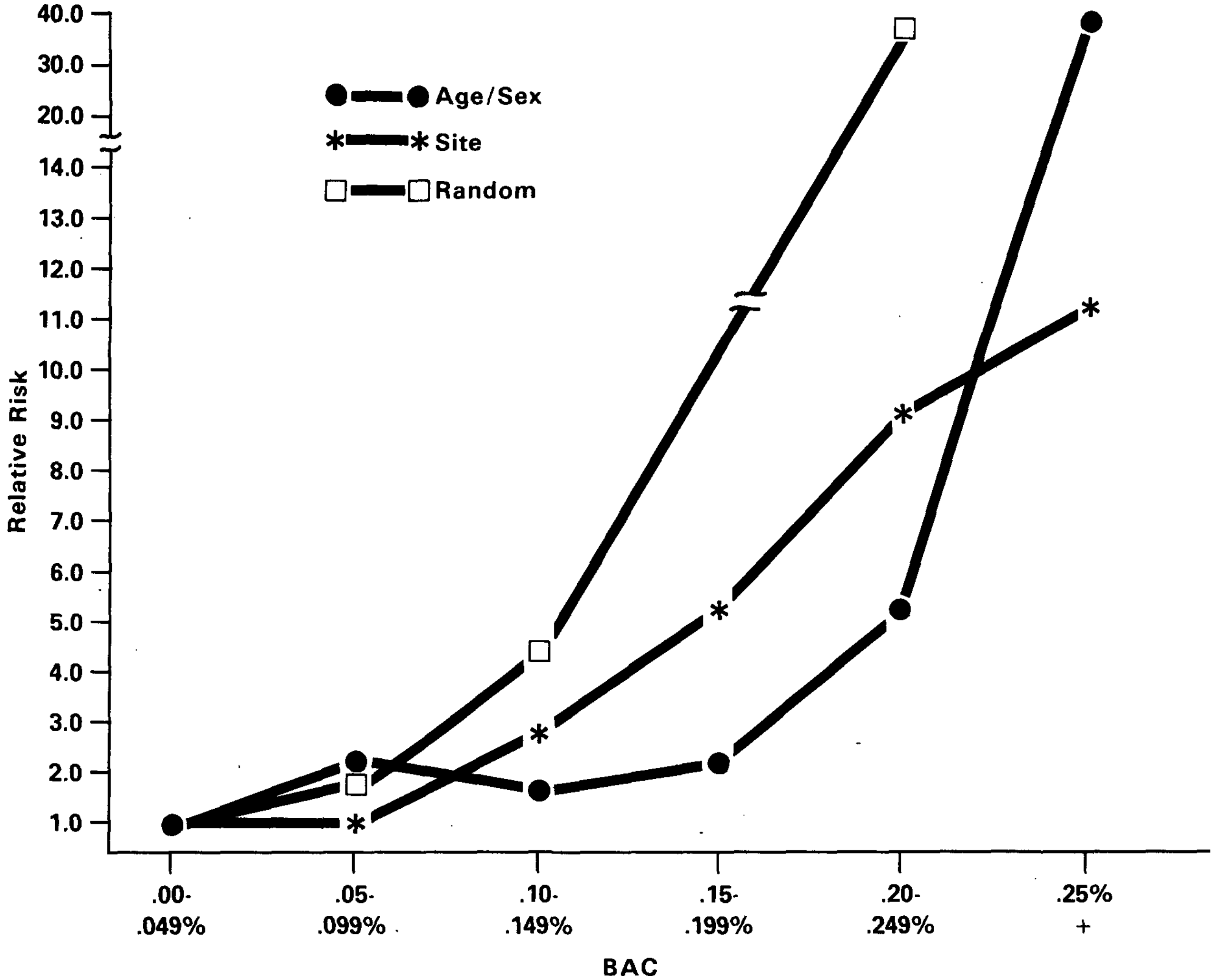
To determine the relative risk of being involved in a pedestrian accident given a pedestrian has been drinking, an equation as suggested by Clayton [15) was used:

$$\text{Relative Risk (of accident involvement at specified Blood Alcohol Concentration (BAC) levels)} = \frac{\dfrac{\text{\% accident sample at specified BAC level } (\geq .05\%)}{\text{\% control sample at same BAC level } (\geq .05\%)}}{\dfrac{\text{\% accident sample @.00 - .049\%}}{\text{\% control sample @.00 - .049\%}}}$$

The results of the relative risk calculations are shown in Figure 6. The relative risk of accident involvement does not show a sharp increase until .20 percent BAC or higher when the conservative age/sex matched control group is used (this control group consisted of that one subject at the accident site location who was the same sex as the pedestrian victim and was closest to the victim in age). This finding may imply that in order for pedestrians to get into roadway crossing problems they must be at very high BAC levels, as opposed to drivers who get into driving problems at .10 percent BAC or higher. The other control groups show an increase in accident risk to the pedestrian at .15 percent and .10 percent BAC.

Figure 6

Relative Risk of Accident Involvement by BAC as Determined by the Three Control Groups



Courtesy of Blomberg, Et Al [12]

With regard to accident types and behavioral errors, it was noteworthy in the findings that 13.6 percent of the accidents involving significant alcohol levels (pedestrian BAC$\geq$.10) were assigned the "pedestrian strikes vehicle" type while only 2 percent of the non-alcohol involved accidents were assigned this type. Apparently, some of these pedestrians are so intoxicated that they are walking or running into the side of a moving vehicle without any detection of the vehicle at all.

The study suggested several countermeasure areas. Here are two of the more promising:

- Regulations - the alarming number of pedestrian victims with BAC levels $\geq$.20 would indicate that a law such as "walking while intoxicated" that Puerto Rico has adopted should be considered. Pedestrians at these high alcohol levels should exhibit very obvious behavior and be readily detectable by police.

- Case Finding/Detection - this study documented a profile of the pedestrian accident in terms of pedestrian age, sex, drinking practices, previous arrests, and situational/location factors. The alcohol involved accident tended to occur between 8 pm and 4 am on week-ends, on two-way roads and expressways where no traffic control exists. The alcohol involved pedestrian tended to be male, between 30 and 59 years old, had a BAC $\geq$.10 and had at least one previous arrest of any type. This profile could be used as a detection aid for screening purposes whenever pedestrians are arrested for alcohol involved offenses or other related problems or for random patrols to remove intoxicated pedestrians from dangerous street situations (see also Reference [16]).

The authors of the study add, however, that no single approach to this complex, socially oriented problem is likely to provide a solution. Only the sum of several efforts has a chance for accident reduction.

FUTURE RESEARCH

Although, perhaps, a bleak picture of the pedestrian accident problem has been painted in this chapter, there is still promise for the future. With the advent of better highway designs and controls in the U.S. in the 1930s and 40s, a significant reduction in the pedestrian accident and fatality rate was seen. But a leveling off of that rate in the 1960s and 70s has indicated there are no easy solutions.

This death and injury toll has been the concern of several safety organizations in the U.S. for some time. The U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) is currently considering possible standards for future vehicle performance which would make the impacts between pedestrians and the vehicles less violent. This proposed rulemaking requires the use of soft bumper materials which would not generate a force of more than 100g at 20 mph in a collision with a pedestrian's leg. Other research at NHTSA and crash tests on pedestrian dummies with various vehicle front end designs indicate that other vehicle countermeasures could be taken. For example, more rounded, contoured hoods could reduce pedestrian injury severity, especially to the upper torso and head.

Pedestrian safety messages and education programs for children have been initiated over the past few years in various areas of the U.S. Many of these demonstration programs are aimed for pre-school and young children where we know the problem is at a peak. Children in these demonstration areas are receiving messages via television and in early school years teaching basic pedestrian safety principles which get at the heart of the child accident problem (e.g., dart-outs at non-intersections; crossing between parked cars). Some of these programs have shown significant impact on accident reduction in certain locations. It will be a few years, however, before we see any national effect of these programs.

Finally, a new accident statistical system has been initiated at NHTSA to track the details of the U.S. accident problem for the next several years. The National Accident Sampling System (NASS) [2] has been established which, by 1983, will consist of 75 accident research teams located at carefully sampled sites around the country. When the accidents these teams investigate are combined, it will be a representative sample of accidents capable of estimating many national figures with known accuracy. The 75 teams will be investigating a sample of 15,000 accidents per year, approximately 2,000 of which will be pedestrian/bicyclist accidents. The data collected in these pedestrian accidents will enable researchers and safety experts to monitor the key issues in the pedestrian problem--the injury severities and associated vehicle contact points; the location of the pedestrians prior to the crash; the "type" of accident in behavioral terms; and the alcohol involvement in adult pedestrian fatalities. These details, along with basic data on pedestrian age, sex, etc., will enable researchers to determine if any impact is being made on the problem on a national basis.

As the four major studies discussed in this chapter have concluded, the pedestrian problem is unique and has no single, high impact solution. A concerted effort of several promising approaches must be made if we are to reduce this significant loss to our nations people.

REFERENCES

[1] U.S. Department of Transportation, National Highway Traffic Safety Administration: "Fatal Accident Reporting System - 1979," Publication No. DOT-HS-805-570, Washington, DC, January 1981.

[2] National Highway Traffic Safety Administration, U.S. Department of Transportation: "The National Accident Sampling System, Report on Traffic Accidents and Injuries for 1979," Publication No. DOT-HS-805-746, Washington, DC, February 1981.

[3] Wolfe, Arthur C. and O'Day, James: "Factbook on U.S. Pedestrian Accidents" Highway Safety Research Institute, University of Michigan, Report No. UM-HSRI-81-05, Ann Arbor, Michigan; sponsored by Motor Vehicle Manufacturers Association, Detroit, MI, February 1981.

[4] National Safety Council: "Accident Facts: 1980 Edition," Stock No. 021.60, Chicago, IL, 45M980, 1980.

[5] Tharp, K. J.: "Multidisciplinary Accident Investigation - Pedestrian Involvement", University of Houston, Houston, TX; sponsored by U.S. Department of Transportation under Contract No. DOT-HS-087-1-177, Publication No. DOT-HS-801-165, PB-233118; available through NTIS, Springfield, VA, March 1974.

[6] American Association for Automotive Medicine: "The Abbreviated Injury Scale - 1980 Revision", Morton Grove, IL, 1980.

[7] Tharp, K. J., and Tsongos, N. G.; "Injury Severity Factors - Traffic Pedestrian Collisions" University of Houston and National Highway Traffic Safety Administration, Society of Automotive Engineers, International Automotive Engineering Congress, 1977; SAE Publication 770093, March 1977.

[8] Garrett, J. W.; Baum, A. S., and Parada, L. O.: "Pedestrian Injury Causation Parameters - Phase II," Calspan Report No. ZS-6117-V-1, March 1981. (Data Analysis Final Report; to be published by U.S. Department of Transportation in 1981).

<u>Data Collection Reports:</u>

Braisted, R. C.; Garrett, J. W., and Hendricks, D.L.: "Pedestrian Injury Causation Parameters - Phase 1," Report No. DOT-HS-805-689, September 1980.

Baird, J. D.; Didion, J., and Heffernan, A.: "Pedestrian Injury Causation Parameters," Report No. DOT-HS-805-652, June 1980.

Durham III, A. M.; Moore, W., and Knoblauch, R. L.: "Pedestrian Injury Causation Parameters," Report No. DOT-HS-805-651, May 1980.

Lawrason, G. C.; Swiercinsky, T. H., and Mason, R.H.: "Pedestrian Injury Causation Study," Report No. DOT-HS-805-653, June 1980.

Schmidt, D. N.; Ravani, B., and Brougham, D.: "Pedestrian Injury Causation Study," Report No. DOT-HS-805-650, August 1980.

[9] Knoblauch, Richard L.: "Causative Factors and Countermeasures for Rural and Suburban Pedestrian Accidents: Accident Data Collection and Analysis," BioTechnology, Falls Church, VA; sponsored by U.S. Department of Transportation under Contract No. DOT-HS-355-3-718, Publication No. DOT-HS-802-266, Washington, DC, March 1977.

[10] Snyder, Monroe B., and Knoblauch, Richard L.: "Pedestrian Safety: The Identification of Precipitating Factors and Possible Countermeasures," Operations Research, Inc., Silver Spring, MD.; sponsored by U.S. Department of Transportation under Contract No. FH-11-7312, Publication No. DOT-HS-800-404, Washington, DC, PB 197750, January 1971.

[11] Hale, A.; Blomberg, R. D., and Preusser, D. F.: "Experimental Field Test of the Model Ice Cream Truck Ordinance in Detroit," Dunlop and Associates, Inc.; sponsored by U. S. Department of Transportation, National Highway Traffic Safety Administration, Publication No. DOT-HS-803-410, Washington, DC, April 1978.

[12] Blomberg, R. D.; Preusser, D. F., Hale, A., and Ulmer, R.G.: "A Comparison of Alcohol Involvement in Pedestrians and Pedestrian Casualties," Dunlap and Associates, Darien, CN; sponsored by U.S. Department of Transportation under Contract No. DOT-HS-4-00946, Publication Nos. DOT-HS-805-248 and DOT-HS-805-249, Washington, DC, October 1979.

[13] U.S. Department of Transportation, National Highway Traffic Safety Administration: "Alcohol and Highway Safety, A Review of the State of Knowledge - 1978," Publication No. DOT-HS-805-172, Washington, DC, December 1979.

[14] Farris, R.; Malone, T. B., and Lilliefors, H.: "A Comparison of Alcohol Involvement in Exposed and Injured Drivers, Phases I and II," Essex Corp., Alexandria, VA; sponsored by U.S. Department of Transportation under Contract No. DOT-HS-4-00954, Publication No. DOT-HS-801-826, Washington, DC, February 1976.

[15] Clayton, A. B.; Booth, A. C., and McCarthy, P.E.: "A Controlled Study of the Role of Alcohol in Fatal Adult Pedestrian Accidents," Great Britian Transport and Road Research Laboratory, Supplementary Report No. 332, 1977.

[16] Blomberg, Richard D.; Fell, James C., and Anderson, Theodore E.: "A Comparison of Alcohol Involvement in Pedestrians and Pedestrian Casualties," presented at and appears in Proceedings of 23rd Conference of the American Association of Automotive Medicine, Louisville, KY, 1979; also published by U.S. Department of Transportation, DOT-HS-805-521, October 1979.