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PEDESTRIAN TRIP MAKING CHARACTERISTICS AND EXPOSURE MEASURES

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16. Abstract

The objectives of this project were to identify specific pedestrian trip making characteristics, develop pedestrian exposure measures and to examine these trip making characteristics and exposure measures relative to accident information in order to determine the relative hazardousness of various pedestrian characteristics and behaviors.

A large-scale field study was conducted in five Standard Metropolitan Statistical Areas (SMSAs). A total of 12,528 person-hours were devoted to observing vehicles and pedestrians at a stratified random sample of locations in five SMSAs. Volume and activity data were recorded on 612,395 vehicles and 60,906 pedestrians. Additionally, 20,147 pedestrians were coded by demographic characteristics and behavior. A total of 1,357 sites were measured, photographed, and described.

Data on pedestrian trip making characteristics and behavior are presented: who walks, where they walk, how they walk (or run), and when they walk. Pedestrian exposure is described in terms of the number of pedestrian-vehicle (P x V) interactions. Exposure data are presented in terms of various pedestrian and site characteristics. Relative hazardousness was determined by comparing the exposure data to pedestrian accident data. The relative hazard associated with various site characteristics, pedestrian and vehicle characteristics, and pedestrian and vehicle actions is presented.

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PEDESTRIAN RISK EXPOSURE MEASURES

PEDESTRIAN RISK EXPOSURE MEASURES
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LIST OF TABLES

LIST OF TABLES
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LIST OF FIGURES

I: INTRODUCTION

Pedestrian deaths represent approximately 18% of all traffic fatalities, and pedestrian accidents account for 5% of all traffic accidents. Public safety agencies regularly compile statistics on pedestrian-vehicle accidents and the resulting pedestrian injuries. This accumulation and analysis of accident statistics is an important task, for the information can identify changes in accident patterns over time and changes in the categories of pedestrians affected by traffic accidents.

This data serves an important alerting function, but it is misused when it is the sole source of data examined in the consideration of safety countermeasures. Missing from analysis of most accident statistics are comparisons of accident behavior with normal, non-accident pedestrian behaviors. These comparisons can permit a determination of relative hazardousness of various pedestrian behaviors. This normal, non-accident baseline data is referred to as pedestrian exposure information.

Acquiring exposure data is critical if accurate assessments of relative hazardousness are to be derived. To explain this, the following example from motor vehicle accident rates is offered. More people have automobile accidents during the day than at night, which would indicate that daytime driving is more hazardous than nighttime driving. But once exposure is considered, it is obvious that while there are more daytime accidents than nighttime accidents, the proportion of nighttime accidents to nighttime exposure is considerably greater than the proportion of daytime accidents to daytime exposure--and therefore, nighttime drivers are more at risk. In looking at pedestrian risk, exposure measures are crucial because they assist in identifying which pedestrian activities are risky and they help identify the characteristics of those pedestrians who perform high risk activities. These "high risk" situations then can be targeted for safety improvements.

With regard to pedestrian accidents, it is known from previous studies (Snyder and Knoblauch, 1970) that the most common category of pedestrian accidents is a "dart-out" at a midblock location. Exposure data contributes information indicating how often dart-outs occur in the course of normal non-accident walking. A statistic derived from both accident and normal non-accident performance can reveal the relative hazardousness of darting out; and we suggest this relative hazardousness statistic is the proper context for studying pedestrian safety.

In recent years, numerous researchers have conducted studies of pedestrian exposure and risk. These include Routledge, Howarth, and Repetto-Wright (1976); Mackie and Older (1965); Todd and Walker (1980); Hillman and Whalley (1979); Jacobs and Wilson (1967); Hauer (1980); and Cameron (1981), among others. While agreeing that exposure must be perceived as a component of risk and that exposure is a condition which must be present as a precondition for an accident occurrence, these researchers have not agreed upon any single measure as the preferred means for counting pedestrian exposure. The measures which have been used, ranging from the general to the specific, include:

1. Population
2. Time spent walking
3. Distance traveled when walking
4. The number of daily walking trips
5. The number of roads crossed
6. Time spent crossing roads
7. The number of pedestrians at a given location
8. The product of pedestrians and vehicles (P x V) at a given location.

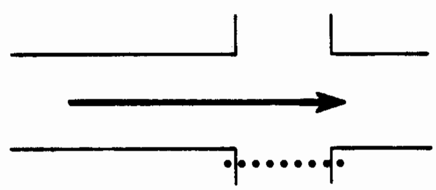
The more general of these measures have been used to give an indication of which segments of the pedestrian population are most exposed, whereas the more specific measures have been used both to determine the exposure of various segments of the population and to compare the exposure at different locations in a roadway system.

Cameron (1967, 1981), an Australian researcher, is most associated with the "pedestrian x vehicles" exposure measure. He makes a very simple point: Pedestrians are simply not exposed to the risk of being hit by a car unless they are at a location where cars are travelling. This is a strong argument against using "time" or "distance" or "number of journeys" as exposure measures. To determine P x V, Cameron et. al. (1976) calculated the product of five-minute pedestrian and vehicle counts in each road section and then summed these over all locations and times to obtain a total measure of pedestrian risk exposure. Cameron (1981) cites two desirable features of the use of PxV as an exposure measure: (1) it is the product of pedestrian and vehicle paths (which has intuitive appeal); and (2) it is consistently summable when partitioned by descriptors of pedestrians and/or vehicles.

The product of **pedestrians** times **vehicles** is an exposure measure which assumes independence between the behaviors of pedestrians and the behaviors of vehicles. Cameron submits that this assumption is justifiable if pedestrians and vehicles are counted within a relatively identical time frame and the periods of observation are short so that it makes sense to presume that any particular pedestrian had a realistic opportunity to encounter any particular vehicle and vice versa.

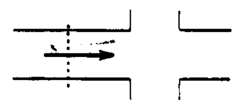
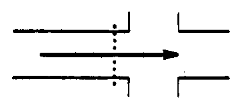
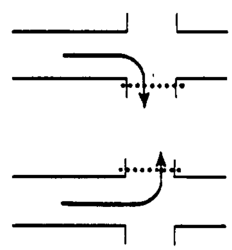
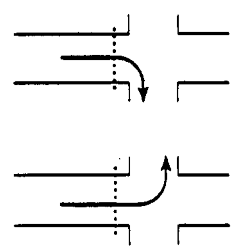
In the present research program this assumption was satisfied by collecting pedestrian and vehicle data within 15-minute segments at any one site.

A limitation of this definition of exposure is that it does not distinguish between different categories of vehicular and pedestrian behaviors occurring within any single site. If the site includes an intersection, the assumption of independence is challenged because a pedestrian crossing a roadway can be in close proximity to a vehicle proceeding through that intersection but never directly encounter the vehicle; since they travel on parallel paths, no accident can result.



Pedestrians times **vehicles** becomes a more precise measure if categories of paths are grouped together in ways that comprise potential accident-possible encounters. Data variable equations for the specification of all exposure variables are provided in Appendix C.

The following categories of pedestrian activity and vehicular flow are grouped into constituent components of exposure. These are the categories of exposure used in the present study. Any single vehicle or any single pedestrian can contribute to more than one constituent exposure measure in the course of transversing a site. Exposure on a per-site basis can be thought of as the summation of the constituent components, or any of the constituent types of exposure could be examined individually. The examples are presented in the context of two hypothetical streets, "Site street" and "Cross street".

Category	Pedestrian Activity	Vehicle Flow	Diagram
Midblock crossing	Pedestrian midblock crossing on site street	Vehicle proceeding straight on site street	
Intersection crossing	Pedestrian crossing site street at intersection	Vehicle proceeding straight on site street	
Intersection crossing with vehicles completing their turns *	Pedestrian crossing site street at intersection	Vehicle turning from site street onto cross street	
Intersection crossing with vehicles preparing to turn *	Pedestrian crossing site street at intersection	Vehicle turning from site street onto cross street: a "pre-turn" encounter	

KEY:

.... PATH OF PEDESTRIAN

———————► PATH OF VEHICLE

*These two vehicles turning exposure measures are subdivided into left turn and right turn situations.

The Data Base

This introductory chapter has two purposes: (1) to introduce the data variables and methodology used in the study and (2) to explain the capabilities of the data base. This latter goal is important since more analyses are possible than could be conducted in the course of this study; it is hoped that other researchers will avail themselves of these data to further examine pedestrian exposure.

There are two components to the data base: Exposure Information and Accident Information. The Exposure Information, in addition to its tabulations of observed pedestrian and vehicle behaviors, includes Exposure Site Weights. The exposure site characteristics describe sites where exposure data was collected and by a projection of the sampling process serve as a description of the nation. The Exposure Site Weights are those multipliers which enable the exposure site descriptions to represent the sites of the nation and the exposure data to represent the behaviors of the population.

The Accident Information consists of Accident Data transcribed from police reports of pedestrian-vehicle accidents. Additionally, there are Accident Site Characteristics and Accident Site Weights. The site characteristics recorded on accident sites include a set of descriptors identical to those used at exposure sites. The Accident Site Weights permit the expansion of the Accident Data from that which was sampled to that which can be compared with the projected exposure data.

Exposure Data

The following data items were collected at each research site. From these items the exposure measures were derived. The first group of items was collected from all pedestrians at the exposure sites. The second group, entitled Pedestrian Activity Sampling, represents data taken from a random selection of about one-third of the pedestrians at each data collection site. Counts were also made of the number of bicyclists, joggers, skaters, blind pedestrians and transportation handicapped pedestrians observed at the exposure sites. In addition to the vehicle counts necessary for the enumeration of the specified exposure measures, other descriptive vehicle variables were also tabulated.

Pedestrian Volumes and Actions

- Number and percentages of pedestrian crossings within a crosswalk
- Number of pedestrian crossings within 50 feet of a crosswalk
- Number of midblock pedestrian crossings
- Number of pedestrian crossings diagonally across intersections
- Total number of pedestrian crossings by site and by hour of the day

Pedestrian Activity Sampling

- Age (estimated)
- Sex
- Accompaniment
- Location
  - on sidewalk
  - on the shoulder (if present), oriented with traffic or against traffic
  - in the roadway, oriented with traffic or against traffic
  - crossing roadway without walking along the site (as in egress from or to a building or car)
  - in the roadway, but not engaged in crossing the road

- Distance walked within site
- Visual obstruction; whether the pedestrian crossed next to or between:
  - parked or stopped car
  - car in traffic lane
  - parked or stopped truck or van
  - truck or van in traffic lane
  - bus at curb
  - bus in traffic lane
- Encroachment by vehicles in crosswalks
- Signal compliance; whether the pedestrian crossed a signalized intersection:
  - on the green with a "Walk" message
  - on the green with a "Don't Walk" message
  - on the green at a signal without a pedestrian signal head
  - on the red or whether the signal changed from green to red during a crossing
- Mode of crossing:
  - Walking
  - Running
- Time exposed in roadway
- Time gap to approaching vehicle (the shortest gap in any lane)
- Vehicle turning behavior while pedestrians cross at intersection
  - no vehicle turned
  - left turn in front of pedestrian
  - left turn behind pedestrian
  - right turn in front of pedestrian (green or no signal)
  - right turn behind pedestrian
  - RTOR in front of pedestrian
  - RTOR behind pedestrian
- Turning vehicle: adaption to pedestrian:
  - no adaption
  - slowed
  - stopped
  - speeded up
  - moved over a lane
- Vehicle proceeding straight: adaption to pedestrian:
  - no adaption
  - slowed
  - stopped
  - speeded up
  - moved over a lane
- Pedestrian crossing: adaption to turning vehicle:
  - no adaption
  - slowed
  - stopped in street
  - speeded up
  - stopped at sidewalk
- Pedestrian crossing: adaption to vehicle proceeding straight:
  - no adaption
  - slowed
  - stopped in street
  - speeded up
  - stopped at sidewalk
- Hypothetical accident types:
  - on sidewalk, no cross
  - midblock cross--normal speed
  - intersection--normal speed
  - midblock dart-out
  - intersection dash
  - right turn on red
  - vehicle turn-merge
  - multiple threat
  - bus stop related
  - exiting/entering parked vehicles
  - trapped by changing light
  - disabled vehicle
  - school bus related
  - hitchhiking
  - walking along roadway
  - playing in roadway
  - vendor, ice cream truck
  - expressway crossing
  - mailbox related

Vehicle Volumes and Action

- Number of total vehicles
- Number/percentage of vehicles of various types:
  - passenger cars
  - vans, pickups
  - other trucks
  - buses
  - taxis
  - motorcycles
- Number/percentage of vehicle turns at data sites:
  - vehicles proceeding straight
  - vehicles making left turns
  - vehicles making right turns (on green signal or intersections without traffic signals)
  - vehicles making right turn on red signals
- Number/percentage of vehicles encountering pedestrians at an intersection:
  - vehicles turning in front of pedestrians
  - vehicles turning behind pedestrians as they cross
  - vehicles turning through the flow of crossing pedestrians
- Number/percentage of vehicles that perform any of the following actions in the data site:
  - signal violations
  - backing up
  - parallel parking
  - driving into or out of alleys or driveways

Special People Counts

- Number of bicyclists
- Number of joggers
- Number of skaters
- Number of blind pedestrians
- Number of transportation handicapped pedestrians

Site Factors

Another group of variables, site factors, are data items which describe characteristics of the research sites. Any of the exposure data variables can be analyzed by site characteristics. For instance, the location of pedestrian crosses can be examined in the context of the number of lanes, roadway width, adjacent land use, etc.

These same site factors were recorded for each of the accident sites. These data, then, are employed in the analysis of differences between accident locations and the randomly selected exposure sites.

The following is a listing of these site factors:

- Intersection land use category and block land use category:*
  - 100% residential (no parks, playgrounds, schools, churches, commercial or industrial uses, or open land uses)
  - residential sites (including schools, parks, playgrounds, and/or churches
  - residential and open
  - open only--undeveloped
  - 75%-99% residential (with the remainder commercial or whatever)
  - 51%-74% residential
  - 50%-75% commercial
  - 76%-100% commercial
  - 51%-100% industrial

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* The intersection description includes just the structures adjoining the intersection; the block land use refers to those structures along the length of the site street.

- Roadway functional classification:
  - suburban, small town, city locations:
    - -- limited access (grade separated intersections only)
    - -- controlled access (intersections, but no access to abutting property)
    - -- major arterial highway (direct access to abutting property)
    - -- collector-distributor
    - -- local street
    - -- frontage or service road
    - -- other
  - County locations:
    - -- limited access (i.e., interstate)
    - -- primary highway
    - -- secondary highway
    - -- improved surface roadway
    - -- unimproved surface road-way
    - -- frontage or service road
    - -- other

- Parking on commercial premises (does not refer to on-street parking):
  - no business with parking on premises (POP)
  - < 1/4 of frontage has POP
  - ≥ 1/2, < 1/2 of frontage has POP
  - ≥ 1/2, < 3/4 of frontage has POP
  - ≥ 3/4 of frontage has POP

- Parking restrictions (signs or markings):
  - permitted, both sides of roadway
  - permitted, one side of roadway
  - prohibited, both sides
  - no posted restrictions, roadway width limits parking, one direction
  - no posted restrictions, roadway width limits parking, both directions
  - restrictions vary by time of day and/or day of week

- Parking meters:
  - none
  - one side
  - both sides

- Road surface material:
  - concrete
  - bituminous (blacktop)
  - gravel
  - dirt and sand

- Road surface condition:
  - Good (no cracks over 1" and no holes or bumps)
  - Fair (some large cracks and small depressions)
  - Poor (potholes, bumps and/or ruts)

- Median (the portion of a divided highway separating the traveled ways for traffic in opposite direction):
  - none
  - barrier (fence, guardrail, safety shape, etc.)
  - curb or island
  - painted pavement (other than center line markings)
  - grass
  - dirt or sand
  - gravel
  - trees and/or shrubs
  - other

- Shoulder surface (roadway edge from traveled way to change in slope, suitable for stopped vehicles, emergency use, or lateral support):
  - none
  - concrete
  - bituminous (blacktop)
  - gravel, shell, shale
  - dirt or sand
  - grass
  - combination
  - other

- Roadway center markings:
  - none
  - double solid center line
  - single solid center line
  - one dashed, one solid center line
  - left-turn lane markings
  - single dashed center line
  - other

- Roadway edge markings:
  - none
  - pavement edge markings (paint only)
  - roadside delineators (raised and/or reflectorized)
  - pavement delineators (raised and/or reflectorized)
  - pavement edge markings and roadside delineators
  - pavement edge markings and pavement delineators
  - parking lanes (marked)
  - other

- Roadway lane markings:
  - none
  - dashed lane markings
  - solid lane markings
  - dashed or solid lane marking
  - markings with pavement delineators
  - other

- Pedestrian crosswalks:
  - none
  - marked pedestrian crosswalk for site roadway
  - marked pedestrian crosswalk for cross roadway
  - marked pedestrian crosswalk for both roadways

- Crosswalk markings:
  - none
  - crosswalk: lines only
  - crosswalk: lines and diagonal stripes
  - other

- Pedestrian accommodations:
  - unimproved shoulder
  - improved shoulder
  - pedestrian pathway (gravel or blacktop)
  - sidewalk (concrete), with curb
  - sidewalk (concrete), without curb
  - curb only, no sidewalk
  - other

- Street lighting (luminaires):
  - none
  - regularly spaced
  - non-regularly spaced

- Commercial lighting (for signs and/or businesses):
  - none
  - through whole site (at least one side)
  - not whole site

- Intersection type:
  - none
  - 4-leg
  - "T"
  - "Y"
  - multiple leg
  - jog
  - "L"
  - interchange
  - other

- Signalization:
  - no signalization
  - red, green, amber (RGA) signal
  - RGA and pedestrian signal
  - Flashing red and/or amber beacon

- Channelization:
  - none
  - left turn channelization
  - right turn channelization
  - both right and left turn channelization

- Roadway signs:
  - stop sign
  - 4-way stop sign
  - yield sign

- Posted or legal speed limit

- Site length, site road width, and crossroad width

Exposure Site Weights

Sample Selection. Each exposure site was assigned a sampling weight, enabling the data to be projected to a representation of exposure in the country. The choice of data collection sites was based on two concerns. One was that the data must be representative of the full range of typical ongoing pedestrian and vehicular activity. The second was that the sample must permit the extrapolation to national representativeness.

In constructing a sample design there is a necessity for determining the exact probability of selection of any sampling unit, based on the necessary stratification factors and the formulas used in building estimates of the parameters of the target population. The site selection process may be conceptualized as a series of decision stages which progressed from the gross selection of city municipalities or counties--referred to as the Primary Sampling Units (PSUs)--to the precise selection of specific intersections and street blocks.

In a national sample survey, the usual initial step is to divide the whole country into a number of PSUs. To facilitate extrapolation of national estimates, PSUs were chosen via a process which utilized as a model the National Accident Sampling System (NASS), developed by the National Highway Traffic Safety Administration. The stratified sample of NASS enables automobile accident data to be extrapolated to nationally representative figures. In the initial specification, 1279 PSUs were identified. These PSUs were stratified into ten strata using the following characteristics: population, gasoline sales per capita, road miles per capita, percent urban geography, and climate. We confined the present survey (for reasons of efficiency and effectiveness) to NASS strata 1, 2, 3 and 4. Their characteristics are:

- Stratum 1: Central cities of the ten largest SMSAs (Total SMSA population greater than 2,500,000)
- Stratum 2: Central cities of the 11th-60th largest SMSAs (Total SMSA population over 600,000)
- Stratum 3: Other areas of 17 largest SMSAs, (Total SMSA population over 2,000,000) service station sales below average
- Stratum 4: Other areas of 17 largest SMSAs, service station sales above average

Each of the 10 strata contains approximately equal amounts of the United States population (between 19,633,000 and 24,123,630). Thus, they each contain about 10% of the total U.S. 1977 population (less Alaska).

Five PSUs plus a pilot test PSU were included in the study. An effort was made to more precisely measure pedestrian activity in the larger population areas. In these areas there would presumably be greater amounts, and possibly greater variability, of behavior (and fewer empty data collection hours). Therefore, two PSUs were chosen from Stratum 1, two from Stratum 2, and one PSU from the combined Strata 3 and 4 (collapsing over the stratification variable of gasoline sales). The effect of this decision limited then representativeness of the study to the more urban areas of our country, eliminating PSUs which represent populations smaller than the 61st largest SMSAs and non-central cities of the 18th to 60th largest SMSAs.

The present study, therefore, can only represent pedestrian exposure of the approximately 88 million people who live in our more urban areas--the central cities of the 60 largest

SMSAs, plus other areas of the 17 largest SMSAs.

The PSUs included in this study were:

Stratum 1
Brooklyn, New York
St. Louis, Missouri

Stratum 2
Seattle, Washington
St. Petersburg, Florida

Strata 3 and 4
Prince Georges, Charles Counties, Maryland

Pilot Study
Washington, D. C.

Within PSU Site Selection. The selection of the ultimate sampling units--the intersection and blocks where exposure data were collected--followed a sampled process developed exclusively for this study.

Theoretically, the perfect research design would involve data collection at every intersection and associated block segment in a municipality. This "census" of pedestrian behavior would cost more than anyone would be willing to spend. Failing to achieve this comprehensive coverage, one would want to know the composition (both geometry and adjoining land usage) of every intersection and associated block segment,so that actual data collection sites could be compared with the full range of all possible sites and correctly interpreted as a sample of the population of all possible sites.

The chosen alternative was to inventory a selection of intersections and blocks within the sample's PSUs. This inventory served three purposes:

1. It was used as a representation of the complete PSU for purpose of extrapolation of the data.
2. It was used to determine a stratification scheme for choosing the actual data collection sites.
3. It provided a pool of sites from which the actual data sites will be chosen.

For this inventory, random square areas were selected and every potential site within the chosen squares was charted. The size of the squares were chosen so as to inventory approximately 5% of the total area (and total number of sites) in each PSU. The number of inventoried squares in each PSU most commonly was 20.

The squares were chosen on the basis of random selection using municipal maps' grid coordinate systems. A modification was imposed on simple randomness to selectively over-represent the major commercial and highest density sections of the PSU. Instead of simple random selection, the potential squares from the central area were pulled from a separate random draw--to ensure that some CBD squares were chosen. Additionally, more CBD squares were chosen than would have been predicted by chance selection of the PSU. This over-representation assures that the areas of great pedestrian concentration will be more accurately sampled than might otherwise be possible. This over-representation is corrected in the final extrapolation of data.

Inventory Categories. For every potential site, intersections and blocks were inventoried on the basis of the following categories:

- Land use
  - 100% residential (no parks, playgrounds, or churches)
  - Residential--(with parks, playgrounds, schools and/or churches, but no commercial or industrial)
  - Residential and open

- Open only--undeveloped
- 75%-99% residential (with the remainder commercial or whatever)
- 51%-74% residential
- 50%-75% commercial
- 76%-100% commercial
- 51%-100% industrial
- other

- Signalization
  - Intersection with traffic signal
  - No signal at intersection

- Number of traffic lanes

- Length of block

The field Site Inventory form is presented in Appendix B.

Site Selection. Upon completion of the inventories, stratification categories were determined based on land use (aggregated to three categories: 100% residential; commercial; and other, mixed residential uses), signalization, and number of traffic lanes (aggregated to "two lanes or less" and "more than two lanes"). Intersections and site blocks were selected through the following methods:

- Intersections were randomly selected with equal probability within each stratification category.

- Roadways were randomly selected within each category (excluding signalization) by locating points along an enumeration of all roadway lengths within categories, assuring probability of selection proportionate to size.

- For each roadway selected, one of the two possible intersections were randomly assigned.

- For each intersection selected one of the attached roadways was randomly assigned.

Estimation. Through these processes, each intersection had a definite calculable probability of selection. It would be extremely cumbersome to calculate these probabilities of selection for the overall estimation based on the four point selection process. A more efficient alternative was adopted in which the total sample of intersections within stratification categories was considered the result of a single equal probability random selection, regardless of whether they were selected directly or through association with selected roadways. This enabled the direct calculation of the probabilities of selection.

The selected roadways were considered in the same manner. They were placed in stratified categories depending on their adjacent land use, number of lanes, and length. A sampling weight was assigned to site blocks in addition to the one assigned to the intersection--reflecting that some variables are of interest to the parameters of intersections, while others need to be discussed in the context of intersection-plus-block units. Since the number of intersections in a PSU differs from the number of sites, two different weights for estimation are necessary. (The computer data file documentation specifies the appropriate weight for each variable.)

The multiplier for estimation is the product of the inverse of the selection probabilities of the different stages:

- Selection of a PSU within a NASS stratum

- Selection of squares within a PSU

- Selection of intersection within a category of intersections (or a block within a category of blocks)

The sample weighting/estimation procedure was used to:

- project the data collection sessions to produce hourly pedestrian and vehicle volumes
- project the hourly volumes to produce daily volumes
- project our weekday and weekend data collection schedule to produce a full week of pedestrian and vehicle activity
- project our stratified random sample intersections and roadway segments to represent an entire city
- adjust for our deliberate over-sampling of CBD areas
- project our city totals to represent their NASS strata
- project our NASS strata totals to represent the study "nation". In this study, our "nation" is the most heavily populated 40% of the country.

Accident Data

From each of the PSUs a file of recent police accident reports on pedestrian-vehicular accidents was established. Accident reports were selected on the following basis:

- Accidents had to have occurred in the same general time of the year as the exposure data was collected.
- No preselection of reports; the reports were to represent a random collection of pedestrian accidents.
- The desired number of accidents per PSU was 200.

Certain categories of accidents were excluded, including those which fell into aberrant categories of behaviors for which there was no comparable exposure data category--such as joyriders falling off the backs of buses or trucks. These exclusions reduced the total number of accidents analyzed. Additionally, accidents which occurred during hours when exposure data was not collected were not included in the determination of hazardous scores, though they were used for internal analyses. Since police accident reports differ from jurisdiction to jurisdiction, a standard form was developed. The data from police accident reports were transcribed onto this form. The following are the data items on this form:

- Day of accident
- Time of accident
- Accident was
  - At intersection
  - Not at intersection
- Number of pedestrians injured
- Injury to pedestrian (most severe injury if more than one pedestrian)
  - Fatal
  - Disabling/Hospitalization
  - Non-disabling
  - None
- Pedestrian age
- Pedestrian sex
  - Male
  - Female
- Road condition
  - Dry
  - Wet
  - Ice/Snow

- Light condition
  - Daylight
  - Night
  - Dawn
  - Dusk

- Vehicle type
  - Passenger Car
  - Taxi
  - Van, Pickup
  - Other truck
  - Bus
  - Motorcycle

- Pedestrian location
  - In marked crosswalk
  - In unmarked crosswalk
  - With 50' of intersection (not in X-walk)
  - More than 50' from intersection
  - Diagonally across intersection
  - on sidewalk

- Pedestrian crossing
  - With signal (green)
  - Against signal (red)
  - Midblock
  - Between parked cars
  - Intersection with no signal
  - At signal but no information as to whether green or red.

- Pedestrian Grouping
  - Alone
  - With others

- Pedestrian sobriety
  - Had not been drinking (sober)
  - Had been drinking

- Driver action
  - Going straight
  - Backing up, parallel parking
  - Turning right
  - Right turn on red
  - Turning left
  - Entering, exiting roadway
  - Other

- Driver sobriety
  - Had not been drinking (sober)
  - Had been drinking

- Accident type
  - On sidewalk, no cross
  - Midblock cross--normal speed
  - Intersection-normal speed
  - Midblock dart-out
  - Intersection dash
  - Right turn on red
  - Vehicle turn-merge
  - Multiple threat
  - Bus-stop related
  - Exiting/entering parked vehicles
  - Trapped by changing light
  - Disabled vehicle
  - School bus related
  - Hitchhiking
  - Walking along roadway
  - Playing in roadway
  - Vendor, ice cream truck
  - Expressway crossing
  - Mailbox related

- Traffic condition
  - Heavy
  - Medium
  - Light

- Pedestrian mode
  - Walking
  - Running
  - Jogging

In addition to the coded items, a brief (80 characters or less) narrative of the accident was transcribed.

Accident Site Characteristics

All accident sites were visited by field investigators and a site description form was filled out identical to that used at exposure sites (and previously described).

Accident Site Weights

Site weights for the accident statistics are considerably less complicated than those attached to exposure sites. Within each PSU, the weight reflected the number of pedestrian accidents occurring in a year divided by the number of accidents included in our sample. The weights associated with extrapolation from the PSU to the stratum level are identical to those as presented in the discussion of the exposure data.

Size of the Data Sample

One of the formats in which exposure measures are presented in this report are as national projections of Pedestrian-Times-Vehicle exposure. Since a few cities' data are extrapolated to represent the nation's, these projections become quite huge (despite the fact that this sample's "nation" is limited to the upper 40% of our population centers). Indeed, what becomes important are not the absolute numbers but the relationships between them.

Not only do the site weights represent large multipliers in the determination of these projections, but the raw data itself is substantial --reflecting the seriousness of the Federal Highway Administration and of the researchers on the staff of the involved contractors who were committed to the task of providing a national picture of the characteristics of pedestrian exposure.

Data findings in this report are organized in three areas: Pedestrian Tripmaking Characteristics, Exposure Measures, and Indices of Relative Hazardousness. While the weighting formulas necessary for developing sensible national estimates of behavior may be sophisticated, the intended use of the data is straightforward. The goal in each area is description. Because the aim is to describe behaviors, the report findings are presented in a simple format which may belie the complexity of the process which generated the data. For instance, data is mostly presented in terms of percentage differences within categories of behaviors or categories of the environment. Generally absent are statistical statements indicating the significance levels of various findings.

This is done for several reasons; foremost among them is that the purpose of this project was the collection and presentation of a descriptive data base. Our stated goals were to describe pedestrian characteristics and pedestrian exposure and to determine the relative hazardousness of various pedestrian factors. The third section, on relative hazardousness, illustrates this point. Two data bases are combined. One is pedestrian accident data, the other, pedestrian exposure data which represents the activities of the normal non-accident involved population. Within any category--either behavioral or environmental--contributions to the two data bases are compared. For instance, males account for 60% of pedestrian accident victims and they also represent 60% of the walking population. The hazard score compares these two percentages of involvement in a single descriptive statistic--in this case, 1.0--indicating that while males are more involved in accidents, this involvement is in accord with their contribution to the population.

Such a statistic is neither significant or non-significant. It is merely descriptive. Fifty-three percent of the accidents involve a pedestrian who is running across the street; only 11% of pedestrians were observed running across the street. The hazard score for this behavior is 4.7. Each hazard score tells its own story of over-involvement or under-involvement in the accident data base. Comparisons are appropriate only when looking at hazard scores for various categories of one response variable.

The Pedestrian Tripmaking Characteristics Chapter presents pedestrian volumes and actions from sampled sites which have been weighted to national projections. The weighting involved using the number of sampled sites of that type and the number of that type of site in the nation. Chi-square tests run on the weighted data produced high levels of significance--primarily because the numbers are very large.

Statistical tests could not be run on the unweighted data because the sampling was not strictly random. CBD areas, for example, were oversampled to ensure that they would be represented. Therefore, presenting the sampled N's could be misleading as each case is weighted differently. The computer files are available to any interested person doing further research on the data. Request data tapes from John Fegan, Federal Highway Administration, HSR-30, 6300 Georgetown Pike, McLean, VA 22101. The tapes can be consulted to check any finding that may seem to be caused by a small N weighted to a large number.

Chi-square tests were run on the data frequencies within each category as part of the standard computational procedures. These scores are not presented for three reasons: 1) They were all significant at extreme levels of probability; 2) This significance is, in large part, a reflection of the huge sample size in its raw as well as its weighted form. Significance differs from meaningfulness, and the search for meaningfulness is the actual interpretive task. This point is never clearer than it is with large data bases; 3) Asking whether, in the example of the pedestrian running across the road, if a percentage of one data base is significantly different from a percentage of another is not a simple exercise in contingency table analysis (the family of statistical tests which includes chi-squares).

What complicates the matter further is that the exposure data base is a weighted, projected sample. In light of the fact that no contract objective justified such statistical tests, and that such a contingency table analysis could be a major component of expense in the contract--in effect changing the nature of the contract--and that, in our professional opinion, to ask this question of significance level is to misinterpret what hazard scores provide by way of description, the decision was to exclude such measures of significance from the report.

In this study:

- 612,395 vehicles were tabulated, typed, and coded by particular action.
- 60,906 pedestrians were tabulated and coded by action.
- Additionally, 20,147 pedestrians were coded by demographic characteristics and an extensive behavior typing.
- 12,528 hours of pedestrian and vehicle data were encoded.
- 1357 sites (762 in the accident sample and 495 in the exposure sample) were measured, photographed and described.

The various data bases described in this section have been organized into three basic descriptive areas. The remainder of this report presents these three areas.

- Pedestrian Tripmaking Characteristics and Behavior
- Observed Pedestrian Exposure
- Relative Hazardousness of Pedestrian Characteristics and Behaviors

The project was conceived and executed to obtain descriptive information on the characteristics of pedestrians and the nature of pedestrian exposure. It was not an effort to conduct an experimental evaluation or perform hypothesis testing. The three sections that follow describe various pedestrian characteristics that are associated with certain site factors, behaviors and related conditions. It is important that the reader recognize that correlation between such factors is not necessarily an indication of a causative relationship.

II: PEDESTRIAN TRIPMAKING CHARACTERISTICS AND BEHAVIOR

To better comprehend issues of exposure and risk, it is helpful to develop an understanding of who makes up the pedestrian population and what types of pedestrian activities are most common. By conducting tracking studies, this study noted pedestrian sex, estimated age, mode (running and walking), crossing location, accompaniment, signal observance, and other factors that provide a useful basis for describing American pedestrians' activity and behavior.

A person's likelihood to be walking is dependent on a variety of personal and social characteristics such as age and sex, and the attributes of an area, such as presence or absence of sidewalks, presence of traffic congestion, etc. These factors influence the distance of a pedestrian trip, how many pedestrian trips are made, and how many roads are crossed. They also influence the pedestrian's behavior, as will be discussed later in the chapter.

Throughout this chapter, data on pedestrian activity is presented. Except where otherwise noted, the data is for a full week (five weekdays plus Saturday and Sunday) for the entire nation. Data is generally presented in terms of weighted Ns and percentages.

Who Walks?

This study has defined the nation's urban and suburban walking population in terms of age and sex. Both factors account for many differences in pedestrian behavior. For example, men walk more than women (60% of the walking population is male); men tend to stand in roads more than women (of those observed standing in the road, 70% were men). Children tend to run more than older people; older people tend to walk less in the road or on the shoulder than young people.

Another advantage in describing the pedestrian population in terms of age and sex is that these are variables always reported in accident statistics, facilitating comparisons between accident and exposure data.

Table I shows the age and sex breakdown of the national walking population. The population has been divided into seven age brackets. These age groups have distinctly different patterns of walking and are useful categories to use in comparison with accident statistics.

Young people walk more than older people: pedestrians under 30 account for 50.5% of the sample population, while pedestrians between 30 and 59 and those over 60 accounted for 42% and 7.5%, respectively. Considering that the very youngest children do not walk, the difference is even more dramatic. Young people walk more for several reasons: they have more free time than older people, their activities are generally shorter in duration so they have more activities to walk to in a day (i.e., school, followed by a trip to the store, followed by a visit to a friend's house), and they generally have no automobile available for their trip.

TABLE 1: PERCENTAGE BREAKDOWN OF PEDESTRIAN POPULATION BY AGE & SEX

AGE BRACKET	MALE	FEM	TOTAL
1-4	45.8 0.5	49.4 0.5	95.2 1.0
5-9	332.9 3.5	182.7 1.9	515.6 5.4
10-14	664.2 6.9	304.2 3.2	968.4 10.1
15-19	659.4 6.8	449.6 4.7	1109.0 11.5
20-29	1257.9 13.0	919.3 9.5	2177.2 22.5
30-59	2442.6 25.3	1586.5 16.5	4029.1 41.8
60 & OVER	355.0 3.7	389.9 4.0	744.9 7.7
TOTAL	5757.8 59.7	3881.6 40.3	9639.4 100.0

NOTE: SMALL-TYPE NUMBER REPRESENTS MILLIONS OF PEDESTRIANS IN CATEGORY; LARGE-TYPE NUMBERS REPRESENT PERCENTS

Auto availability, however, initially appears to play no part in pedestrian tripmaking. Table I indicates that the 10-14 year age group comprises 10.1% of the total pedestrian population, the 15-19 year age group comprises 11.5%, and the 20-29 comprises 22.5%. Assuming that this latter group has comparable behavior across all ages in the bracket, a five-year sub-bracket would contribute 11.3%--virtually the same as the previous two age brackets. Automobiles, however, would be available to the older age group and not to the younger ones.

One might have expected the 20-29 year age group to have a smaller percentage of walking population than the next younger group's because of this. One possible explanation is that with the trailing end of the baby boom population in the 20-29 year age group, this ten-year bracket represents more than twice as many people than the previous five-year bracket. However, as Table 2 shows, this difference is only slight. One hypothesis is that the young adult population, although making trips in cars, may tend overall to be a more mobile group than even the younger age groups, making fewer long walk journeys, but more short ones (from the house to the car, from the car to the shop, etc.). The present data base could be further analyzed using the "distance" variable and the results of this analysis could support or discourage this hypothesis.

TABLE 2: PERCENTAGE BREAKDOWN BY AGE & SEX OF NATIONAL URBAN/SUBURBAN NATION (88 MILLION PEOPLE)

AGE BRACKET	MALE	FEM	TOTAL
1-4	3.4	3.2	6.6
5-9	3.4	3.3	6.7
10-14	4.0	3.8	7.8
15-19	4.6	4.6	9.2
20-29	9.6	10.1	19.7
30-59	16.5	17.9	34.4
60 & OVER	6.2	9.4	15.6
TOTAL	47.7	52.3	100.0

More notable than the difference in various age groups' walking is the difference in walking by men and by women. Of the American urban/suburban walking population, 60% are men and 40% are women. This is significantly different than results obtained in England in an analysis of the National Travel Surveys of 1972-3 and 1975-6. This analysis (Hillman and Whalley, 1979) established that women walk more than men by a considerable margin. Men aged 16-64 years were reported to have a mean pedestrian trip rate of .67 per day, whereas women have a mean pedestrian trip rate of .99 per day. It should be noted, however, that men made more total trips per day--a mean 3.14 compared to the women's mean of 2.70.

Another pedestrian study conducted in England (Todd and Walker, 1980) showed women more exposed as pedestrians than men under three measures: mean number of roads crossed per day (9.6 as compared with 8.1), mean time spent walking per day (37.6 minutes as compared with 26.9 minutes) and mean distance walked per day in kilometers (2.04 as compared with 1.82).

In the present study a short access trip to a car is considered as a walking trip and the length of trips is not considered, so this could possibly account for the difference. However, if women in America, as in England, make considerably longer journeys by foot than men do, a random sample could then be expected to reveal a larger portion of women, which it did not. Taking into account all trips (and thus access trips to a car), English men make 53% of all trips made by all means, according to the Hillman and Whalley analysis. This finding narrows the gap in the difference of walking patterns of men and women in the two countries, but does not eliminate it altogether.

There are several possible explanations for the difference. The first would relate to the fact that the American sample is limited to the urban and suburban portion of the nation, and that men may be overrepresented because in the CBDs of large cities there are more men present than women. The English surveys were based on national research, covering rural areas as well as urban and suburban areas.

A second explanation would be that in America more women have access to automobiles than they do in England and therefore they make fewer and shorter walk journeys. Todd and Walker's analysis of the difference between men's and women's journey rates concluded that men would probably have a higher pedestrian activity rate than women if car use was as high among women as it is among men.

It should not be overlooked that land use patterns in this country have led to the types of development that often make use of a car necessary for even the most simple errand. This is the case not only in rural areas, but in large suburban and urban areas, as well. Most English towns, however, developed in times when walking was the main form of transportation, and therefore more of their population may have easier pedestrian access to their town center or local shopping street.

An important issue to consider when looking at age and sex distribution of the walking population, however, is the age and sex distribution of the population at large. Table 2 lists the breakdown for the urban and suburban population as a whole, using the seven age brackets chosen for analyzing pedestrian behavior. In the population there is a 48% to 52% male-female breakdown, which is dramatically different from the 60% male- 40% female breakdown of the walking population.

Figure 1 profiles the difference between the age and sex distribution of the population and the sample. The distribution of the walking population vs. the national population for women is fairly regular, following generally the same curve until the 60+ age category. Because women are longer-lived than men, the percentage of women able to walk after age 60 is presumably higher than the percentage of men able to do so. Young boys (age 10-14) walk considerably more than their percentage in the national population would suggest, as do middle- aged men ages 30-59.

It might be be expected that the age and sex distribution of the sample would vary across the different NASS strata. When considering that the first stratum is comprised of central cities of major metropolitan areas, the male to female ratio would likely be higher there than in the less urbanized strata because more men might be working in Stratum 1--commuting in from the less urbanized areas surrounding the central city. In fact, however, this does not appear to be the case. NASS Strata 3 and 4 have a very high male to female ratio in almost all age groups, with 70% men to 30% women in 30-59 age group. Stratum 1 has a somewhat lower ratio-- 65% men to 35% women--in the 30-59 year age group. Differences in pedestrian behavior across the different strata, then, are not readily explained. Such differences may be an accumulation of small differences attributable to differing land use patterns, work patterns, etc.

Where Do Pedestrians Walk?

Pedestrians obviously will have different types of walking patterns and behaviors given different land uses. While these behaviors will be

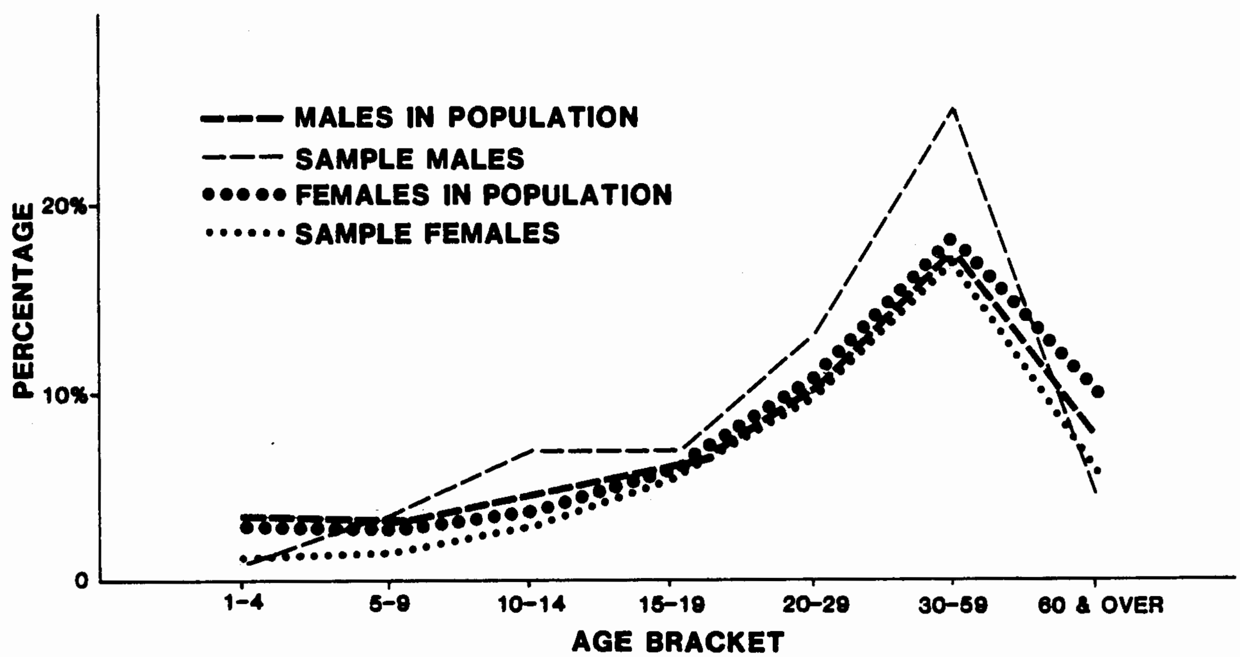


FIGURE 1: COMPARISON OF POPULATION & SAMPLE AGE & SEX BREAKDOWN

analyzed in detail later in the chapter when discussing pedestrian behavior, it is useful to consider here the overall variation in pedestrian activity by land use.

Table 3 highlights pedestrian activity in the three land use aggregations--100% residential, commercial and industrial, and other residential (which includes residential with less than 50% commercial activity, or churches, parks/playgrounds, or some degree of industrial use less than 50%). It is clear that commercial and industrial sites account for the largest share of pedestrian activity overall (39%) and an even greater share of crossing activity (49%). It is the commercial aspect rather than the industrial aspect of this category that causes this great degree of pedestrian activity.

TABLE 3: PEDESTRIAN ACTIVITY FOR THE FULL WEEK ACROSS THREE LAND USE TYPES (IN PERCENTS)

	PEDS WHO CROSS	PEDS WHO DONT CROSS	ALL PEDS
100% RES	1091.2 20.9	1581.2 35.6	2672.4 27.7
COMM & INDUST	2576.9 49.4	1254.7 28.2	3831.6 39.6
OTHER RES	1550.5 29.7	1611.8 36.2	3162.3 32.7
TOTAL	5218.6 100.0	4447.7 100.0	9666.3 100.0

NOTE: SMALL-TYPE NUMBER REPRESENTS MILLIONS OF PEDESTRIANS IN CATEGORY; LARGE-TYPE NUMBERS REPRESENT PERCENTS

The pedestrian activity sampling categorized pedestrians by their crossing actions, and as Table 3 shows clearly, these actions vary by land use. One would expect that trips in residential areas may be shorter than trips in commercial areas, because they might be just to the car or to a neighbor's house. This might also account for the very high percentage of "no crossers" in the "100% residential" and "other residential" categories.

If adjoining land use has an impact on crossing activity, would it not also have an impact on crossing location? As would be expected, in the busiest commercial areas (76-100% commercial) only 26% of the crossings are midblock, whereas in the 100% residential areas, 42% of the crossings are midblock. Because land use, vehicle volumes and pedestrian volumes are all very closely linked, one cannot quickly conclude that land use itself is the critical variable in analyzing this difference in behavior. It is, however, a useful indicator. Differences in crossing mode, grouping, and other pedestrian behavior also varies by land use--primarily because vehicle volumes and pedestrian activity also vary by this factor. These will be discussed in detail later.

Such differences in tripmaking and behavior by land use are reflected across the NASS strata. Obviously the strata exhibit different levels of commercialization. Additionally, these differing levels of development are correlated with differing roadway characteristics.

For example, in Strata 3 and 4 (the suburban areas), a high percentage of people walk in the roadway. This is easily explained: People cannot walk on sidewalks unless sidewalks exist, and in many suburban parts of this country, residential areas and even highway strip developments, (which are commercial) do not have sidewalks. Similarly, suburban areas tend to have longer blocks than central cities, so if (as will be later suggested) more midblock crossings take place at longer blocks, the difference in development patterns regarding block length would cause pedestrian behavior to vary across the strata.

When Do They Walk?

How does pedestrian activity vary by time of day? One might suspect these time-of-day effects might be dependent on such factors as land use, age, and sex. Men's walking patterns, for example, might be different from women's. Another pattern to look for might be that men would walk more at night than women, as this has been a finding in European pedestrian research (Todd and Walker, 1980). This would make sense in this country, since men generally are not as hesitant to walk at night.

To test these hypotheses, Figure 2 plots pedestrian activity by sex across the sixteen sampled hours for the full week. The results are not exactly as would have been expected. While men do show peaks in the 12-1 PM and 4-5 PM ranges, there is no similar morning peak. This may be because noontime and after work hours are often used for errand-running and shopping journeys that are made on foot. In the morning, there is less of this because people generally do not allow time for such activities in the morning, and also, shops are generally not open until after working hours begin.

Men do walk more at night than women, but considering that men represent 60% of the walking population overall, the disparity is not as great as would be expected except in the 10-11 PM hour, when men account for 72% of all pedestrian activity.

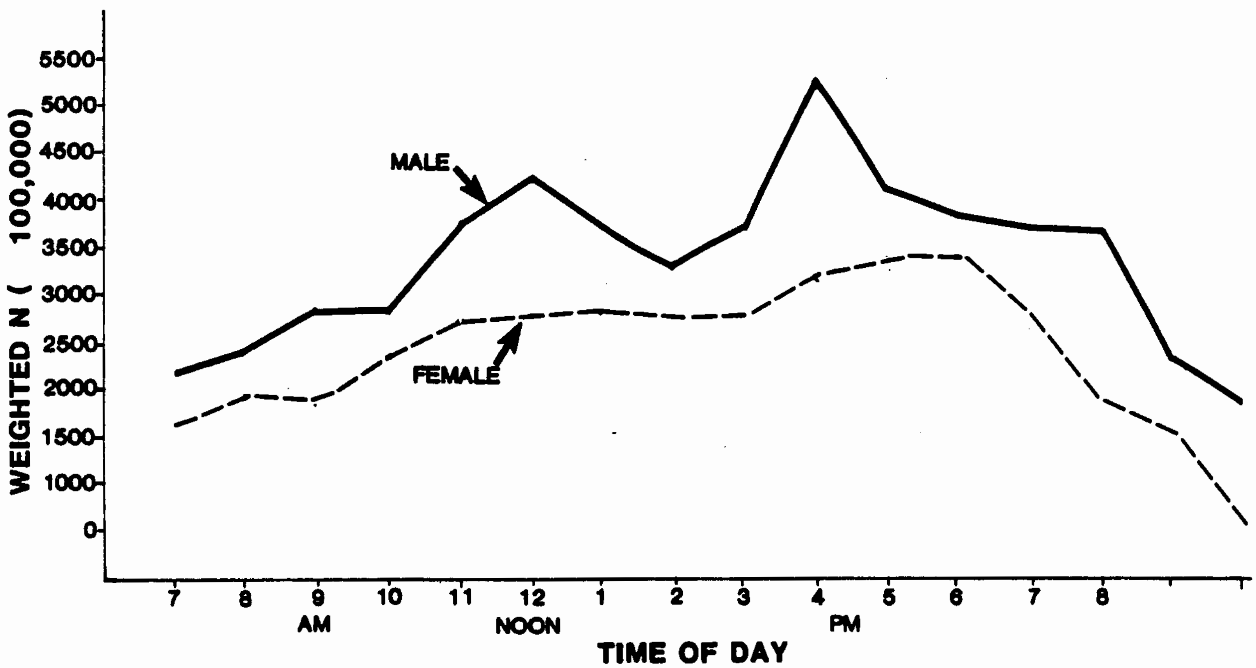


FIGURE 2 : PEDESTRIAN ACTIVITY, BY SEX, ACROSS THE HOURS OF THE DAY, FOR THE FULL WEEK

Women's walking has no noontime peak, which is odd because although fewer women work than men, some peaking would be expected to occur. Because Strata 3 and 4 (the suburban strata) represent half of our study nation, it is possible that the activities of non-working suburban women would flatten the peak. Women's walking has a peak in the 6 PM-7 PM period that seems to be a "returning from work" peak--but it is less marked and occurs later than the male peak evening pedestrian activity.

Table 4 presents the percentage of walking in each hour of the 16-hour sample day and highlights the morning, noon, and evening peak periods. The 4-5 PM hour is the busiest of the day--greater than that of the two-hour 7-9 AM morning peak period.

Pedestrian activity presumably varies by time of day across land use categories, with more activity in the middle of the day in commercial areas than earlier or later in the day, or more activity in industrial areas at shift change times. While these items will not be explored here, issues such as this can be further analyzed with that study's data base.

How does pedestrian crossing activity vary by day of week? As might be expected, weekdays account for the overwhelming majority of pedestrian trips--not only because there are five weekdays versus one Saturday and one Sunday, but because there is obviously more activity on weekdays. The overall activity on a Saturday is 82% as much as that on a weekday and the overall activity on Sunday is just 63% as great as that on a weekday.

Type of crossing, however, does not appear to vary substantially by day of week. Table 5 indicates that on a site-mean basis, midblock crossing contributes 14% of all activity on a weekday, 12% on a Saturday, and 15% on a Sunday. A site mean figure indicates the number of crossings per site per hour, recalling that a site has one intersection and one leg, so only one of the legs around the intersection is counted. Therefore, it should not be interpreted that midblock crossings only account for 14% of all crossings in the nation, as this would be an understatement because an intersection generally has three or four legs.

TABLE 4: TOTAL PEDESTRIAN ACTIVITY BY HOUR OF DAY FOR FULL WEEK

		% OF THE WEEKS PED ACTIONS OCCURRING IN THE PERIOD
TIME (BY HOUR)	7-8AM	4.0
	8-9AM	4.7
	9-10AM	5.2
	10-11AM	5.7
	11-12NOON	7.1
	12-1PM	7.6
	1-2PM	7.1
	2-3PM	6.6
	3-4PM	7.2
	4-5PM	9.1
	5-6PM	7.9
	6-7PM	7.8
	7-8PM	7.1
	8-9PM	6.0
	9-10PM	4.3
	10-11PM	2.6
		100%
	BY KEY PERIODS	
TIME	7-9AM	8.7
	11-1PM	14.7
	4-6PM	17.0

TABLE 5: SITE MEANS FOR MIDBLOCK AND INTERSECTION CROSSES, BY DAY OF WEEK

	INTERSECTION		MIDBLOCK		TOTAL	
	SITE MEAN	% OF TOTAL	SITE MEAN	% OF TOTAL	SITE MEAN	% OF TOTAL
WEEKDAY	17.8	86.0	2.9	14.0	20.7	100.0
SATURDAY	14.8	87.5	2.1	12.5	16.9	100.0
SUNDAY	11.1	85.4	1.9	14.6	13.0	100.0

The following chapter, Observed Pedestrian Exposure, discusses exposure by type of crossing and finds that vehicle volumes cause exposure by type of crossing to vary considerably across the days of the week.

Figure 3 compares the age and sex distribution of pedestrians across weekdays, Saturdays, and Sundays. Women's crossing activity, while always less than men's crossing activity, is even lower still on Saturdays.

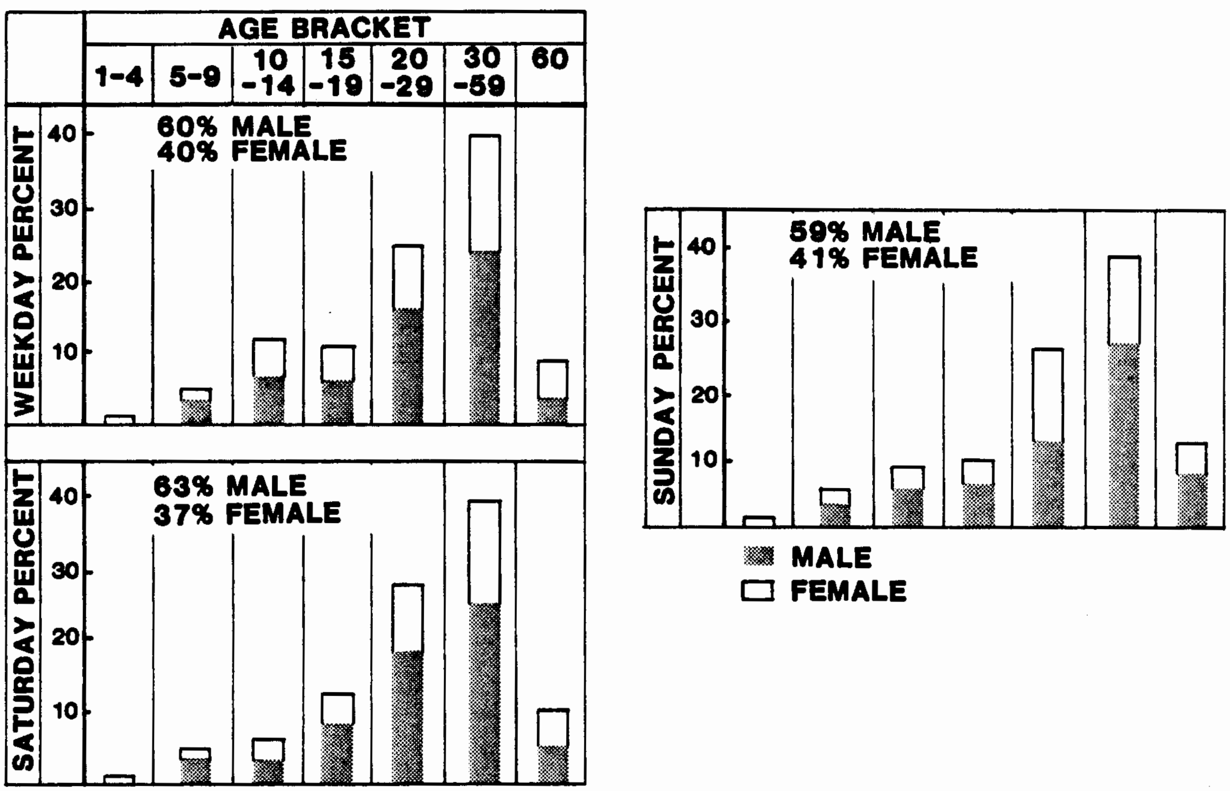


FIGURE 3: COMPARISON OF AGE & SEX PERCENTAGE DISTRIBUTION BY DAY OF WEEK FOR PEDESTRIANS WHO CROSS A STREET

TABLE 6: CROSSING LOCATION BY DAY OF WEEK, EXPRESSED AS PERCENTAGE OF CROSSES BY EACH SEX

	INT & MIDBLOCK		INTERSECTION ONLY		MIDBLOCK ONLY	
	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE
WEEKDAY	493.0 59	335.1 41	284.0 53	249.0 47	209.0 71	86.0 29
SATURDAY	385.9 63	231.6 37	265.1 60	174.9 40	120.8 68	56.7 32
SUNDAY	267.6 59	185.5 41	198.3 60	134.4 40	69.3 58	51.1 42

NOTE: SMALL-TYPE NUMBER REPRESENTS MILLIONS OF PEDESTRIANS IN CATEGORY; LARGE-TYPE NUMBERS REPRESENT PERCENTS

Older people contribute considerably more to the walking population on Sundays than they do any other day of the week, and men comprise more than half this, which is surprising and has no readily understandable cause.

Table 6, however, points out an interesting phenomenon: women account for proportionally more midblock crossings on Saturdays and Sundays than they do on weekdays. There may be several explanations for this; and they hinge on the concept of a threshold level of acceptable gap for safe crossing, and it may be only on weekends that vehicle volumes are low enough to meet this level. Another explanation may be that women may walk more in residential areas on the weekend than men do, and midblock crossings are more common in residential areas than in commercial and industrial areas.

What Do Pedestrians Do?

Pedestrian behavior varies by age and sex of pedestrian, characteristics of the roadway, characteristics of the vehicle flow, and surrounding land use. When several variables correlate with differences in behavior and there is a high degree of collinearity between various variables, it may be difficult to state definitively which variable is the explanatory one. Often it is truly a combination. For example, a pedestrian is more likely to cross the street at an intersection in a commercial area, but he is also more likely to cross at an intersection in a high vehicle volume site. Is the land use or the vehicle volume the explanatory variable?

This section will explore pedestrians':

- crossing behavior
- time spent in roadway
- mode (walking or running)
- accompaniment (alone or together)
- observance of signals/ pedestrian heads
- gap acceptance

TABLE 7: PERCENTAGE BREAKDOWN OF CROSSING LOCATION BY SEX

	ALL PEDESTRIANS (9642.4 MILLION)				PEDSTRIANS WHO CROSS A STREET (5211.4 MILLION)			
	MALE		FEMALE		MALE		FEMALE	
CROSSINGS	N	%	N	%	N	%	N	%
IN CROSSWALK	1474.0	25.6	1284.2	33.0	1474.0	47.3	1284.2	61.4
WITHIN 50' OF THE CROSSWALK	322.4	5.8	217.4	5.6	332.4	10.6	217.4	10.4
DIAGONAL	76.9	1.3	53.3	1.4	76.9	2.5	53.3	2.5
MIDBLOCK	1235.0	21.5	538.4	13.9	1235.0	39.6	538.4	25.7
NO CROSS	2639.6	45.8	1791.8	46.1				
TOTAL	5757.9	100.0	3885.1	100.0	3118.3	100.0	2093.3	100.0
	59.7% OF TOTAL		40.3% OF TOTAL		59.8% OF TOTAL		40.2% OF TOTAL	

Crossing Behavior

Pedestrians are rarely at risk except when crossing streets, so this is obviously the most critical area of pedestrian behavior to discuss. Not surprisingly, there is a great deal of variation in pedestrian behavior across sex and age groupings, land use, vehicle volumes and other variables.

Sex. In looking at pedestrian activity women's and men's crossing behavior is very different. Table 7 displays a percentage breakdown of male and female crossing behavior for all pedestrians and their crossing location. In the sample, females exhibited higher percentages of "no cross" and crosswalk crossings than males. This illustrates clearly that men's walking is made up of greater allegedly unsafe crossing behaviors than women's walking is. So, not only do more men walk (recall that 60% of the walking population is male), but more male activity is unsafe compared with female activity.

Why do women make safer crossings than men? It is possible--though not likely--that women do more of their walking in high vehicle density and commercial areas. These areas generally have allegedly safer pedestrian action because pedestrians perceive the possible dangers, but because volumes are high, total numbers of accidents are higher notwithstanding greater caution on the part of the pedestrian.

Age. Crossing location varies considerably by age, as well. Figure 4 shows the percentage of each age's pedestrian activity in each crossing classification. This exhibit reveals a general pattern--as the pedestrian gets older he tends to cross more in the crosswalk and is less likely to cross within 50 feet of an intersection. (The area within 50 feet of an intersection has been proven, in European research especially, to be a dangerous crossing location.) As the pedestrian gets older, his trips tend to get longer, also, as judged by the relatively lower percentage of "no crosses" in the oldest age category.

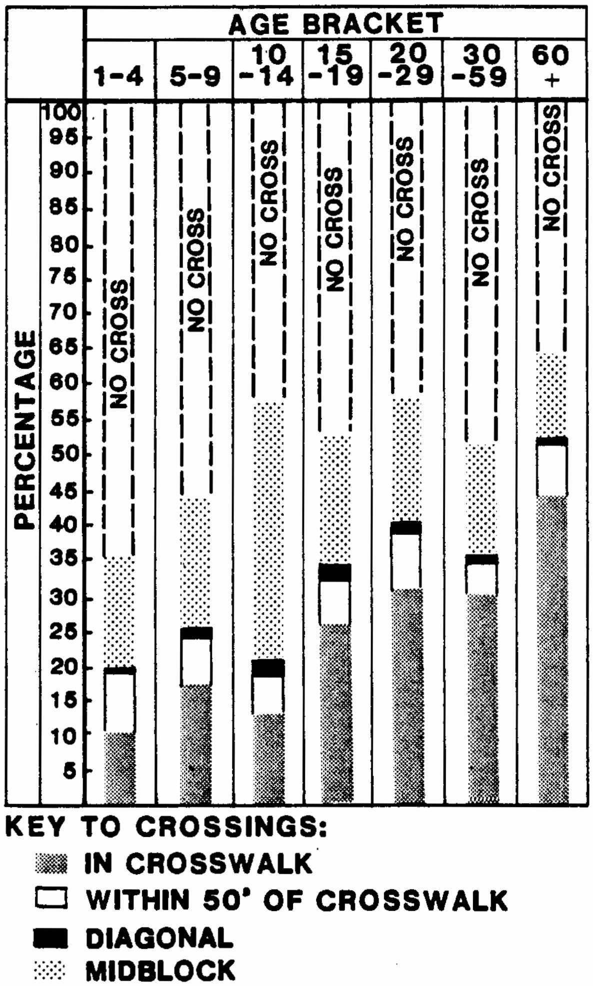


FIGURE 4: PERCENTAGE OF CROSSING LOCATIONS USED BY EACH AGE GROUP

The 10-14 year old age group stands out in terms of its high percentage of midblock crossings and its low percentage of "no crosses". This group also has proportionally more diagonal crosses than the other groups in the population. This finding would indicate the the wisdom of targeting pedestrian safety campaigns at this age group. Of course, before concluding that age, in and of itself, is the cause for unsafe crossing behavior--and that this behavior puts the 10-14 year old pedestrian at risk--it would be useful to examine where these pedestrians are crossing. For instance, if all their midblock crossing is on roads with extremely low volumes in residential areas, they will be less at risk than middle-aged people who might, for example, do all their midblock crossing in busy commercial areas.

Land Use. Commercial land uses account for 40% of all pedestrian activity and an even larger amount--49%--of crossing activity. Of the crossings in the commercial areas, 67% are in crosswalks, as compared with only 41% in the 100% residential areas and 37% in the mixed residential areas. Exhibit II-L provides information on crossing behavior by land use in three forms: the raw numbers of crossings in each category, the percentage of all land uses' crossing activity by crossing location (column percentages), and the distribution of crossing activity across the three land use categories (row percentages).

By looking at the percentages in this way it is clear that while, for example, crossing within fifty feet of an intersection accounts for only 10% of the commercial land use group's crossings, it represents a greater number of crossings than the 14% of the 100% residential groups' crossings at that location (255.7 million weekly, as compared with 151.8 million).

In Table 8, an interesting area to note is the crossing behavior in the "other residential" category. Midblock crossings comprise fully half of this land use's crossing activity. This seems reasonable, since mixed land use areas contain attractions (schools, playgrounds, small amounts of commercial activity) that people would want to reach, without the obstacles of high vehicle volumes that might persuade a pedestrian to cross at the crosswalk. But because mixed land use (other residential) areas tend to have more actual on-street parking than 100% residential areas, midblock crossings might often be made

TABLE 8: RELATIONSHIP OF CROSSING LOCATION AND LAND USE TYPE

		CROSSING LOCATIONS FOR EACH LAND USE TYPE (COLUMN PERCENTS)			LAND USE TYPE FOR EACH CROSSING LOCATION (ROW PERCENTS)			
		100%RES	COMM & INDUST	OTHER RES	100%RES	COMM & INDUST	OTHER RES	TOTAL
CROSSINGS	AT CROSS WALK	448.8 41.1	1732.4 67.2	582.1 37.5	448.8 16.2	1732.4 62.7	582.1 21.1	2763.3 100.0
	WITHIN 50' OF CROSS WALK	151.8 13.9	255.7 9.9	142.8 9.2	151.8 27.6	255.7 46.5	142.8 25.9	550.3 100.0
	DIAGONAL	40.3 3.7	35.0 1.4	55.1 3.6	40.3 30.9	35.0 26.8	55.1 42.3	130.4 100.0
	MIDBLOCK	450.3 41.3	553.8 21.5	770.5 49.7	450.3 25.4	553.8 31.2	770.5 43.4	1774.6 100.0
	TOTAL	1091.2 100.0	2576.9 100.0	1550.5 100.0				

NOTE: SMALL-TYPE NUMBER REPRESENTS MILLIONS OF PEDESTRIANS IN CATEGORY; LARGE-TYPE NUMBERS REPRESENT PERCENTS

between parked cars, and thus would be hazardous. Chapter IV, Relative Hazardousness, discusses in detail the actual hazardousness of different types of crossings.

Vehicle Volumes. Because a pedestrian is only at risk when exposed to a vehicle, it is worthwhile to examine how much pedestrian crossing activity occurs at each level of vehicle density at a site. Table 9 establishes that where vehicle volumes are heavy, pedestrians are more likely to cross in "safe areas"--65% of all crossings in high vehicle volume roads are at the crosswalk, as opposed to only 25% of the low volume area's crossing.

Nonetheless, it should not be overlooked that in actual numbers of crossings, the heavily travelled roads account for more pedestrians--48% of the total pedestrian population. Therefore, while the percentage of crossers making any given type of crossing can be lower in the heavily

TABLE 9
PERCENTAGE OF CROSSINGS AT EACH LOCATION ACROSS THREE LEVELS OF VEHICLE VOLUMES

		VEHICLE VOLUME AT SITE		
		0-160	161-620	621+
CROSSINGS	AT CROSSWALK	289.8 25.2	843.8 54.6	1629.7 64.5
	WITHIN 50' OF CROSSWALK	143.6 12.5	165.1 10.7	241.8 9.6
	DIAGONAL	45.5 3.9	53.0 3.4	31.9 1.3
	MIDBLOCK	671.9 58.4	482.7 31.3	620.0 24.6
	TOTAL	1150.8 100	1544.6 100	2523.4 100

NOTE: SMALL-TYPE NUMBER REPRESENTS MILLIONS OF PEDESTRIANS IN CATEGORY; LARGE-TYPE NUMBERS REPRESENT PERCENTS travelled roads, the number of pedestrians making these movements can actually be higher. For example, crossings within 50 feet of a crosswalk account for 10% of the heavy volume roads' crossings and 13% of the low volume roads' crossings. The actual number of these crossings in the heavy volume roads, however, is almost double that in the low volume roads: 241.8 million per week as compared with 143.6 million per week.

Because vehicle volumes are considered when determining roadway improvements (signals, regular painting of road markings, etc.) and also are the major determinant of the number of lanes on a road, these following variables will be strongly correlated with vehicle volumes.

Signals. As Table 10 shows, greater crosswalk compliance and fewer midblock crossings are observed when a signal is present at an intersection. Of the total of 5218.7 million crossings, the 2100.7 million crossings at signals account for 40% of all crossings. This is important to note because only 6.9% of the intersections in the study's nation are signalized.

Number of Lanes. The breakdown of crossing locations by roads with more than two lanes vs. roads with two lanes or fewer resembles the breakdown by signalized vs. unsignalized intersections, as would be expected. Of the total crossings, 33% take place at roads with more than two lanes, and of the crossings on these roads, 67% take place at crosswalks and only 21% take place midblock. One would suspect a very high proportion of roads with more than two lanes to also be signalized. One could further analyze the data base and look at the crossing behavior at unsignalized roads with more than two lanes to see if the presumed dangers of wider roads encourage pedestrians to cross at the crosswalk.

TABLE 10
PERCENTAGE OF CROSSINGS AT EACH LOCATION AT SIGNALIZED & UNSIGNALIZED INTERSECTIONS

		NO SIGNAL	SIGNAL
CROSSINGS	AT CROSSWALK	1226.3 39.3	1537.0 73.1
	WITHIN 50' OF CROSSWALK	368.6 11.8	181.8 8.7
	DIAGONAL	114.3 3.7	16.1 0.8
	MIDBLOCK	1408.8 45.2	365.8 17.4
	TOTAL	3118.0 100	2100.7 100

NOTE: SMALL-TYPE NUMBER REPRESENTS MILLIONS OF PEDESTRIANS IN CATEGORY; LARGE-TYPE NUMBERS REPRESENT PERCENTS

One would also expect, then, that the busy, wide roads would have marked crosswalks and this might encourage crossing in this allegedly safe location. However, the data in Table 11 discourages this opinion. While true that compliance with crosswalk markings is best in roads where both roads are marked (71% of all crossings in this type of intersection are made at crosswalks), the majority of all pedestrian crossing activity occurs in areas where crosswalks are not marked. This means that there are quite a few heavily travelled (probably commercial) intersections in the nation where the crosswalks are not marked. In fact, in the nation, 68% of the commercial and industrial sites have no crosswalks marked, as shown in Table 11.

An item of interest is that the "other residential" category--the mixed use--has few marked crosswalks. If there is reason to associate presence of marked crosswalks with compliance at crosswalks, this land use would be an area of interest for further research.

TABLE 11 :CROSSING LOCATION AT SITES WITH VARIOUS CROSSWALK MARKINGS (IN PERCENTS)

		NO MARK	1 ROAD WITH MARK CROSS WALK	2ROAD WITH MARK CROSS WALK
CROSSINGS	AT CROSSWALK	1146.3 46.6	203.2 27.0	1413.9 70.5
	WITHIN 50' OF CROSSWALK	301.5 12.3	56.2 7.5	192.7 9.6
	DIAGONAL	106.0 4.3	7.8 1.0	16.5 0.8
	MIDBLOCK	907.5 36.8	484.8 64.5	382.4 19.1
	TOTAL	2461.3 100.0	752.0 100.0	2005.5 100.0

NOTE: SMALL-TYPE NUMBER REPRESENTS MILLIONS OF PEDESTRIANS IN CATEGORY; LARGE-TYPE NUMBERS REPRESENT PERCENTS

TABLE 12
PERCENTAGE OF MARKED CROSSWALKS IN DIFFERENT LAND USE CATEGORIES

	100% RES	COMM & INDUST	OTHER RES
NO MARKED CROSSWALKS	916.4 79.2	218.6 68.1	431.9 81.1
ONE ROAD WITH MARKED CROSSWALK	57.7 5.4	19.3 6.0	79.4 14.9
BOTH ROADS WITH MARKED CROSSWALKS	102.7 9.5	83.3 25.9	21.0 3.9

NOTE: SMALL-TYPE NUMBER REPRESENTS MILLIONS OF PEDESTRIANS IN CATEGORY; LARGE-TYPE NUMBERS REPRESENT PERCENTS

Block Length. Another factor affecting crossing location is block length. It is known that more accidents occur on longer blocks--the median block length for accident sites is 400.3 feet, whereas for all sites in the sampled nation it is 354.8 feet. It is possible that people cross streets midblock when blocks are longer? It is likely that where blocks are long, trip lengths are short, and vehicle volumes and/or speeds are low, a pedestrian will be especially tempted to cross midblock. While this point cannot be fully pursued here, it is a point that can be further analyzed using this data base. In Chapter IV, Relative Hazardousness, block length and hazardousness is discussed.

Time Spent In the Roadway

It is intuitively obvious that the longer a pedestrian stands in the road, the more chance he/she has of being hit by a vehicle. Researchers have used "time spent crossing the road" as a measure in determining pedestrian exposure (Todd and Walker, 1980; Howarth, et. al.). The present study used the nearest second to measure time exposed in the roadway and notable differences on the basis of age, sex and other variables were determined. Because of the difficulties of precisely measuring this activity, only large differences are discussed here.

A very clear finding was that pedestrians crossing at an intersection have a mean time exposed in the roadway of 9.2 seconds, as compared with a 15.4 mean time spent in the roadway for pedestrians crossing midblock. This is, in part a measurement artifact since instances of pedestrians playing in the road would be added in with midblock crossings. Also, pedestrians crossing midblock often have to step into the road to look past parked cars. Being in a hurry, they may also walk along the road until a suitable gap presents itself, and thus be exposed for a longer period of time. Furthermore, midblock crosses are often diagonal crosses, which require a longer period of time in the road.

Table 13 presents time exposed in the roadway by age and sex. What is apparent is that overall no major differences exist between age groups and sexes at intersection crossings, except for the understandable fact that older people and young children tend to take longer to cross a road. At the midblock, however, there are considerable differences. A 32.8 seconds mean exposure was observed for males aged 10-14 and a 22.2 seconds mean exposure was observed for women aged 15-19. (Why females aged 10-14 have a very short mean exposure time is unclear.) As the pedestrians get older, the mean exposure time at a midblock crossing is only slightly longer than that at an intersection. In fact, for the 60+ age group, the mean time exposed in the road at midblock is virtually the same as it is at the intersection. While it could be possible that older people walk--or run--more quickly midblock because they perceive it to be a hazardous location, this finding seems to contradict the general finding that midblock crosses are associated with longer exposure in the road because of diagonal crosses and walking in the road. Of course, when midblock crosses involve none of this behavior and gap determination is made from the curb, a midblock crossing would take the same amount of time as an intersection cross.

It would be expected that mean time exposed in the road would be longer on larger roads because, after all, they are wider. For intersection crossings this holds true, although the difference appears not to be as great as would be expected: For roads with two lanes or less, the mean time exposed in the road was 8.4 seconds, whereas for roads with more than two lanes, the time exposed was 9.3 seconds. At the midblock, however, there was an extreme difference: For roads with two lanes or less, the mean time spent in the roadway was 16.6 seconds, as compared with 10.7 seconds at roads with more than two lanes. Possible explanations of this phenomenon are that more people play or stand in the road when the road is smaller and consequently probably has less traffic, or that people make longer diagonal midblock crosses on narrow roads with low traffic volumes.

TABLE 13 : MEAN TIME EXPOSED IN THE ROADWAY BY AGE & SEX (SECONDS)

AGE BRACKET	INTERSECTION CROSS			MIDBLOCK CROSS		
	MALE	FEMALE	AVG	MALE	FEMALE	AVG
1-4	10.1	14.5	13.2	6.8	11.0	9.7
5-9	8.0	8.1	8.0	9.9	14.3	10.9
10-14	9.0	9.2	9.1	32.8	9.4	28.4
15-19	9.7	8.3	9.0	14.1	22.2	17.1
20-29	8.4	8.4	8.4	14.5	13.5	14.3
30-59	9.0	9.2	9.1	10.3	8.9	9.9
60+	10.3	10.3	10.3	10.5	10.0	10.2
		FOR ENTIRE POPULATION	9.0		FOR ENTIRE POPULATION	15.4

The amount of time spent in the roadway is, of course, related to the pedestrian's walking location, and the long times observed for exposure in the roadway may be partially due to the fact that some roads have no sidewalks so pedestrians **must** be exposed in the road if they walk at all. As Table 14 shows, 4018.4 plus 2989.9 million or 7008.3 million of the total of the 8688.3 million total pedestrian (5193.8 + 3494.5) walk on the sidewalk. Thus, 81% of the pedestrians walk on the sidewalk. However, of the remaining 19% who walk in allegedly unsafe places (walking in the road, standing in the road, walking on the shoulder), males account for 14% of that 19%. The category of particular interest is "standing in the road", which is a 79% male activity.

Age may offer a partial explanation for why so many men stand in the road. Males aged 10-19, while comprising only 17.9% of the pedestrians who cross at intersections, comprise 40.1% of all pedestrians who are located standing in the road before making an intersection crossing.

Another possibility may be that the absence of sidewalks in some areas may skew the sample. For example, the sample PSUs in Strata 3 and 4 account for 28% of all pedestrian activity overall in a week, but for 56% of the standing in the road. Because men comprise 70% of the pedestrian population in these strata, it would be interesting to explore this point further.

Mode

A pedestrian running across a road is often more at risk than a pedestrian who walks because he is distracted and not aware of approaching vehicles, but any discussion of running must be couched in terms of

TABLE 14
PERCENTAGE BREAKDOWN BY SEX OF PEDESTRIANS AT VARIOUS LOCATIONS ON THE ROAD

LOCATIONS		MALE	FEMALE
	SIDEWALK	4018.4 **57.3**	2989.9 **42.7**
	SHOULDER	122.4 **62.5**	73.3 **37.5**
	ROADWAY	410.7 **60.9**	263.7 **39.1**
	STANDING IN ROAD	642.3 **79.3**	167.6 **20.7**
	TOTAL	5193.8 **59.8**	3494.5 **40.2**

NOTE: SMALL-TYPE NUMBER REPRESENTS MILLIONS OF PEDESTRIANS IN CATEGORY; LARGE-TYPE NUMBERS REPRESENT PERCENTS

the fact that only 11% of the pedestrian population runs.

Overall, pedestrians who are alone run slightly more than pedestrians who are with another person, as shown below in Table 15,

TABLE 15:PERCENTAGE BREAKDOWN OF PEDESTRIAN MODE BY ACCOMPANIMENT

MODE / ACCOMPANIMENT	WALK	RUN
PEDESTRIANS ALONE	88.0	12.0
PEDESTRIANS WITH OTHERS	90.1	9.9
ALL PEDESTRIANS	88.9	11.1

but the real difference in walking and running appears to be more easily seen when separating midblock and intersection crosses. At an intersection, 9% of all crosses are made by people who run, whereas at the midblock, 14% are made by running. It seems from the discussion so far that people who do one hazardous thing may also do another--if they cross midblock, they will also run.

There is proportionally no more running seen in more heavily developed areas of the city. Such a finding is not observed for the simple reason that there are fewer children and hence less play activity in the CBDs. Examining the phenomenon in slightly different terms in Table 16, a very slight increase in running in commercial areas is seen. This increase in running is wholly accounted for by midblock crossings. In fact, were midblock crossings to be considered alone, the ratio of walking crosses to running crosses would be 77% to 23%.

TABLE 16
PEDESTRIAN CROSSING MODE

BY LAND USE CATEGORY	WALK	RUN
100% RES	937.5 87.3	135.8 12.7
COMM & INDUS	2276.7 88.9	283.6 11.1
OTHER RES	1385.3 89.7	159.1 10.3
TOTAL	4599.6 88.8	578.5 11.2

NOTE: SMALL-TYPE NUMBER REPRESENTS MILLIONS OF PEDESTRIANS IN CATEGORY; LARGE-TYPE NUMBERS REPRESENT PERCENTS

One-way streets and streets with more than two lanes are more frequently crossed by running than would be expected, all things being equal. Table 17 shows that the running is accounted for by midblock crossers. There is a high degree of collinearity between one-way streets and streets with more than two lanes, and therefore the data on these two variables is presented together.

Because one-way, large streets often have high vehicle volumes, it would be interesting to look at the crossing mode at these streets across a range of vehicle volumes. One would expect that as vehicle volumes are higher there would be less running.

Accompaniment

It is interesting to look at accompaniment in terms of age and land use. Figure 5 confirms common sense: as people grow older they tend to walk more alone. Very young children are

TABLE 17 : CROSSING MODE AT ROADS WITH DIFFERENT WIDTHS AND DIRECTIONS

		INTERSECTION				MIDBLOCK			
		WALK		RUN		WALK		RUN	
		N	%	N	%	N	%	N	%
LANES	2 OR LESS	1905.6	92.0	165.7	8.0	1218.0	87.8	168.7	12.2
	MORE THAN 2	1223.3	90.3	130.7	9.7	252.7	69.0	113.4	31.0
	TOTAL	3128.9	91.3	296.4	8.7	1470.7	83.9	282.1	16.1
DIRECTION	ONE-WAY	1357.0	92.2	114.7	7.8	192.9	72.7	72.4	27.3
	TWO-WAY	1771.9	90.7	181.7	9.3	1277.8	85.9	209.6	14.1
	TOTAL	3128.9	91.3	296.4	8.7	1470.7	83.9	282.1	16.1

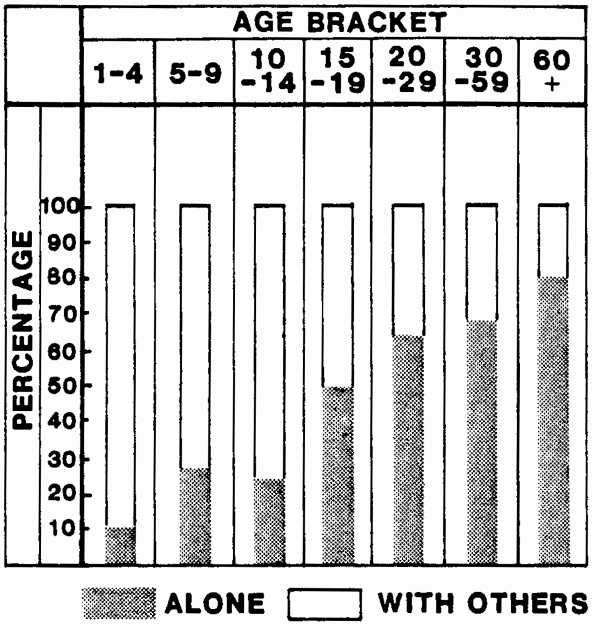


FIGURE 5:
PEDESTRIAN ACCOMPANIMENT BY AGE

almost always accompanied (86% of the time), and older people are almost always alone (79% of the time). That 64% of walking in commercial areas is done by pedestrians alone is not surprising, then, because fewer young people walk in these areas. In 100% residential areas where children would be seen frequently, 53% of the walking is done by unaccompanied pedestrians, and in other residential areas--the mixed use category--59% of walking is done by unaccompanied pedestrians.

Observance of Signals and Pedestrian Heads

Women in all age groups have a very high compliance with signals at signalized intersections--92% of women who cross at a signal cross on the green, as shown in Table 18, and there is little variation between age groups. Men, on the other hand, show an extreme difference in signal observance between age groups, and their overall observance of signal regulations is only 89%. Men between 15 and 19 are the worst offenders; they cross on the red about 18% of the time.

Signal compliance is generally better in the central business district than outside of it, which is understandable because the CBD has heavier vehicle and pedestrian traffic. Table 19 pictures a full week's signal observance by all pedestrians who cross at signals in terms of CBD vs. non-CBD, vehicle volumes, and land use (these variables were chosen as it was felt these items are interrelated). The three variables point to the same conclusion: people are more observant of signals where there is a need to be observant--in commercial areas like the CBD where vehicle volumes are high.

TABLE 18:
SIGNAL OBSERVANCE BY DIFFERENT AGE GROUPS OF EACH SEX, IN PERCENTS

	MALE		FEMALE	
	GREEN	RED	GREEN	RED
AGE BRACKET 1-4	98.4	1.6	100.0	0.0
5-9	91.1	8.9	96.6	3.4
10-14	86.3	13.7	87.6	12.4
15-19	82.2	17.8	99.2	10.6
20-29	87.1	12.9	92.3	7.6
30-59	92.1	7.9	92.7	7.3
60 & OVER	86.8	13.2	91.5	8.5
TOTAL %	89.3	10.7	92.1	7.9
TOTAL N	786.4	93.9	762.7	66.6

A very similar pattern is seen for observance of pedestrian heads--"walk" and "don't walk" signals. Pedestrian heads are present at only half of the signalized intersections, so there are very few low volume sites with pedestrian heads. Obviously, pedestrian heads are installed where they are needed--generally at busy intersections with high traffic volumes.

Table 20 summarizes observance of pedestrian messages at signals by pedestrians who cross on the green. Notice that this correlates with the information in Table 19: a person at a busy street is likely to wait for the green and then have a "walk" message. In other areas there is probably less stopping and waiting for a safe crossing.

Gap Acceptance

Gap acceptance is a function of roadway crossing. How far away must a car be from the pedestrian before the pedestrian will feel that a crossing is safe? This is a complex issue--one which involves the pedestrian's perception of the approaching car's speed as well as his own walking speed, his confidence, and his ideas about whether a driver will slow down to let him pass. These perception issues can all be related to age, certainly. For example, an older pedestrian, who walks infrequently in traffic, may not accurately judge the time required to cross the street. Land use differences also play a role in the pedestrian's perceptions. In residential areas, a pedestrian may feel a driver will be more likely to slow down to let him cross, whereas in heavily trafficked commercial areas, he might not think a driver would be willing to do this.

There are also very basic traffic flow characteristics that affect gaps. Signals will cause very short gaps for a dispersing queue and then very long gaps after a platoon has passed. Roads with no stop sign or signal at the intersection will have relatively long gaps. Intersections would have fewer gaps than midblocks because there are turning vehicles as well as straight vehicles to consider. Low volume roads will, of course, have longer gaps than high volume roads.

Crossing location might also be a factor in gap acceptance, as vehicles tend to travel slower near an inter-

TABLE 19 : SIGNAL COMPLIANCE VIEWED IN TERMS OF CBD/NON CBD AREA, VEHICLE VOLUMES, & LAND USE IN PERCENTS

		CROSSED ON:	
		GREEN	RED
CBD DESIGNATION	CBD	92.2	7.8
	NON-CBD	86.2	13.8
	TOTAL	1561.6 90.7	160.5 9.3
VEHICLE VOLUMES (PER HOUR)	160 OR LESS	81.3	18.7
	161-620	82.1	17.9
	621 OR OVER	92.5	7.5
	TOTAL	1561.6 90.7	160.5 9.3
LAND USE	100% RES	83.2	16.8
	COMM & INDUST	92.3	7.7
	OTHER RES	79.9	20.1
	TOTAL	1561.6 90.7	160.5 9.3

NOTE: SMALL-TYPE NUMBER REPRESENTS MILLIONS OF PEDESTRIANS IN CATEGORY; LARGE-TYPE NUMBERS REPRESENT PERCENTS

		CROSSED ON MESSAGE:		
		NO PED HEAD	WALK	DONT WALK
CBD DESIGNATION	CBD	10.3	74.6	15.1
	NON-CBD	41.9	39.1	19.0
	TOTAL	272.8 18.0	997.6 65.9	242.4 16.0
VEHICLE VOLUME (PER HOUR)	160 OR LESS	36.3	54.3	9.4
	160-620	24.6	54.7	20.7
	621 OR OVER	16.7	68.1	15.2
	TOTAL	272.8 18.0	997.6 65.9	242.4 16.0
LAND USE	100% RES	49.8	26.0	24.2
	COMM & INDUST	14.9	69.4	15.8
	OTHER RES	37.6	46.4	16.0
	TOTAL	272.8 18.0	997.6 65.9	242.4 16.0

NOTE: SMALL-TYPE NUMBER REPRESENTS MILLIONS OF PEDESTRIANS IN CATEGORY; LARGE-TYPE NUMBERS REPRESENT PERCENTS

TABLE 20:
COMPLIANCE TO PEDESTRIAN SIGNAL VIEWED IN TERMS OF CBD/NON CBD AREA VEHICLE VOLUMES, & LAND USE (IN PERCENTS)

section than in the midblock of a long block. This would be a factor that the pedestrian would consider in choosing an acceptable gap.

This study collected data on gap acceptance to the nearest second, by field investigator observation. Table 21 presents gap acceptance data for midblock and intesection crossings made by pedestrians, broken down by age. This table shows that--somewhat surprisingly--at both locations, middle-aged people (30-59) accept the shortest gaps.

What could explain this? One might suspect that middle-aged people do much of their walking in commercial areas, but looking at gap acceptance by land use does not make the picture clearer. As Table 22 shows, at intersections in commercial areas there is less than average short gap acceptance but at midblocks there is more than average short gap acceptance.

Concluding Remarks

This section of the report has characterized the urban and suburban nation's pedestrian population and its walking behavior. Notable is that this walking population is 60% male, which differs from European and Australian findings, where women comprise the larger portion of the pedestrian population.

Although the nature of the data make summarizations very difficult, some general conclusions are possible:

- With the exception of the 1-4 years and 60 years and over age groups, males make up more of the pedestrian population than females.
- Males make up a greater portion of the pedestrian population than would be expected based on the composition of the general population.
- Commercial and industrial areas produce 40% of the pedestrian crossing behavior, 100% residential areas produce 20% while other residential areas produce 30%. Pedestrians who do not cross were found to be more evenly distributed among the 3 land use categories.

TABLE 21:GAP ACCEPTANCE (SECONDS) BY AGE, AT INTERSECTION CROSSING LOCATIONS (IN PERCENTS)

		INTERSECTION (ON RED SIGNAL)				MIDBLOCK			
		2 OR LESS	3-5	6-8	9 OR MORE	2 OR LESS	3-5	6-8	9 OR MORE
AGE BRACKET	1-4	0	0	0	100.0	0.0	0.4	0.0	99.6
	5-9	3.8	58.0	0.5	37.7	2.9	8.9	0.9	87.3
	10-14	1.5	23.1	2.5	73.3	5.6	10.3	1.0	83.1
	15-9	9.0	25.6	2.5	62.9	9.6	9.1	2.6	78.7
	20-29	6.5	33.4	2.6	57.5	8.0	10.8	3.2	77.9
	30-59	13.1	20.3	5.1	61.5	12.3	24.8	2.6	60.2
	60 +	0.8	10.7	8.2	80.3	1.5	9.6	3.5	85.4
	TOTAL %	8.3	24.7	4.2	62.8	8.6	15.2	2.4	73.9
	TOTAL N	17.5	51.7	8.8	62.8	152.0	269.9	42.1	1310.6

TABLE 22: GAP ACCEPTANCE (SECONDS) IN DIFFERENT AREA TYPES, AT MIDBLOCK & INTERSECTION CROSSING LOCATIONS (IN PERCENTS)

	INTERSECTION (ON RED SIGNAL)				MIDBLOCK			
	2 OR LESS	3-5	6-8	9 OR OVER	2 OR LESS	3-5	6-8	9 OR OVER
100% RES	2.8	39.4	4.4	53.4	4.2	5.3	0.6	89.9
COMM & INDUST	8.1	22.6	2.9	66.4	16.7	17.8	5.2	60.3
OTHER RES	10.6	29.1	9.1	51.2	5.3	19.1	1.4	74.2
TOTAL %	8.3	24.7	4.2	62.8	8.6	15.2	2.4	73.8
TOTAL N	17.5	51.7	8.8	131.5	152.0	269.9	42.1	1310.6

III: OBSERVED PEDESTRIAN EXPOSURE

Introductory Comments

The purpose of this chapter is more description than analysis. In the final chapter, hazardousness will be examined by analyzing the exposure data in comparison with accident data. For now, the purpose is to present an accounting of the amount of pedestrian exposure and the relative contributions to it from various site descriptor categories.

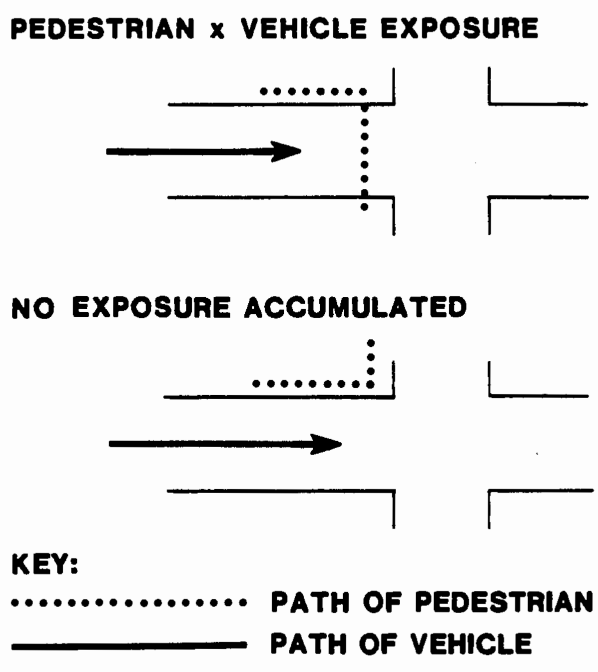
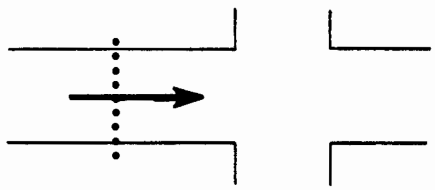


FIGURE 6: AN ILLUSTRATION OF PEDESTRIAN EXPOSURE

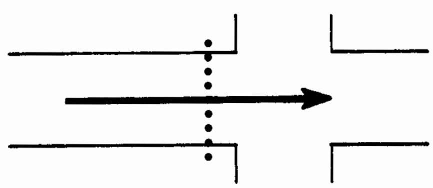
The exposure sites in this study were "constructed" of an intersection and one of the attached roadway legs. The exposure measure used is a refinement of Cameron's (1976, 1981) pedestrian-times-vehicles (PxV) concept. In addition to Cameron's constraints that pedestrians and vehicles need to be counted within a relatively identical time frame and that the periods of observation be short, the present research imposed an additional structure on the measure: paths of particular vehicles and pedestrians had to cross each other in order for those vehicles and pedestrians to enter the exposure count. This is illustrated in Figure 6.

In other words, categories of action and location are organized so as to resemble potential accident encounters. The counts of vehicles and pedestrians were organized so that only vehicles proceeding along the roadway leg were used to determine the exposure of a midblock crossing pedestrian. Similarly, pedestrians crossing at the intersection are not exposed to all vehicles in the site. Such pedestrians suffer exposure to vehicles which proceed through the intersection on the perpendicular road or those turning from a parallel path. Vehicles proceeding straight on the parallel road are not included in the exposure for these particular pedestrians. Furthermore, the exposure from turning vehicles is computed separately for left-turning and right-turning vehicles. In all, six exposure measures are calculated as follows:

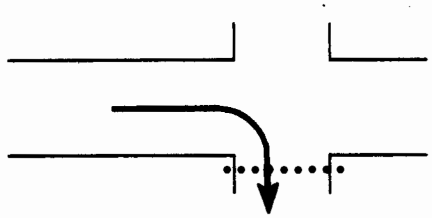
Exposure Measure	Description
I	Pedestrian midblock crossing; vehicle on the same road.



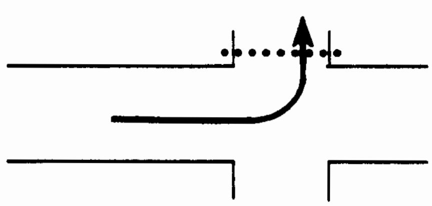
II	Vehicle proceeding straight through intersection; pedestrian crosses perpendicular road.



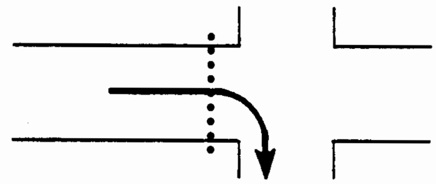
IIIA	Vehicle concluding right turn; pedestrian crossing road that vehicle is on after its turn.



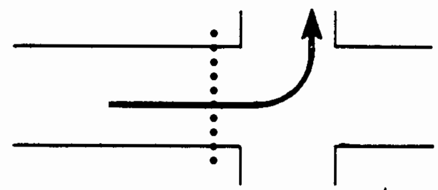
IIIB	Same as previous, for left turns.



IVA	Vehicle initiating right turn; pedestrian crossing road which vehicle intends to leave.



IVB	Same as previous, for left turns.



The illustrations provide a simplistic depiction of each exposure measure. They show only vehicles approaching from a single leg of the intersection. The actual exposure measures were determined by counting all vehicular traffic passing through the intersection.

At any site, these exposure measures may be summed to depict total site exposure, or any of the constituent aspects (I, II, IIIA, IIIB, IVA, IVB) may be examined separately. For ease of analysis, the exposure measures having in common pedestrian intersection behavior are aggregated in an intersection exposure subtotal.

The exposure data is presented in two formats. The first provides site exposure means, and is preferred when examining questions of relative activity on a site level. For instance, does a 100% residential site generate more exposure than a residential site which includes either parks, playgrounds, schools or churches? (The answer is no; the average exposure of the former is 45 PV per hour versus 324 PV per hour for the latter). This format offers means per hour, calculated for the site as previously defined: one intersection with a single attached roadway leg.

The second format displays national projections of exposure. These can answer such questions as whether more exposure occurs in all the 100% residential sites or in all residential sites containing parks, playgrounds, schools or churches. (The greater number of 100% residential sites assures that more total exposure occurs in these sites, 778 million PV per weekday versus 647 million). These figures represent extrapolations from one type of site to all similar sites in the projected "nation" (remembering that this sample's nation is urban and suburban America--encompassing regions containing the top four-tenths of the country's population, approximately 88 million people). The function of these nationally projected exposure measures is to identify the relative contribution of different categories or conditions of exposure to a total national sum. These projections, unless otherwise indicated, represent a week's exposure.

This projection alters the concept of a site by extrapolating behavior to all blocks surrounding the site intersection. Thus, the relative contribution to total exposure of Exposure Measure I (pedestrian midblock crossing) changes from one format to the other, since in the national projection--or in cities in general--there are more blocks than there are intersections. Defining the sample site as an intersection with one attached leg was a decision made for practical data collection reasons, but also because we think this one-intersection-with-one attached-leg site structure is a useful geographic framework for conceptualizing pedestrian behavior.

The data tables add all six constituent exposure measures to achieve a total site mean. Therefore, a particular interpretive caveat is necessary. Since this total site mean is for a site with a single leg attached to an intersection, it does not represent the midblock crossings occurring on all legs emanating from the intersection. A reader who forgets this point would over-appraise the volume of pedestrian behavior at intersections compared with midblocks.

It is quite easy to convert the data to represent an alternative site structure. This alternative structure would consist of an intersection plus all roadway legs extending from the intersection (up to the next intersection or 500 feet of roadway whichever was first encountered). To convert the data presented in this chapter, one merely needs to multiply Exposure Measure I, the midblock crossing exposure component, by a factor of 3.22. The total site mean figures would need to be recalibrated by adding this midblock exposure to the intersection exposure subtotals.

This 3.22 conversion factor includes two terms. The first is a multiplier representing the average number of roadway legs emanating from intersections. If the world consisted of only 4-legged intersections, this number would simply be four. T-intersections and multiple-leg intersections change this number and since there are more of the former than the latter, reduce it. The second term is of considerably smaller magnitude. It is a factor which compensates for the fact that the sample selection procedure contained a slight bias in favor of shorter blocks (since approximately one-third of roadway legs were selected with probability proportional to their length, while two-thirds were selected on an equal probability basis).

A few of this chapter's tables organize data in terms of weekday versus Saturday and Sunday exposure. Because the number of sites sampled differed weekday to weekend, the sample weights and this conversion factor differ. For these tables, weekday midblock site means would be multiplied by 3.38; for both Saturday and Sunday the multiplier would be 2.83.

With regard to the question of which site structure is the more correct, we would argue it is rather a moot point. In this chapter, analyses on this data are generally comparisons drawn between categories of site factors. The issue of interest is not "What is the midblock exposure count for say, CBD sites?", but "For which type site, CBD versus non-CBD, is a larger percentage of total per site exposure contributed by midblock crossings?" To answer such a question, it matters little whether the midblock exposures are "X" and "Y" or 3.22 times "X" and 3.22 times "Y". Their relative differences remain interpretable.

To reiterate, the national projections differ from the site means in three ways. First, they convert data from an intersection with a single leg structure to an intersection with all attached roadway legs. Second, site means are per hour averages; national projections are for a full week. Third, they extrapolate from an intersection average to a figure which represents all intersections of such type in the sample nation.

As indicated, this chapter is primarily descriptive and in it are presented a great many tables of data. The narrative which accompanies them highlights, but does not supplant the tables. Space constraints preclude discussing individually most of the data points, thus the purpose of the tables is to provide the comprehensive presentation of the exposure measures collected in this study.

Exposure measures will be discussed relative to:

- adjoining land use
- parts of the week
- NASS strata
- time periods of the day
- lane combination/functional roadway classification/ block length
- intersection configuration
- special activity magnets

Adjoining Land Use

The most obvious way to organize exposure data is in terms of the adjoining land use of the data sites. The first two tables provide the average site exposure and the national projection of exposure for the nine land use categories selected as descriptors. These categories are:

- 100% residential (no parks, playgrounds, schools, churches, commercial or industrial activities)
- Parks, playgrounds, schools and/or churches (with residential)
- Residential and open
- Open only--undeveloped
- 75%-99% residential (with the remainder commercial or whatever)
- 51%-74% residential
- 50%-75% commercial
- 76%-100% commercial
- 51%-100% industrial

One of the limitations of the data base is that when the nine categories of land use are assembled, only typical weekday exposure can be depicted. The data in this instance cannot be extrapolated to a full week. To do that, it is necessary to use aggregated land use categories: 100% Residential, Commercial or Industrial, and Other Residential (including Open Only). Generally, the data is easier to interpret when presented in the context of these three land use groupings, and this aggregation provides probably more stable measurements than the nine land use groupings.

Table 23 shows site means representing a typical hour of weekday behavior. The mean number of PV exposures per hour for each type of site are shown. Table 24 projects a national exposure total for a typical weekday. The national projections displayed in other charts in this interim report give full week projections, which include the relative contributions of Saturdays and Sundays with weekdays. While most features which can be identified in these exhibits will be highlighted in later charts, at this time several items are worth noting.

The first is to point out how small the total exposure site mean is for the 100% residential sites. While the exposure per site may be minimal, this category of blocks with just houses is the most common site type. In this study's projected nation, 55.8% of all sites belong to this category. The effect is that this site type's nationally projected exposure is the fourth largest of the nine categories.

TABLE 23 :
SITE MEAN EXPOSURE BY LAND USE (FOR WEEKDAYS)

	EXPOSURE MEASURES							
LAND USE CATEGORY (PVs X 10^9)	INTERSECTION						MID-BLOCK I	TOTAL
	II	III A	III B	IV A	IV B	SUB TOTAL		
100% RES	45	4	5	5	5	64	11	75
PARK, PLAY SCHOOL CHURCH	324	43	40	48	53	508	49	557
RES & OPEN	62	6	4	4	5	82	11	93
OPEN ONLY/ UNDEV	81	5	4	4	4	98	23	121
75-99% RES	500	70	70	82	73	795	622	1417
51-74% RES	414	25	20	21	39	519	62	581
50-75% COMM	832	103	90	8	85	1208	97	1305
76-100% COMM	3688	352	396	416	322	5173	500	5673
51-100% INDUST	90	25	18	18	18	170	32	202

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TABLE 24 :
NATIONAL PROJECTION OF EXPOSURE BY LAND USE (FOR WEEKDAYS)

LAND USE CATEGORY (PVs X 10^9)	EXPOSURE MEASURES							
	INTERSECTION						MID-BLOCK I	TOTAL
	II	III A	III B	IV A	IV B	SUB-TOTAL		
100% RES	0.8	0.08	0.08	0.09	0.08	1.1	0.6	1.7
PARK, PLAY SCHOOL CHURCH	0.6	0.09	0.08	0.09	0.01	1.0	0.3	1.3
RES & OPEN	0.2	0.02	0.01	0.01	0.02	0.3	0.2	0.5
OPEN ONLY/ UNDEV	0.08	0.004	0.003	0.004	0.004	0.09	0.05	0.014
75-99% RES	0.5	0.07	0.08	0.09	0.08	0.9	2.4	3.3
51-74% RES	0.5	0.03	0.03	0.03	0.05	0.7	0.4	1.1
50-75% COMM	1.6	0.2	0.2	0.2	0.2	2.3	0.4	2.7
76-100% COMM	10.0	1.0	1.1	1.1	0.09	14.1	4.2	18.3
51-100% INDUST	0.04	0.01	0.008	0.006	0.009	0.08	0.04	0.12

The land use category with both the largest national projection and the largest site-mean is the commercial category in which sites are between 76% to 100% commercial. The 5673 PV/hour measured here represents over 75 times that accumulated at an average 100% residential site. The study projects that the 169,900 sites of this type (or 8.8% of all sites) generate 18.3 billion PVs in a typical weekday. While 28.7% of the accidents occur in these sites, suggesting at first that they may be over-represented in accidents (28.7% vs. 8.8%), the great magnitude of their exposure reverses this perception.

Also of note are the two categories which have residential uses mixed with other non-specified land uses--the 75%-99% residential and the 51%-74% residential. Generally, a site in one of these categories has a mixture of residential with some commercial establishments (though not enough to change its label to one of the two commercial categories). For instance, a residential block with a single store at the corner would fall into the first of these categories. According to Table 22, the mixed residential categories seem to resemble the lower-density commercial category, which is reasonable, for these are the middle categories in the continuum of development densities.

One of the capabilities of the data base is the opportunity to select sites on the basis of commercial frontage percentage. Thus, if one wished, all sites with any commercial activity could be grouped together. The advantage of the organization as presented in Tables 23 and 24 is that it highlights the difference in exposure which accrues at the highest density levels of commercialization compared with that at areas of lesser commercialization.

Table 24 aggregates the information in the two previous exhibits. The 100% residential category represents the same sites. The national projections for this category, though, differ because Exhibit III-C provides a full week's projection. This projection is not simply the typical weekday figures multiplied by seven: it takes into account exposure differences on the two weekend days.

These 100% residential results provide a good example for a data interpretation aid. Exposure Measures I and II account for all the non-turning vehicles. Pedestrians crossing midblock contribute to Exposure Measure I and those crossing at the intersection figure in Exposure Measure II. At 100% residential sites, a mean of four times as much non-turning exposure occurs at the intersection as at the midblock (42 vs. 11 PVs/hour). When the national projections are examined, these two terms become relatively close in magnitude. What accounts for this apparent transposition is that the national projection includes the geography of all blocks surrounding intersections while the site means show the relationship between one intersection and one attached leg. The point is not that Exposure Measure I is correct in half the chart and erroneous in the other half. It is instead that there are two different ways of accounting data, each with its own purposes.

Of the data displayed in Table 25, one aspect is paramount. The amount of pedestrian exposure generated at commercial sites is much greater than that which comes from sites in either of the other two categories. Indeed, it is greater than the other two combined. The projected estimation is that commercial sites produce 72% of all the exposure in the study's urban nation. As Table 26 indicates, that amount of exposure is doubly impressive when one realizes those sites account for just 16.6% of our urban nation.

TABLE 25 : EXPOSURE FOR THREE LAND USE TYPES (FULL WEEK)

		EXPOSURE MEASURE							
		INTERSECTION						MID-BLOCK	TOTAL
		II	IIIA	IIIB	IVA	IVB	SUB-TOTAL	I	
SITE MEANS (PVs/hr)	100% RES	42	5	5	5	6	63	11	75
	COMMERCIAL	1811	189	203	217	172	2592	307	2899
	OTHER RESIDENTIAL	211	25	25	24	29	314	89	403
	ALL SITES	391	42	44	47	40	564	79	643
NATIONAL PROJECTIONS (PVs X 10⁹)	100% RES	5.0	0.6	0.6	0.6	0.7	7.6	4.1	11.7
	COMMERCIAL	67.4	7.0	7.6	8.1	6.4	96.4	31.5	127.9
	OTHER RESIDENTIAL	12.7	1.5	1.5	1.5	1.7	18.8	19.7	38.5
	ALL SITES	85.0	9.1	9.7	10.2	8.8	122.9	55.3	178.2

TABLE 26: SITES DISTRIBUTED BY LAND USE CATEGORY

SITE LAND USE	NUMBER OF SITES	% OF SITES
100% RES	1,076,900	55.8%
COMM & INDUS	321,300	16.6%
OTHER RES	532,300	27.6%
TOTAL	1,930,500	100%

In interpreting this exposure data, it is important to remember that the Exposure Measures include pedestrians only if they enter the roadway. Those who do not cross are not tabulated for the purposes of exposure. These people did contribute to the data file, though, and the Tripmaking Characteristics chapter include them. One of the items from that chapter is pertinent here: There are more non-cross pedestrian trips in residential than commercial areas. This is understandable given that many residential trips are only from house to car or car to house. A corollary to this fact that there are proportionately more roadway crossing trips at commercial sites is that longer pedestrian trips are taken in commercial areas.

The relative contribution to total exposure by midblock versus all intersection crosses reveals fewer midblock crosses in commercial than at the 100% residential sites--12% of the site mean data as compared to 17%. The obvious explanation is that the volume of traffic in commercial sites presents more impediments to midblock crossing than are found on residential blocks. It is notable, then, that the highest percentage of midblock crosses occur in the "other" category. These sites offer reasons for crossing--parks, schools, some stores--yet few impediments to midblock crossing compared with commercial sites. While the relative involvement of the midblock crosses varies across land use, this is not the case when considering the percent of exposure accumulated by pedestrians encountering turning vehicles. This stays nearly constant--33%, 30% and 33% for 100% Residential, Commercial and Other Residential, respectively.

To present an analogy, in the study of philosophy the statement is sometimes heard that all philosophy since the Greeks has only been a refinement of Plato and Aristotle. The analogy is that Table 25 (Exposure by Three Land Use Aggregates) holds a similar keystone position to all the rest of the exposure data. A confluence of factors make the typical commercial site different from the typical residential. It is not just adjoining land use; it is roadway configuration, signalization, traffic densities, etc. These factors run together in syndromes which can be labeled for convenience "commercial" or "residential". Those geographic and behavioral factors which contribute to the syndromes seen first in Table 25 will be detailed and examined through the remainder of this chapter.

Residential Sites

In addition to the land use designations presented in Tables 23 and 24, the data base can be ordered in terms of sites which contain single family residences or multi-family housing units (or, for that matter, chosen in terms of percentage-of-the-site of either housing type). Table 27 illustrates the exposure at these two types of residential sites as well as sites containing both types of residences. This characterization ignores non-residential land uses accompanying the residential ones.

TABLE 27: EXPOSURE AT HOUSING SITES

		EXPOSURE AT:		
		INT	MID	TOTAL
SITE MEANS (PVs/hr)	ALL SINGLE FAMILY or DUPLEXES	116	42	158
	ALL MULTI-FAMILY UNITS	1659	142	1801
	SINGLE/ DUPLEXES MIXED WITH MULTI-UNITS	664	30	694
NATIONAL PROJECTIONS ($PVs \times 10^9$)	ALL SINGLE FAMILY or DUPLEXES	18.7	21.2	39.9
	ALL MULTI-FAMILY UNITS	23.7	8.0	31.7
	SINGLE/ DUPLEXES MIXED WITH MULTI-UNITS	6.7	1.2	7.9

The most predictable finding concerns the site means figures in the top half of the chart. Sites in which all housing is multi-unit generate more exposure than sites which combine multi-unit with single or duplex housing. These, in turn, show higher exposure than sites where all the housing is single family. When midblock crossing is examined, a different phenomenon is observed. While multiple housing sites demonstrate more midblock exposure than single family sites in absolute numbers, the contribution to total exposure is relatively smaller. At the single family sites, 27% of the mean exposure comes from midblock crosses; with multi-unit sites, this figure is just 8%.

Commercial Sites

Just as there are several ways to organize the exposure associated with residential sites, there are a variety of ways to display commercial site data. Table 25 presented an aggregation of site types in the commercial category. The number of projected sites from each contributing component of this aggregation is seen in Table 28.

TABLE 28: COMPOSITION OF THE COMMERCIAL AND INDUSTRIAL SITES

		No. OF SITES	% OF COMM & IND	% OF ALL SITES
SITE TYPE	50-75% COMM	121,400	37.8	6.3
	76-100% COMM	169,900	52.9	8.8
	51-100% INDUS	300,000	9.3	1.6

As Tables 23 and 24 illustrated, the higher density commercial sites represent the category with the single largest amount of exposure. Obviously, most central business district sites fall into this category. Still, most CBDs also contain some non-commercial sites* plus many of these 76%-100% commercial sites exist outside of the CBD.

While percentage of commercialization is the most obvious way to organize the exposure data from these busier sites, there are other methods for focusing on this data. Table 29 presents several of them. What the table shows is that there is a range of generated exposures within these high density designations.

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* The sampling procedure in this study selected grid coordinates on metropolitan maps which would include the CBDs within them; in order to encompass all of the CBDs, these grid coordinates would also "catch" some nearby non-commercial.

TABLE 29 :EXPOSURE BY DEGREE OF COMMERCIALIZATION

			EXPOSURE AT:		
			INT	MID	TOTAL
SITE MEANS (PVs/hr)	WEEKDAY ONLY	50-75% COMM	1208	97	1305
		76-100% COMM	5173	500	5673
		CBD	6688	168	6855
	FULL WEEK	CBD	4765	136	4901
		METERS	13,394	355	13,749
		RTOR NOT ALLOWED	10,888	179	11,065
NATIONAL PROJECTIONS (PVs x 10^9)	WEEKDAY ONLY	50-75% COMM	2.3	0.4	2.7
		76%-100% COMM	14.0	4.2	18.2
		CBD	13.1	1.2	14.3
	FULL WEEK	CBD	78.3	7.8	86.1
		METERS	58.9	4.3	63.2
		RTOR NOT ALLOWED	34.2	2.0	36.2

TABLE 30 :EXPOSURE BY PRESENCE OR ABSENCE OF PARKING METERS

		EXPOSURE AT:		
		INT	MID	TOTAL
SITE MEANS (PVs/hr)	METERS (ONE OR BOTH SIDES)	13,394	355	13,749
	NO METERS	302	60	362
NTL PROJECTIONS (PVs X 10^9)	METERS (ONE OR BOTH SIDES)	58.8	4.3	63.1
	NO METERS	63.5	40.7	104.2

TABLE 31:EXPOSURE BY RIGHT TURN ON RED PROHIBITION

		EXPOSURE AT:		
		INT	MID	TOTAL
SITE MEANS (PVs/hr)	ALLOWED	4675	596	5271
	NOT ALLOWED	10,886	179	11,065
NATIONAL PROJECTIONS (PVs X 10^9)	ALLOWED (at 103,700-81%-of sites)	55.1	26.0	81.1
	NOT ALLOWED (at 23,900-19%-of sites)	34.2	2.0	68.4

The exhibit lists the exposure two categories that averaged higher exposure counts than were found in the CBD as a whole: for sites with signals where right turns on red are not allowed and sites with parking meters. Indeed, of all the ways there are to characterize busy sites, locations with meters presage the highest pedestrian exposure. Table 30 contrasts sites that have parking meters with sites without meters.

A similar table, Table 31, demonstrates the differences between those signalized sites that permit right turns on red and those prohibiting it. Most (81%) signalized intersections permit right turn on red; those which do not tend to be in the city's busiest sectors and hence are responsible for the high levels of pedestrian exposures. The magnitude of difference between the two categories is encouraging for it suggests that the decisions as to which signalized locations should prohibit right turn on red are not being formulated on spurious grounds.

Parts of the Week

Previous researchers (Cameron, 1981; and others) suggested exposure on weekdays would differ from that counted on weekends. Accordingly, a portion of the study sites were sampled on a Saturday and a Sunday as well as on a weekday. From this data, projections of exposure during the different parts of the week were developed. These are seen in Table 32.

Two data interpretation comments are offered here. These weekday national projections represent a single weekday, not a full complement of five weekdays. (Taking five of the weekday projections and adding to them Saturday's and Sunday's figures will constitute a full week's estimated national projection of exposure.) Second, this projection was compiled without data from the late afternoon and evening hours of Fridays (3-11 PM). Friday does not fit entirely as either a weekday or a weekend. It starts as one and ends as the other. The mornings were deemed ordinary weekdays while the evenings were excised from data collections, as were comparable times in the pedestrian accident statistics, to preserve comparability when determining hazardousness ratios.

Not surprisingly, there is more pedestrian exposure on the typical weekday than on either Saturday or Sunday, both for site means per hour and for national projections. An interpretive generalization would be that weekday exposure reflects obligatory trips while weekends are more the province of discretionary travel, and there is simply more of the former than the latter.

It might be thought that Saturday's figures represent an average of CBD and non-CBDs which disguises the fact that exposure in the CBDs might actually be as large on Saturday as on weekdays but is brought down by a particularly low non-CBD volume. The common visual image of Saturday CBDs, after all, is one of bustling shoppers generating a large pedestrian exposure.

The data, however, does not entirely support this image. On weekdays, the total site mean exposure for CBD and non-CBD are 6846 and 331 PVs, respectively. On Saturday, these figures are 2634 and 231; on Sunday the numbers are 1364 and 171. The CBDs' exposures are certainly greater than that in the non-CBD areas. On weekdays, they are 20 times larger. On Saturday this difference drops to about half as much (or eleven times

TABLE 32 : EXPOSURE BY PART OF WEEK

		EXPOSURE MEASURE							
		INTERSECTION						MID-BLOCK I	TOTAL
		II	IIIA	IIIB	IVA	IVB	SUB-TOTAL		
SITE MEANS (PVs/hr)	WEEKDAY	468	47	50	53	45	664	82	746
	SATURDAY	253	38	40	42	37	410	73	483
	SUNDAY	151	20	21	20	21	233	63	296
NTL PRO-JECTIONS (PVs X10 9)	WEEKDAY	14.5	1.5	1.5	1.6	1.4	20.5	8.6	29.1
	SATURDAY	8.0	1.2	1.3	1.3	1.2	13.0	6.5	19.5
	SUNDAY	4.8	0.6	0.7	0.6	0.6	7.4	5.7	13.1

more per site mean). Undoubtedly, the relative contribution to CBD exposure from shoppers compared with office workers is greater on Saturday, but their numbers are not large enough to cover the diminishment in exposure from fewer office workers being in the CBDs on the weekends.

One difference between exposure on weekdays and on the weekend is that as the total exposure count is smaller, the relative contribution from midblock crossings becomes larger. This effect can be identified in either the Site Means format or the National Projections format. Looking at that latter data, on weekdays 30% of exposure (or 8.6×10^9 PV out of 29.1×10^9 PV) is from midblock crossings. On Saturday, the figure is 33%. For Sunday, with the smallest PV total, the midblock contribution is 44%.

The obvious explanation is that when traffic offers obstacles to midblock crossing there is relatively less of it. On Sundays when these obstacles are minimal, the relative amount of midblock crossing is largest. In the previous chapter, a discussion on the similar topic of crossing behavior, as seen across parts of the week, did not show this finding as clearly. The difference in the two reports is that the present instance, by being exposure data, integrates vehicle volumes with pedestrian counts and it is the decrease in vehicle volumes from weekday to Saturday to Sunday which establishes this effect.

Exposure by Strata

This study's sample was selected along lines originally devised by the National Highway Traffic Safety Administration (NHTSA) for their vehicular accident data base, NASS, or National Accident Sampling System. This system identified 1279 potential municipal areas or Primary Sampling Units (PSUs) and assigned each to one of 75 strata. In a preliminary effort, these 75 strata were organized into ten pilot strata with each representing about 10% of the 1977 USA population (less Alaska), or approximately 22 million people. The present study used the NASS pilot strata designations and chose its sampling areas from the NASS PSUs within those pilot strata. The four most urbanized strata were chosen for this study. The definitions of these strata are:

- Stratum 1: Central cities of ten largest SMSAs (Total SMSA population greater than 2,500,000).
- Stratum 2: Central cities of the 11th-60th largest SMSAs (Total SMSA population over 600,000)
- Stratum 3 and 4: Other areas of the 17 largest SMSAs (Total SMSA population over 2,000,000)

Table 33 compares the pedestrian exposure measured in these different strata. As would be expected, the site means in the first two strata are considerably larger than that in the third. The latter stratum, after all, represents suburban and even exurban areas while the first two strata stand for the central areas of the country's larger cities.

The total exposure site means from Strata 1 and 2 are very similar to each other. This does not, however, occur in the national projections. The reason is that there are so many fewer total sites in Stratum 1

TABLE 33: EXPOSURE BY STRATUM

		EXPOSURE MEASURE: INTERSECTION II	IIIA	IIIB	IVA	IVB	SUB-TOTAL	MID-BLOCK I	TOTAL
SITE MEANS (PVs/hr)	STRATUM 1	779	64	74	69	63	1048	115	1163
	STRATUM 2	731	79	83	93	72	1058	42	1100
	STRATA 3+4	57	11	10	9	12	99	96	195
	ALL STRATA	391	42	44	47	40	564	79	643
NATIONAL PROJECTIONS (PVs X 10^9)	STRATUM 1	21.4	1.7	2.0	1.9	1.7	28.8	11.1	39.9
	STRATUM 2	57.3	6.2	6.5	7.3	5.7	83.0	10.7	93.7
	STRATA 3+4	6.4	1.2	1.1	1.0	1.4	11.1	33.5	44.6
	ALL STRATA	85.0	9.1	9.6	10.2	8.8	122.9	55.3	178.2

(245,036 vs. 700,384) that the national extrapolations project nearly two and a half times more exposure for Stratum 2. Indicating there are fewer sites in Stratum 1 does not mean big cities have fewer streets than cities of the second order (an illogical and false notion). It simply means it takes fewer cities (and hence fewer sites) to equal the 22 million people who comprise each strata.

In every part of the country one hears colloquial comments characterizing the local pedestrians or drivers--whether it is to regard them aggressive or meek or accommodating or barbarous or whatever. While not trying to issue such broad characterizations, the ratio of intersection to midblock exposure suggests some differences in behavior between the largest cities and the second order ones. The per site ratio of midblock exposure to that accumulated at all intersections in Stratum 1 is one to 10; in Stratum 2, this ratio is one to 25; and in Strata 3 and 4, it is one to one. This is pictured in Figure 7.

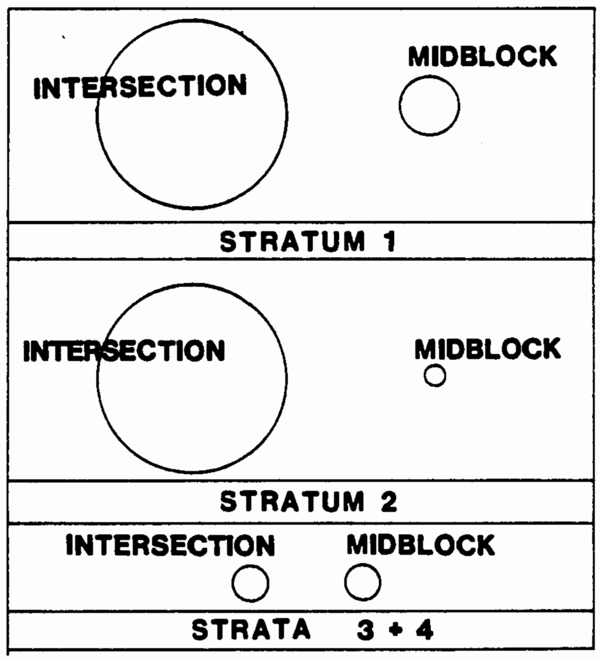

FIGURE 7: RELATIVE CONTRIBUTION OF INTERSECTION & MIDBLOCK EXPOSURE, BY STRATUM

This seems to indicate, as regards Strata 1 and 2, that the greater density of Stratum 1's urban configuration may indeed embolden the pedestrian. There may be a subtle threshold effect in which the perceived hazards of urban life discourge midblock crossings until such a point that the urban density increases and a larger proportion of pedestrians begin midblock crossings.

In discussing midblock and intersection pedestrian exposure, what is striking is the parity of their volumes in Strata 3 and 4, the suburban areas. Under almost no other division of data analysis, whether it be land use, day of week, time periods, lane widths, etc., is the midblock exposure as large as the intersection exposure. (Sites on which churches are located are the other instance of this happening.)

What this affirms is the rather obvious point that when the impediments to midblock crossings are minimal, crossings become as likely there as at intersections. On trips of any length of over, say, two blocks, it is extremely improbable that a single pedestrian traveler will cross as many midblocks as intersections.* The equalizing of midblock and intersection exposure, therefore, indicates that a large amount of the pedestrian activity must come in the form of short trips of under a block or two. In the suburban areas it is likely that more pedestrian trips are to and from cars and thus would be shorter than city journeys. When the national extrapolations are examined (remembering that these include all legs emanating from intersections, while the site means only consider one leg) the projected amount of midblock exposure for Strata 3 and 4 is three times greater than the intersection exposure. For the urban and suburban nation as a whole, midblock exposure is less than half as great as intersection exposure.

Exposure by Time Periods

The next topic is exposure as counted in various time periods. This data is displayed in Table 34. The tables were constructed using time groupings that highlight characteristic activity periods. The times were intended to encapsule morning, noon and after work pulses. The "rest of the day" category was included to provide a comparison with non-pulse times. In the national projection portion of the chart, the rest of the day entries are so large because they are an accumulation of exposure from 10 hours (out of the 16-hour data collection day). For purposes of comparison, the site means for this rest of the day category are probably more useful.

The most striking finding is that there is no morning exposure peak analogous to that seen in the evening rush hour. This, at first, may seem a paradox since from common experience we know that people do manage to get to work (and thus are in a position to contribute to the noon and afternoon

* This is because midblock crossings indicate a recent or imminent change in path direction, or the initiation or completion of the trip. For a lengthy pedestrian trip to thus have as many midblock crosses as intersection ones, the course would need to be a route of interminable zig-zags.

TABLE 34 : EXPOSURE BY TIME PERIODS

		EXPOSURE MEASURE							
		INTERSECTION						MID-BLOCK	TOTAL
		II	III A	III B	IV A	IV B	SUB-TOTAL	I	
SITE MEANS (PVs/hr)	7AM-9AM	287	21	25	22	29	384	42	426
	11AM-1PM	461	51	55	70	43	681	92	773
	4PM-6PM	573	54	74	64	64	829	153	982
	REST OF DAY	361	42	40	44	37	524	69	593
NATIONAL PROJECTIONS (PVs X 10^8)	7AM-9AM	7.8	0.6	0.7	0.6	0.8	10.4	3.7	14.1
	11AM-1PM	12.5	1.4	1.5	1.9	1.2	18.5	8.1	26.6
	4PM-6PM	15.6	1.5	2.0	1.7	1.7	22.6	13.4	36.0
	REST OF DAY	49.1	5.7	5.5	5.9	5.1	71.3	30.1	101.4

peaks). This same point was identified in the Pedestrian Tripmaking Characteristics chapter. A lack of pedestrian volume and a lack of pedestrian exposure (since exposure equals P times V) are consistent-- if unexpected findings.

One might also think the explanation could lie in the relative contribution to the total exposure from CBD and non-CBD sites, since it would seem likely that at least CBD sites should display a morning peak. The next table (Table 35) presents data on this issue but does not substantiate the idea, since data for both CBD and non-CBD sites indicate that the morning 7-9 AM period averages fewer PVs than the rest-of-the-day comparison period (consisting of 9-11 AM, 1-4 PM, and 6-11 PM). The amount of exposure at the CBD sites, of course, has a much higher site mean than the non-CBD. sites. For these time periods it averages 17 times higher, but a similar pattern of low morning exposure is seen for both CBD and non-CBD.

TABLE 35 : EXPOSURE BY CBD BY TIME PERIODS

		EXPOSURE AT:		
		INT	MID	TOTAL
CBD SITE MEANS SITES:146,750	7AM-9AM	3357	157	3514
	11AM-1PM	5890	128	6018
	4PM-6PM	7046	185	7231
	REST OF DAY	4365	123	4488
NON-CBD SITE MEANS SITES:1,798,830	7AM-9AM	141	32	173
	11AM-1PM	255	89	344
	4PM-6PM	322	151	473
	REST OF DAY	211	64	275

The explanation, though, may not be that mysterious; the lack of a morning peak may simply reflect a lack of discretionary walking at that time. It is important to remember that for many people there is very little pedestrian exposure associated with getting to work, given cars parked close to home and access to parking garages or lots adjoining the work place. For people in this situation their pedestrian exposure is likely accumulated in discretionary walking.

Regardless of what the full explanation is, the discussion on hazardousness will provide a pertinent, corroborating statistic, which is that 7-9 AM is the least hazardous of the four time periods.

Another item of interest in Table 35 concerns the relationship between the total exposure per period and that tabulated from midblock crosses. In other instances (namely, the previous discussion of exposure by strata), it was observed that when total exposure was low, the relative percentage of midblock crossing was high.

This is not the case when observing exposure by time periods. Here, the situation is that as exposure becomes larger, the midblock crossing exposure increases--not just in absolute numbers, which is expected, but in its percentage contribution to the total exposure. At the morning period, the total per hour site mean is 426 PVs, with the midblocks contributing 9.8%. In the rest-of-the-day category, 11.6% of the exposure is from midblock crossings. At the noon peak, these crossing exposures account for 11.7%. During the afternoon peak when site means are highest, so, too, is the percentage of midblock crossing exposure at 15.5%.

Exposure by Lane Combinations, Functional Roadway Classifications, and Block Length

Table 36 presents exposure site means by the various combinations of the number of road lanes which can intersect. This exhibit can be misleading unless information is included on the number of sites in each category. The magnitude of site means per category is nearly the inverse of the magnitude of the number of representative sites in each category. A projection of the number of sites in each category is presented in Table 37.

TABLE 36: EXPOSURE BY LANE COMBINATIONS (AT INTERSECTIONS)

		EXPOSURE MEASURE							
		INTERSECTION						MID-BLOCK I	TOTAL
		II	IIIA	IIIB	IVA	IVB	SUB-TOTAL		
SITE MEANS (PVs/hr)	2x2	106	15	15	16	15	165	42	207
	2x4	667	56	49	52	49	873	105	978
	4x4	4503	470	531	562	454	6520	713	7233
	ALL SITES	391	42	44	47	40	564	84	648
NATIONAL PROJECTIONS (PVs X 10^9)	2x2	18.9	2.6	2.7	2.8	2.6	29.6	22.0	51.6
	2x4	18.7	1.6	1.4	1.5	1.4	24.4	9.7	34.1
	4x4	47.5	5.0	5.6	5.9	4.8	66.8	23.2	92.0
	ALL SITES	85.0	9.1	9.7	10.2	8.8	122.9	54.9	177.8

TABLE 37: NUMBER OF SITES BY NUMBER OF LANES

	NUMBER OF LANES	NUMBER OF SITES	% OF SITES
LANE COMBIN-ATIONS	2x2	5,425,300	83.0%
	2x4	794,800	12.2%
	4x4	313,200	4.8%

The effect of these magnitude differences is such that one can focus on data peculiarities which may seem meaningful in terms of site means, but at the same time one must realize that the peculiarity may have minimal impact on the national projection. For instance, an item which seems to characterize the difference between 2 x 2 lane combination sites and those where a two-lane and a four-lane road cross is Exposure Measure II, pedestrians crossing at the intersection with vehicles proceeding straight through the intersection. The 2 x 4 exposure on this variable is more than six times greater than for 2 x 2 lane combinations. Yet the greater number of sites in the latter category is such that the projected exposure is nearly equal for the two lane combinations: the same amount of exposure is accumulated nationally in the one situation as the other.

While some two lane streets are quite busy, an intersection with two-lane streets intersecting generally accommodates less traffic than a site with 2 x 4 or 4 x 4 lane combinations. As such, these less busy sites would present fewer impedences to midblock crosses. The effect of this is that 20% of mean site exposure at 2 x 2 lane combinations is from midblock crossings, while with 2 x 4s and 4 x 4s, it is 11% and 10% respectively.

A finding which one might predict failed to occur. It would seem logical that at the smaller intersections there would be more exposure from turning vehicles than at the larger intersections whose streets, because they are major, carry more through traffic. No such trend is seen. The percentage of turning exposure for 2 x 2 intersections is 29.4% of the total exposure. The 2 x 4 sites show a smaller percentage, 21.1%. But at the 4 x 4 sites where the least turning exposure would be expected it is 27.8%, almost as large as the first figure. This would indicate that 2 x 2 roads and 4 x 4 roads have similar patterns of use, which is, at least initially, a troublesome notion. Since 4 x 4s allow turning from one major road to another, it eliminates the likelihood of any simple trend.

Another way of conceptualizing the scale of roadways is more direct, using the functional road classification designations as coded by the research team. The exposure data from this classification scheme is presented in Table 39. Certain roadway classifications, like frontage roads, are not included in this table, since their percentage of the sample's area was so limited. Also, no data was collected on limited access roads, because it was felt the data collection protocol could not be safely conducted on that type roadway. The three categories shown in Table 38 account for 87% of the roadway system.

TABLE 38: NUMBER OF SITES BY ROADWAY TYPE

		NUMBER OF SITES	% OF SITES
ROADWAY TYPE	MAJOR ARTERIALS	167,100	2.6%
	COLLECTOR DISTRIB	947,100	14.5%
	LOCAL STREETS	4,540,700	69.5%
	ALL OTHER STREETS	878,400	13.4%

TABLE 39 :EXPOSURE BY FUNCTIONAL ROAD CLASSIFICATION

		EXPOSURE MEASURE							
		INTERSECTION						MID-BLOCK	TOTAL
		II	IIIA	IIIB	IVA	IVB	SUB-TOTAL	I	
SITE MEANS (PVs/hr)	MAJOR ARTERIAL HIGHWAY	1532	86	99	78	110	1906	192	2098
	COLLECTOR DISTRIBUTOR	1602	155	169	189	140	2256	273	2529
	LOCAL	121	20	20	19	20	200	26	226
	ALL STREETS	391	42	44	47	40	564	79	643
NATIONAL PROJECTIONS ($PVs X 10^9$)	MAJOR ARTERIAL HIGHWAY	8.9	0.5	0.6	0.5	0.6	11.1	3.3	14.4
	COLLECTOR DISTRIBUTOR	57.3	5.5	6.0	6.8	5.0	80.7	28.5	109.2
	LOCAL	18.2	3.0	3.0	2.9	3.1	30.1	12.7	42.8
	ALL STREETS	85.0	9.1	9.6	10.2	8.8	122.9	55.3	178.2

Table 39 tells a story which is approximately the same as the previous table's: bigger streets have impressively large site means but are relatively rare in the national geography. Notice that for Exposure Measure II, major arterials and collector distributors accumulate approximately equal exposure. Collector- distributors are comparatively common while major arterials are rare and as such the national projection of major arterial exposure is seven times less. As another example of this effect, the site mean at local streets is 13 times smaller than that of major arterial, but in the ultimate projection, local streets account for twice the projected exposure of the large streets.

The table does clarify a point which was obscured in the previous exhibit. The amount of exposure generated by turning vehicles does vary as a function of road classification. The bigger roads have the smaller percentage of pedestrian exposure from turning vehicles. For major arterials, this exposure (which sums Exposure Measures IIIA, IIIB, IVA and IVB) is 20%. For collector-distributors, it is 29%, and for local roads turns account for 40% of the PxV tabulation. This seems sensible since drivers, once they have joined major streets, proceed for longer stretches without turning.

Exposure measures by intersection type are organized in two ways. The first distinguishes between signalized and nonsignalized sites. The second looks at exposure of sites formed by varying numbers of roadway legs. Table 40 presents the former data. These charts corroborate a simple fact: signals are generally placed where a need exists.

What is surprising, though, is that the national projection indicates that over two-thirds of all exposure is actually accrued at signalized sites. One might have thought that the small percentage of signalized sites would have precluded this; even

TABLE 40:
EXPOSURE BY TRAFFIC SIGNAL INTERSECTIONS WITH TRAFFIC SIGNALS

		EXPOSURE MEASURE							
		INTERSECTION						MID-BLOCK I	TOTAL
		II	IIIA	IIIB	IVA	IVB	SUB-TOTAL		
SITE MEANS (PVs/hr)	SIGNAL	4122	430	460	491	407	5910	513	6423
	NO SIGNAL	104	12	12	13	12	153	43	196
NTL PRO-JECTIONS (PVs X10^9)	SIGNAL	64.1	6.7	7.1	7.7	6.3	92.0	29.3	121.3
	NO SIGNAL	20.9	2.4	2.5	2.5	2.4	30.9	25.6	56.5

though just 6.9% of the sites in the "nation" (or 133,100) have signals, their large per site exposure totals generate this result. From a traffic safety management perspective, this finding is encouraging, because it indicates that a relatively small number of signals, through strategic placement, are used by the great number of pedestrians.

Where signals are available, only 24% of the projected national exposure comes from midblock crossings. At the non-signalized sites, 45% is associated with midblock crossings. On a site mean basis, these figures are 8% midblock exposure with signalized locations and 22% for non-signalized. The latter streets are, of course, less busy-which is why they do not have signals and why more midblock crossings occur on them. The point is only that where there is a need for signals, they, indeed, serve their function.

Figure 8 expands on this site characterization of signalized and non-signalized locations by showing how this varies across land uses. Even within the commercial and industrial category, the percentage of signalized sites is not large. The common image of a city grid of uniformly signalized corners is mainly found

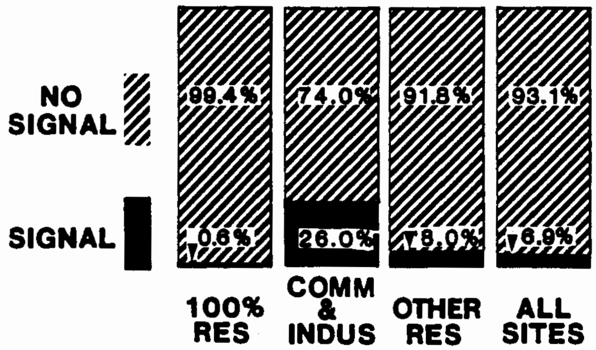

FIGURE 8: INTERSECTION SIGNALIZATION BY LAND USE

only in CBD areas. Another aspect of signalization which is of interest shows that according to our projection of the urban nation, 51% of all signals (68,200) possess pedestrian "Walk-Don't Walk" devices; 49% or 64,900 signalized sites do not.

The other way of characterizing intersections is by the number of roadways which form them. Table 40 provides this data, illustrating the difference between the three most commonly occurring intersection types. The site characteristics information in Table 41 is included to help in data interpretation.

TABLE 41 : EXPOSURE BY INTERSECTION TYPE

		EXPOSURE AT:		
		INT	MID	TOTAL
SITE MEANS (PVs/hr)	4 LEG	1148	99	1247
	"T"	72	33	105
	MULTI-LEG	1521	292	1813
	ALL INT TYPES	564	79	643
NATIONAL PROJECTIONS (PVs X 10^9)	4 LEG	102.2	30.9	133.1
	MULTI-LEG	7.9	8.5	16.4
	"T"	10.2	14.3	24.5
	ALL INT TYPES	122.9	55.3	178.2

TABLE 42 :NUMBER OF SITES BY INTERSECTION TYPE

		NUMBER OF SITES	% OF SITES
INTERSEC-TION TYPE	4 LEG	749,200	38.8%
	"T"	1,010,300	52.3%
	MULTI	72,400	3.8%
	ALL OTHERS	98,600	5.1%

Two points are striking. "T" intersection sites are much more common in residential districts and this correlates with its low site mean exposure figures. The converse is true of multiples. They are more likely to involve busier streets and generate larger exposure volumes. While exposure is greatest at multiple-leg intersection sites, the national projections, given the predominance of 4-legged intersections and the relative scarcity of multiples, estimate that 75% of exposure occurs at 4-legged intersection sites.

Sites of different lengths were examined to determine if exposure varies as a function of block length. It is unlikely the length of blocks would affect pedestrian trip routes, since traveling from point A to point B would, in a grid system, involve an identical total of long and short blocks regardless of route taken. What might differ is whether block length affects crossing location. The question is whether pedestrians are more apt to cross in the middle of the block on longer streets.

Exposure information on this issue is presented in Table 43 for this analysis. Streets were divided into three groups: those of length 250 feet (76.2 meters) or less; those between 251 feet (76.5 meters) and 499 feet (152.1 meters); and those of length 500 feet (152.4 meters) or longer. Examining the site means to compare a typical block of each of the three lengths offers a somewhat equivocal response to the question. As block length increases, the average amount of exposure generated by midblock crosses also increases--40 PV for the short blocks, then 65 PV, then 123 PV, for the long blocks. In looking at midblock exposure as a percentage of total exposure, though, this pattern is not so clear. For the shortest blocks, 14% of exposure is from midblock crosses. This figure is only 8% for medium length blocks. For the longest blocks, though, the percentage of exposure from midblock crossings is largest at 21%.

TABLE 43 : EXPOSURE BY BLOCK LENGTH

		EXPOSURE AT:		
		INT	MID	TOTAL
SITE MEANS (PVs/hr)	≤ 250'	246	40	286
	251'-499'	780	65	845
	≥ 500'	476	123	599
NATIONAL PROJECTIONS (PVs x 10^9)	≤ 250'	13.4	7.9	21.3
	251'-499'	81.5	16.1	97.6
	≥ 500'	27.8	31.3	59.1

It may be a matter of personal conjecture as to which of the two is the appropriate method for interpreting this data, the actual amount of midblock exposure or the percentage that midblock exposure is of total exposure at each site length. The point is rendered somewhat moot by the analysis which is to be presented in the hazardousness chapter. The gist of that analysis suggests there are factors more pertinent to hazardousness than block length.

Exposure by Special Activity Magnets

When the nine land use categories were designated, one was composed of what were presumed to be activity magnets--land uses that might occur in blocks which were otherwise residential but which would attract pedestrian or vehicular activity in such numbers as to distort the impression given of residential sites unless these special land uses were segregated.

Thus a category was established of sites which included--along with residences--schools, churches, and parks/playgrounds. (Some few non-residential sites were included in this category. A school sharing a site with an undeveloped tract of land would be an example of one.) The exhibits introduced at the beginning of this chapter (Tables 23 and 24) showed the data for this category and offered opportunities for comparisons with the other land use categories. To summarize these, sites with schools, churches, parks or playgrounds have greater volumes of pedestrian exposure than purely residential sites, though not so much exposure as at commercial sites.

The form on which site factors were described permitted such land uses as these items to be coded separately, with an indication of how much of the site frontage was occupied by each. For example, a site could be identified as containing a church even if it is within a 75%-100% commercial site. The data which is presented in the last three exhibits (Tables 44, 45 and 46), therefore, is more inclusive of these special activity magnets than that seen in the land use category bearing their name. The two different ways of designating sites, of course, do greatly overlap and the advantage of the latter approach is not so much its exhaustiveness but its opportunity for examining separately schools, then churches, then parks/ playgrounds.

As a data interpretation aid it should be noted that the present study was conducted during the summer. The effect of school sites is, therefore, diminished from what it would be during other months of the year. Still, "school sites" included colleges which have summer classes, as do many public schools. Additionally, many schools offer sporting or craft activities which attract pedestrian exposure.

Another data interpretation aid concerns the format of these three exhibits. It seemed that the predicted behavior of these activity magnet locations might be affected by the time of the week; therefore, weekday data was presented separately from Saturday and Sunday data. This means that national projections account for a day's worth of activity rather than a week's. (This format of separating exposure by parts of the week across the items of site descriptors variables is an option available for any of the site factors introduced in this chapter. For the sake of conciseness and given the difficulty of predicting which type of questions the audience for this data is most interested in, this generally has not been done in the present chapter. It is, however, an available feature of the data base.)

One last data interpretation aid is offered: the national projections for school sites, church sites and sites with parks and playgrounds are consistently smaller, miniscule even, when compared with sites not possessing these activity features. This only reflects the obvious fact that most blocks in America do not have a church, a school or a park or playground on them. Presenting these "lopsided" national projections is important for they provide a perspective with which to interpret the meaning of the exposure counted at these special activity sites.

Regarding the school sites exhibits, one item offers an encouraging sign which is the opposite of what one might predict. The percentage of exposure resulting from midblock crossings is less at school than non-school sites for all three periods of the week. On weekdays, it is less by half--5% versus 11%. The difference on Saturdays and Sundays is greater still, 4% versus 16%, and 6% versus 20%, respectively. Without looking further, one cannot say whether the limited amount of midblock crossings by schools reflects encouragement and

TABLE 44: EXPOSURE AT SCHOOL SITES

			EXPOSURE MEASURE							
			INTERSECTION						MID-BLOCK	TOTAL
			II	IIIA	III B	IVA	IVB	SUB-TOTAL	I	
SITE MEANS (PVs/hr)	WEEKDAY	SCHOOL	639	43	46	47	37	811	47	858
		NO SCHOOL	461	48	50	54	45	657	85	742
	SATURDAY	SCHOOL	894	62	76	50	72	1154	42	1196
		NO SCHOOL	232	37	39	42	36	386	74	460
	SUNDAY	SCHOOL	514	24	26	17	27	608	39	647
		NO SCHOOL	139	20	21	20	21	220	64	284
NATIONAL PROJECTIONS (PVs X 10^8)	WEEKDAY	SCHOOL	0.8	0.06	0.06	0.06	0.05	1.1	0.2	1.3
		NO SCHOOL	13.6	1.4	1.5	1.6	1.3	19.4	8.4	27.8
	SATURDAY	SCHOOL	0.9	0.06	0.08	0.05	0.07	1.2	0.1	1.3
		NO SCHOOL	7.1	1.1	1.2	1.3	1.1	11.8	6.4	18.2
	SUNDAY	SCHOOL	0.5	0.02	0.03	0.02	0.03	0.6	0.1	0.7
		OTHER SITES	4.2	0.5	0.6	0.6	0.6	6.7	5.5	12.2

enforcement by schools of good safety procedures or only that schools happen to be located on more major roads where opportune gaps in traffic for midblock crosses are less available.

Table 45 appears, at first glance, to offer an incongruous finding, that church sites experience their greatest exposure on Saturday and not Sunday. It should first be explained that the label "church" refers equally to all religious structures - synagogues, mosques, ashrams, etc. In an earlier day, the large Jewish population of Brooklyn, one of the sample PSUs, might have contributed to this finding. Population shifts render this explanation unlikely.

The preferred explanation may be that most people drive to church, often creating no pedestrian exposure if off-street parking lots are used. People are somewhat less likely to drive to churches in the more urbanized locations. Additionally, such urban churches are less likely to provide off-street parking. In these more urbanized locations, churches are frequently located on the same blocks as commercial establishments as opposed to being located on separated plots of land. Thus, these church

TABLE 45 : EXPOSURE AT CHURCH SITES

			EXPOSURE MEASURE							
			INTERSECTION						MID-BLOCK	TOTAL
			II	III A	III B	IV A	IV B	SUB-TOTAL	I	
SITE MEANS (PVs/hr)	WEEKDAY	CHURCH	265	47	42	39	50	443	239	682
		NO CHURCH	480	47	50	54	45	677	65	742
	SATURDAY	CHURCH	467	158	149	112	149	1036	121	1157
		NO CHURCH	243	33	35	39	32	381	71	452
	SUNDAY	CHURCH	193	42	43	29	45	351	331	682
		NO CHURCH	149	19	20	20	19	227	50	277
NATIONAL PROJECTIONS (PVs X 10^8)	WEEKDAY	CHURCH	0.4	0.08	0.07	0.06	0.08	0.7	2.5	3.2
		NO CHURCH	14.0	1.4	1.5	1.6	1.3	19.8	6.1	25.9
	SATURDAY	CHURCH	0.7	0.2	0.2	0.2	0.2	1.5	0.5	2.0
		NO CHURCH	7.3	0.9	1.1	1.2	1.0	11.5	6.0	17.5
	SUNDAY	CHURCH	0.3	0.06	0.06	0.04	0.06	0.5	1.4	1.9
		OTHER SITES	4.5	0.5	0.6	0.6	0.6	6.9	4.2	11.1

sites are also commercial sites and hence have high PV volumes on Saturdays.

One other note concerning these church sites: On Sundays, the site mean percentage of midblock exposure nearly equalled the amount of exposure attributed to intersection crosses. The explanation may be that traffic volumes are lower on Sundays, and where traffic is light, more midblock crosses occur.

Table 46 presents data from sites with parks or playgrounds. These park and playground sites exhibit more exposure in all data categories than the non-park/non- playground sites. The difference is greatest on Saturdays. As shown in Table 47, the amount of exposure at these sites presented in comparison with 100% residential sites establishes an appropriate context to look at this data since most of these sites also contain residential uses. In effect, they are magnets of exposure against a relatively low level exposure background.

TABLE 47:COMPARISON AT 100% WITH PARKS & PLAYGROUNDS. RESIDENTIAL SITES AND SITES

		EXPOSURE AT:		
		INT	MID	TOTAL
LAND USE	100% RES	63	11	74
	PARKS/PLAY -GROUNDS	907	116	1023

TABLE 46 : EXPOSURE AT PARKS AND PLAYGROUND SITES

			EXPOSURE MEASURE							
			INTERSECTION						MID-BLOCK	TOTAL
			II	IIIA	IIIB	IVA	IVB	SUB-TOTAL	I	
SITE MEANS (PVs/hr)	WEEKDAY	PARK, PLAY - GROUND SITES	738	79	60	93	94	1064	119	1183
		OTHER SITES	459	46	50	52	43	650	81	731
	SATURDAY	PARK, PLAY-GROUND SITES	444	86	120	56	90	796	136	932
		OTHER SITES	245	36	37	41	35	394	71	465
	SUNDAY	PARK, PLAY-GROUND SITES	151	13	39	12	16	232	80	312
		OTHER SITES	151	20	20	20	21	233	63	296
NATIONAL PROJECTIONS (PVs X 10^9)	WEEKDAY	PARK, PLAY-GROUND SITES	0.8	0.08	0.06	0.1	0.1	1.1	0.4	1.5
		OTHER SITES	13.7	1.4	1.5	1.6	1.3	19.4	8.2	27.6
	SATURDAY	PARK, PLAY-GROUND SITES	0.6	0.1	0.2	0.07	0.1	1.0	0.4	1.4
		OTHER SITES	7.4	1.0	1.1	1.3	1.1	11.9	6.1	18.0
	SUNDAY	PARK, PLAY - GROUND SITES	0.2	0.02	0.05	0.02	0.02	0.3	0.3	0.6
		OTHER SITES	4.6	0.6	0.6	0.6	0.6	7.0	5.4	12.4

Concluding Comments

Pedestrian exposure in the urban/suburban population has been described here in terms of adjoining land use, day of week, type of urbanized area, time of day, type of road, intersection configuration, block lengths, and special activity magnets.

This type of data has not previously been collected in America. In addition to the usefulness of these exposure descriptions, they are a critical component in the comparison with accident data to reveal the actual hazardousness of various site characteristics. The next chapter will present such a hazardousness analysis.

IV: RELATIVE HAZARDOUSNESS

Introductory Comments

Purpose

Preceding chapters of this report presented pedestrian exposure measures and pedestrian trip-making characteristics. The pedestrian exposure measures chapter described the number of pedestrian-vehicle interactions that were observed at various types of locations. The pedestrian trip-making characteristics chapter discussed the nature of the pedestrian population and their activities.

This section presents the relationship between pedestrian exposure, pedestrian characteristics and pedestrian accidents. If a factor, running across the street for example, is found to be associated with the accident population more than with the exposure population, then such a factor should be considered relatively hazardous. If a factor, walking across the street, for example, is found more often in the exposure population then it is in the accident population then it may be considered relatively less hazardous.

The relative hazardousness of the following factors will be examined:

- Site Characteristics--where accidents occur compared with the characteristics of the sample nation, such as: land use, signalization, delineation, etc.
- Pedestrian Characteristics--the characteristics of the pedestrians involved in accidents compared with the population at risk, such as: age, sex and pedestrian activity.
- Accident Characteristics--the time and the type of accident compared with the time of normal pedestrian exposure and the type of accident-related behaviors exhibited by the population at risk.

To determine relative hazardousness of any factor, comparable data must be obtained on both the accident population and the exposure population. Three data sources were used for the analyses in this section:

- Accident Reports
- Site Descriptions
- Exposure Data

Police accident reports were obtained from each study city. To control for seasonal variability, accident reports were matched from the same time of year (to the extent possible) as the exposure data. Approximately 200 reports from each city were obtained; accidents that occurred during times when exposure data was not collected (i.e., 11 PM to 7 AM), were eliminated from the sample. The following information was transcribed onto coding forms (see Appendix B):

pedestrian characteristics--age, sex, and actions; vehicle characteristics--trip and action; accident characteristics--location and time. Additionally, the accident was assigned to one of 19 pedestrian accident types--i.e., dart-out, intersection dash, etc.

To provide information on site characteristics a Site Description Form (see Appendix B) was developed. The following characteristics of each accident site and each exposure site was recorded: adjoining land use, roadway type, configuration, delineation, signs, signals, pedestrian accommodations, lighting, parking control, etc.

To determine the relative hazardousness of various types of locations and of various pedestrian behaviors, it is necessary to monitor the typical activity pedestrians and vehicles not involved in pedestrian accidents. The pedestrian and vehicle exposure data forms were designed to obtain the following information at each of the stratified random sample of exposure sites: pedestrian volumes, pedestrian actions, pedestrian characteristics, vehicle volumes and vehicle actions.

Each of the data bases were weighed as previously described to produce projected national estimates. The accident report data was similarly weighted to generate a national accident data base.

Analysis Procedures

Hazard scores were developed to analyze the relationship between the occurrence of certain factors at accident sites and their occurrence in the general population at risk. These hazard scores are the ratio created by dividing the percentage of occurrence of a characteristic in either the accident or general population by the percentage occurrence in the other population.

In order to maintain an interval scale of measurement (i.e., to have similar scales of magnitude for both more hazardous and less hazardous factors), the larger percentage is always divided by the smaller percentage. To distinguish between scores of greater and lesser hazardousness, the following convention was adopted: If the accident sites had the larger percentage, the hazard score is presented as a positive number, an indication that more hazard is associated with the characteristic. If the exposure sites representing sites in the nation had the larger percentage, the hazard score is presented as a negative number, indicating that less hazard is associated with the characteristic. Table 48 shows how these hazard scores were computed:

TABLE 48: ILLUSTRATIVE EXAMPLE OF HAZARD SCORES

	% OF ACCIDENTS	% OF SITES	SITES HAZARD SCORE	% OF PED VOLUME	PEDS HAZARD SCORE	% OF P&V EXPOSURE	P&V HAZARD SCORE
CHARACTERISTIC A	20%	40%	-2.0	40	-2.0	20	1.0
CHARACTERISTIC B	40%	20%	+2.0	40	1.0	60	-1.5
CHARACTERISTIC C	40%	40%	1.0	20	+2.0	20	+2.0

As shown, 20% of the accident sites were found to have characteristic A. Since twice as many of the sites in the general population of sites (40% of the national sites) have that characteristic, a site hazard score of -2.0 is computed. Sites with this characteristic are two times **less** likely to have accidents than would be predicted by chance occurence alone. The opposite is true for sites with characteristic B. They are two times more likely to have accidents than would be predicted by chance. Thus, a +2.0 site hazard score is computed. Accidents occur at sites with characteristic C to exactly the same extent that would be predicted; they are neither under or over-involved in accidents. Thus, a site hazard score of 1.0 is computed.

Three different categories of hazard scores were developed:

- Site hazard scores
- Pedestrian volume hazard scores
- Pedestrian times vehicles (PV) exposure hazard scores.

The site hazard score provides an indication of how frequently sites with various characteristics occur in the accident population relative to the general population of sites.

The site hazard scores were computed by determining the ratio of the projected national total of accident sites to the projected national total of exposure sites. As previously described, the larger percentage was always divided by the smaller to produce a number larger than 1. A positive value was assigned if there were more accident sites, an indication of more hazard being associated with that type of site. A negative value was assigned if there were fewer accident sites, an indication of less hazard. The site hazard score, like the example in Table 48, shows the hazard associated with various site characteristics.

The pedestrian volume hazard scores were computed by determining the ratio of the number of pedestrians observed at the exposure sites to the number of pedestrians observed at the accident sites. As with the site hazard score, the larger percentage was always divided by the smaller. A positive value was assigned to indicate more hazard (the accident percentage was more) and a negative value assigned to indicate less hazard (the accident percentage was less). The pedestrian volume hazard score provides an indication of the number of pedestrians observed at each type of site. In Table 48, 3 hypothetical pedestrian hazard scores are shown. Sites with characteristic A were found to account for 40% of the pedestrian volume. Since they accounted for 20% of the accidents, a pedestrian hazard score of -2.0 is produced. This is the same as the site hazard score, an indication that, from a pedestrian activity standpoint, these sites are neither particularly busy or particularly slow. They are relatively safe for pedestrians. Sites with characteristic B accounted for only 20% of the site total, yet they have a lot of pedestrian activity so they represent 40% of the pedestrian volume. Since they also had 40% of the pedestrian accidents, a hazard score of 1.0 is computed. This is an indication that they are neither particularly hazardous nor particularly safe. Sites with characteristic C had 40% of the accidents and represented 40% of the sites; however, they tend to have lower pedestrian volumes and had only 20% of the pedestrians. A pedestrian hazard score of +2.0 is produced. This indicates that they have two times as many accidents per pedestrian as do sites with characteristic B. From a pedestrian exposure standpoint these locations are hazardous to pedestrians.

In the preceding chapter, the exposure measure PV, the number of pedestrians (P) times number of vehicles

(V), was introduced. A hazard score, using the PV exposure measure, was also developed. Like the pedestrian volumes hazardous score, the PV exposure hazardous score is based on the percentage of exposure (PV) occurring at sites with certain characteristics. Table 48 shows that sites with characteristic A had 20% of the P x V exposure. Since they also had 20% of the accidents, a P x V hazard score of 1.0 results. The low P x V exposure, relative to the pedestrian exposure (40%), indicates that sites with characteristic A have lower traffic volumes. Sites with characteristic B accounted for 60% of the P x V exposure. Since they had only 40% of the accidents, a hazard score of -1.5 is computed. The high P x V exposure, relative to the pedestrian exposure (40%), indicates that sites with characteristic B have higher traffic volumes. In terms of P x V exposure, such locations are relatively safe for pedestrians. Sites with characteristic C account for 20% of the P x V exposure. Since they had 40% of the accidents, a hazard score of +2.0 is computed. This indicates that such locations are relatively hazardous for pedestrians. Since the pedestrian and the P x V exposure at these sites are both 20%, we know that traffic volumes are neither relatively low (as was the case at sites with characteristic A) nor relatively high (as was the case at sites with characteristic B). By examining the interrelationships between the percentage distributions of the sites, pedestrian exposure and P x V exposure, it is possible to determine whether the relative hazardousness values are due to frequency of occurrence of a type of site or because of the pedestrian or vehicle volumes present at that type of site.

Both the pedestrian volume hazard score and the PV exposure hazard score are based on the number of pedestrians observed who crossed the roadway.

These hazard scores are based on ratios of the projected national total of sites, projected national total of P x V exposures and the projected national total of accidents. These projected totals are very large numbers, varying from over 100,000 accidents to literally billions of P x V interactions. Traditional statistical tests readily detect significant differences when the numbers are so large. (It would not be appropriate to conduct statistical tests on the "unweighted" data because it does not represent the nation.) Preliminary examinations revealed that many very small differences, less than 5%, were, in fact, statistically significant. It would be both inappropriate and misleading to present the findings in such a manner. In effect, almost all of the differences between the different types of sites and different pedestrian characteristics, etc., are significant. The purpose of the project was to collect and present descriptive data. The emphasis of the data analysis was to identify meaningful differences. Hazard scores of +1.1, +1.2 and +1.3 indicate that the two percentage distributions only differ by 10%, 20% or 30%, respectively. Such small differences are not meaningful. In the discussion that follows, characteristics that produce very low hazard scores (from -1.3 to +1.3) will be considered to be neither relatively hazardous nor relatively safe.

In the exhibits which follow, site hazard scores, pedestrian volume hazard scores, and PV exposure hazard scores will be presented. Hazard scores were computed on variables that allow the projections of accident sites, national sites, pedestrian volumes, and PV to be organized into discreet sub-categories. Certain pedestrian, vehicle and accident-specific variables (i.e., pedestrian age, sex, activity; vehicle type and accident type) cannot be categorized to produce all three types of hazard scores. In these instances, a single hazard score is computed using the percentage of the pedestrians or vehicles observed and the percentage of the vehicles or pedestrians involved in the accidents. The remainder of this chapter is divided into three categories:

Roadway Characteristics

Functional Classification
Number of Lanes
Length of Block
Road Surface Material
Road Surface Condition
Shoulder Surface Material
Median Type
Roadway Center Markings
Roadway Edge Markings
Roadway Lane Markings
Channelization
Parking Restrictions
Parking Meters
Parking on Commercial Premises
Pedestrian Accommodations
Curbs
Street Lighting
Commercial Lighting

Intersection Characteristics

Adjoining Land Use
Intersection Type
Intersection Configuration
Signalization
Right Turn on Red
Left Turning
Crosswalks
Crosswalk Markings
Signs

Pedestrian, Vehicle and Accident Characteristics

Pedestrian Age
Pedestrian Sex
Pedestrian Accompaniment
Pedestrian Mode
Pedestrian Crossing Location
Pedestrian Signal Response
Vehicle Action
Vehicle Type
Accident Time of Day
Accident Type

Roadway Characteristics

Tables 49 through 52 describe the hazard scores associated with various roadway characteristics: roadway classification, lanes and block length.

Table 49 shows the hazard scores associated with roadway functional classification, number of lanes and length of block. The roadway functional classification site hazard scores indicate that major arterial highways are 6.5 times over-represented and collector-distributors 2.1 times over-represented in the accident population. Although local streets account for 39.4% of the accidents, they represent 69.5% of the total site population, and thus receive a hazard score of -1.8.

When the pedestrian hazard scores of roadway functional classification are considered, several perceptions of hazardousness are reversed. Collector-distributors are no longer seen as hazardous for the hazard score changes from +2.1 to -1.2. Clearly, the relatively large number of pedestrians found on collector-distributors affects the hazardousness.

The PV hazard score indicates that major arterial highways (+2.1), and local streets (+1.6) both represent high levels of hazard. Collector-distributors, with a PV exposure hazardous score of -2.0, on the other hand, are relatively safe. Apparently roadways where pedestrian-vehicle interactions are relatively frequent (collector-distributors) are safer than roadways where there are fewer pedestrians and more vehicles (major arterials) or roadways where there are fewer vehicles and more pedestrians (local streets).

TABLE 49 : HAZARD SCORE– ROADWAY TYPE, NUMBER OF LANES & LENGTH OF BLOCK

VARIABLE	% OF NATIONAL PROJECTIONS OF: ACCIDENTS	SITES	PEDS	P x V	HAZARD SCORE: SITES less ±1	SITES more	PEDS less ±1	PEDS more	P x V less ±1	P x V more
ROADWAY FUNCTIONAL CLASSIFICATION										
MAJOR ARTERIAL HIGHWAY	17.0	2.6	5.0	8.1		6.5		3.4		2.1
COLLECTOR DISTRIBUTOR	30.8	14.5	38.2	61.2		2.1	-1.2		-2.0	
LOCAL STREET	39.4	69.5	52.7	24.0	-1.8		-1.3			1.8
OTHER	12.9	13.4	4.1	6.7	-1.0			3.2		1.9
NUMBER OF LANES										
TWO OR LESS	56.2	87.7	66.3	33.5	-1.6		-1.2			1.7
MORE THAN TWO	43.8	12.3	33.7	66.5		3.6		1.3	-1.5	
LENGTH OF BLOCK										
LESS THAN 250'	27.8	29.2	18.8	12.0	-1.1			1.5		2.3
251'-499'	32.6	32.5	51.0	54.8		1.0	-1.6		-1.7	
GREATER THAN 500'	39.7	38.2	30.2	33.2		1.0		1.3		1.2

The number of traffic lanes variable shows a similar shift in relative hazardousness from the site hazard scores to the PV hazard scores. In terms of the number of locations, sites with more than two lanes are considerably more hazardous (+3.6) and sites with two or less lanes are somewhat safer (-1.6). In terms of pedestrian volume, both types of sites are very similar; two lanes or less have a hazard score of only -1.2 while two lanes or more have a score of only +1.3 The PV exposure measure reverses this notion. Sites with two or fewer lanes have 1.7 times more accidents and sites with more than two lanes have 1.5 times fewer accidents per unit of exposure. Once again, as was the case with roadway classifications, the busier locations--those with more than two lanes--are ultimately safer.

The number of lanes variable thus provides an excellent demonstration of the interrelationship between pedestrian exposure and PV exposure. Sites with two or less lanes have two-thirds of the pedestrian exposure while sites with more than two lanes have the remaining one-third of pedestrian exposure. Since two or more lane roadways carry considerably more traffic, it is reasonable that the distribution of PV exposure should be the reverse of the pedestrian-only exposure. Two-thirds of the PV exposure is at locations with more than two lanes while one third is a location with two or less lanes. This type of reversal between the pedestrian and PV exposure measures occurs fairly often and when it does it demonstrates an effect of the V component in the PV measures.

One might expect that locations with longer blocks, and thus greater distances between intersections, would have more accidents because pedestrians are more apt to cross midblock to avoid the longer walk to the nearest intersection. The hazard scores suggest this is not the case. Accidents occur at blocks of various lengths in almost exactly the same distribution as the blocks occur in the national projection of sites. In terms of pedestrian volumes, shorter blocks have 1.5 times more accidents and longer blocks have 1.6 times fewer accidents. The addition of vehicle volumes to the exposure measure increases the relative values. Short blocks have a PV exposure hazard score of +2.3 while moderate length blocks had a PV score of -1.7. Long blocks (greater than 500 feet, or 152.4 meters) were found to be just slightly hazardous, since the PV score of +1.2 is very close to 1.0.

Road Surface, Shoulder and Median

Table 50 contains hazard score data on road surface material and condition, shoulder and median characteristics. The road surface material data indicates that concrete is less hazardous than either bituminous or gravel in terms of site, pedestrian volume and PV exposure hazard scores. This is somewhat surprising in light of the previously presented data indicating that major arterials are more hazardous than collector-distributors. This may be a function of the fact that fully signalized intersections tend to be less hazardous. (These intersection characteristics will be discussed in a later section.)

The road surface condition hazard scores show a similar consistency across all three measures. Roadways in "good" condition tend to be less hazardous while fair and poor road surface conditions are more hazardous. It is doubtful that this effect is a causative one; it is more likely that hazardousness is correlated with roadway conditions. The poorer quality roads carry less vehicular traffic so the PV exposure measure is smaller (since the V component is smaller) and relative hazardousness is larger.

The scores for shoulder surface are particularly interesting. Locations with no shoulder tend to be neither safe nor hazardous. This is probably because many such sites have curbs and sidewalks. Concrete shoulder locations accounted for 6.6% of the site and only 1.3% of the accidents,

TABLE 50: HAZARD SCORE – ROAD SURFACE MATERIAL, CONDITION; SHOULDER & MEDIAN CHARACTERISTICS

VARIABLE	% OF NATIONAL PROJECTIONS OF: ACCIDENTS	SITES	PEDS	P x V	HAZARD SCORE: SITES (less ±1 more)	PEDS (less ±1 more)	P x V (less ±1 more)
ROAD SURFACE MATERIAL							
CONCRETE	15.6	22.0	37.3	42.2	-1.4	-2.4	-2.7
BITUMINOUS	83.8	75.1	62.3	57.5	1.1	1.4	1.5
GRAVEL,DIRT,SAND	0.7	2.9	0.4	0.3	4.1	1.8	2.3
ROAD SURFACE CONDITION							
GOOD	55.3	69.4	67.1	78.3	-1.3	-1.2	-1.4
FAIR	39.1	28.1	27.4	18.6	1.4	1.4	2.1
POOR	5.7	2.6	5.5	3.0	2.2	1.0	1.9
SHOULDER SURFACE MATERIAL							
NONE	82.0	78.1	95.6	96.1	1.1	-1.2	-1.2
CONCRETE	1.3	8.6	1.6	0.4	-5.1	-1.2	3.3
BITUMINOUS	6.5	0.9	0.4	0.4	7.2	16.3	16.3
GRAVEL,SHELL	4.7	5.4	1.2	0.9	-1.2	3.9	5.2
GRASS	1.9	8.8	1.0	0.2	-3.6	1.9	9.5
COMBINATIONS & OTHERS	3.6	2.2	0.3	0.1			
MEDIAN							
NO MEDIANS	78.4	91.8	90.5	80.6	-1.2	-1.2	-1.0
BARRIER	1.8	0.1	0.2	0.1	18.0	9.0	18.0
CURB OR ISLAND	13.2	3.7	4.5	15.1	3.6	2.9	-1.1
PAINTED PAVEMENT	2.2	2.0	4.4	3.6	1.1	-2.0	-1.6
GRASS	3.7	1.5	0.2	0.3	2.5	18.5	12.3
OTHER	0.7	0.9	0.3	0.4			

thus a site hazard score of -5.1 indicates very low hazard. However, the PV exposure hazard score, +3.3, indicates more hazard. In fact, all of the sites with shoulders, regardless of the material, had high positive hazard scores. This suggests that providing or improving shoulders as a countermeasure to keep pedestrians off the roadway may not be effective. (Note: Before such a recommendation should be strongly pursued, it would be appropriate to examine the data of only those sites which do not have curbs and/or sidewalks. Also, available data on shoulder width should be examined to see the effect of shoulder width on the hazard scores.)

The median charcteristics data are also notable. All three hazard scores for sites with no median are very close to 1.0, indicating that such locations are neither particularly hazardous or particularly safe. Sites with median barriers have very high positive hazard scores for all three measures.

Again, suggestions that median barriers may serve as pedestrian accident countermeasures may be inappropriate. Although pedestrians rarely cross where median barriers are installed, it is apparent that when they do cross at these points, they are involved in a very hazardous activity. Painted pavement medians and curbs on islands, on the other hand, apparently provide a modicum of safety since low, but negative PV exposure hazard scores were found at locations with those treatments. Grass medians, like median barriers, show high positive hazard scores, particularly the pedestrian volume and PV exposure ones. This is surprising because intuitively a grass median provides the same type of pedestrian haven as does a painted median or a curb or island. This effect possibly is a function of vehicle speed or the type of roadway with these types of medians. (Note: Although these findings suggest that median barriers may have a negative pedestrian safety effect, the role of roadway functional classification and vehicle operating speed should be investigated.)

Roadway Markings

Table 51 profiles the roadway center, edge and lane markings as well as the channelization found at the accident and exposure locations. Locations with no center markings tend to be slightly less hazardous than those with markings. The hazard scores are -1.8, -1.8 and -1.5 for the site, pedestrian volume and PV exposure measures, respectively. Places with double solid lines have positive hazard scores of +1.9 for sites and +2.0 for pedestrian volumes. The PV exposure hazard score, though, is only +1.3, so such locations are not particularly hazardous when both pedestrian and vehicle volume are considered. The less common single broken centerline does not increase hazard and, in fact, has a -1.6 score for the pedestrian volume hazard score.

The hazard scores for roadway edge markings indicate that painted edge lines are associated with increased hazard, particularly for the pedestrian volume (+6.6) and the PV exposure (+5.0) hazard scores. Sites with no edge lines had hazard scores very close to 1.0, indicating no net positive or negative safety effect. This suggests that providing pavement edge lines may not increase pedestrian safety as has been indicated in previous research. (Note: It would be desirable to determine if this effect is confounded by roadway classification, vehicle speed, etc.)

Roadway lane markings do not appear to have an effect on hazardousness. Although dashed markings have high positive site hazard (+4.0) and

TABLE 51: HAZARD SCORE–ROADWAY MARKINGS & CHANNELIZATION

VARIABLE	% OF NATIONAL PROJECTIONS OF: ACCI-DENTS	SITES	PEDS	P x V	HAZARD SCORE: SITE (less ±1 more)	PEDS (less ±1 more)	P x V (less ±1 more)
ROADWAY CENTER MARKING							
NONE	37.6	66.7	65.8	57.5	-1.8	-1.8	-1.5
DOUBLE SOLID LINE	34.5	18.2	17.6	27.1	1.9	2.0	1.3
SINGLE DASHED LINE	7.6	7.9	12.4	7.9	-1.0	-1.6	-1.0
OTHER including divided highways	20.3	7.2	4.3	7.6			
ROADWAY EDGE MARKINGS							
NONE	81.8	90.4	86.5	77.2	-1.1	-1.1	1.1
PAINTED EDGE LINE	14.5	8.7	2.2	2.9	1.7	6.6	5.0
OTHER	3.7	0.9	11.3	19.9			
ROADWAY LANE MARKINGS							
NONE	56.1	87.5	65.0	35.2	-1.6	-1.2	1.6
DASHED	35.7	8.9	14.4	27.6	4.0	2.5	1.3
SOLID	1.6	0.6	0.9	1.7	2.7	1.8	-1.1
DASHED & SOLID	6.5	2.6	19.7	35.4	2.5	-3.0	-5.5
OTHER	0.1	0.4	0.1	0.0			
CHANNELIZATION							
NONE	79.3	89.0	81.1	59.6	-1.1	-1.0	1.3
LEFT TURN	11.9	3.7	3.2	4.9	3.2	3.7	2.4
RIGHT TURN	2.7	2.5	11.2	27.4	1.1	-4.2	-10.2
BOTH RIGHT & LEFT TURN	6.2	4.8	4.6	8.1	1.3	1.4	-1.3

pedestrian volume hazard (+2.5) scores, the low (+1.3) PV hazard score does not indicate a major increase in hazardousness. Sites with no lane marking do have a +1.6 PV exposure value, but this is not surprising since most residential local streets do not have lane markings and, as will be shown later, tend to have relatively high hazardousness. Locations with a dashed and solid center line are not very common (2.6% of the population), but do show a high negative PV exposure hazard score. This is because such locations have very high traffic volumes and very high pedestrian volumes.

The hazard scores for channelization indicate that locations with no channelization are neither particularly safe nor hazardous. However, sites with left turn channelization have moderate hazard scores for sites (+3.2), pedestrian volumes (+3.7) and PV exposure (+2.4); indicating that such locations are hazardous to pedestrians.

Right turn channelization, on the other hand, shows strong safety improvement. Although the site hazard score (+1.1) is very close to 1.0, both the pedestrian volume score (-4.2) and the PV exposure score (-10.2) indicates that accidents occur far less frequently than we would expect based on pedestrian or pedestrian and vehicle volumes.

Since right turn channelization is usually provided on major arterials where roadway width allows the addition of a turning lane, this reduction in apparent hazard is partially a function of the high vehicle volumes found at such locations. It is not suggested that right turn channelization results in an improvement in pedestrian safety. This effect is supported by the relative changes shown between the distributions of the pedestrian volume and the PV exposure measures. All sites with channelization have a higher proportion of the PV measure then they have of the pedestrian volume measure--vehicle volumes are higher. Since places with right turn channelization have particularly high vehicle volumes, the PV exposure measure is especially large. Locations with both right and left channelization show no major effects.

Parking

The role of parked cars as a visual obstruction in midblock accidents has long been reported in accident research. Table 50 portrays the role of parking restrictions, parking meters and parking on commercial premises in decreasing or increasing hazardousness to pedestrians.

Places where parking is permitted on both sides of the roadway have about as many accidents as would be expected based on pedestrian (-1.3) and the PV (+1.1) hazard scores. This is despite the fact that such places account for 49.7% of the site population and 33.4% of the accident sites (i.e., have a site hazard score of -1.5). Sites where parking is prohibited on one side do show less pedestrian hazard. The PV exposure hazard score is -3.4. However, sites where

TABLE 52: HAZARD SCORE-PARKING

VARIABLE	% OF NATIONAL PROJECTIONS OF: ACCIDENTS	SITES	PEDS	P x V	HAZARD SCORE: SITES (less ±1 more)	PEDS (less ±1 more)	P x V (less ±1 more)
PARKING RESTRICTIONS							
PERMITTED BOTH SIDES	33.4	49.7	42.5	31.7	-1.5	-1.3	1.1
PROHIBITED ONE SIDE	6.7	7.2	16.8	23.0	-1.1	-2.5	-3.4
PROHIBITED BOTH SIDES	29.7	9.9	11.9	24.6	3.0	2.5	1.2
WIDTH RESTRICTS TO ONE SIDE/NOT POSTED	3.6	15.4	3.4	0.4	-4.3	1.1	90
WIDTH RESTRICTS TO BOTH SIDES/NOT POSTED	8.5	11.0	1.1	1.0	-1.3	77	85
RESTRICTIONS VARY BY TIME OF DAY	18.2	6.9	24.2	19.2	2.6	-1.3	-1.1
PARKING METERS							
NONE	91.7	98.5	76.0	62.3	-1.1	1.2	1.5
ONE SIDE	2.4	0.4	11.1	17.0	60	-4.6	-7.7
BOTH SIDES	5.9	1.0	12.9	20.8	54	-2.2	-3.5
PARKING ON PREMISES — (POP)							
NO BUSINESS WITH POP	52.2	75.1	61.6	53.6	-1.4	-1.2	-1.0
<1/4 FRONTAGE WITH POP	14.6	4.8	12.4	10.2	3.0	1.2	1.4
>1/4<1/2 FRONTAGE WITH POP	10.2	7.6	8.5	7.5	1.3	1.2	1.3
>1/2<3/4 FRONTAGE WITH POP	10.8	8.9	11.0	12.7	1.2	-1.0	-1.2
>3/4 FRONTAGE WITH POP	12.1	3.7	6.5	16.0	3.3	1.9	-1.3

parking is prohibited on both sides are not less hazardous. In fact, on the basis of the site hazard score (+3.0) and the pedestrian hazard score (+2.5), these sites are actually more hazardous.

It is a somewhat unexpected finding that parking prohibitions on both sides of the roadway do not reduce hazardousness as much as prohibitions on only one side. This is probably an effect produced by the nature of the locations where parking is prohibited. Typically, parking is prohibited when traffic volumes reach capacity and the roadway width is needed for an additional traffic lane. Places where parking is still allowed on one side are not as busy and represent a less hazardous location for pedestrians. On roads where the roadway width restricts parking on one or both sides, very high positive PV hazard scores (+9.0, +8.5) indicate that these locations pose a safety hazard to pedestrians. This increase in hazard to pedestrians is a function of the fact that such roadways have few pedestrians and vehicles. Pedestrians may not be prepared for vehicular traffic at these locations. Downtown and commercial areas and collector-distributors where parking restrictions vary by time of day do not appear to present a hazard (pedestrian hazard -1.3, PV hazard -1.1).

Places with parking meters show a reduction in hazard. Where parking meters are provided on one side, a PV hazard score of -7.1 was found. Where parking meters are provided on both sides, a PV hazard score of -3.5 was found. Apparently, places with parking meters on one side are twice as safe as places that have parking meters on both sides. This is because places with meters on only one side tend to have more pedestrian volume than places with meters on both sides. A similar relationship was found in the previous parking restriction variable. Places where parking was prohibited on one side had a PV score of -3.4 while places where parking was permitted on both sides had a PV score very close to unity (+1.1). Parking meters are typically installed at busy commercial locations. Such locations tend to have high vehicle volumes and a lot of pedestrian activity. In terms of the number of PV interactions found at these places, they are relatively safe for pedestrians.

The parking on commercial premises variable was collected to test the hypothesis that locations with commercial establishments that had parking on their premises posed a threat to pedestrians because of increased vehicular traffic across the sidewalk area. The site hazard scores do indicate that such locations are overrepresented in accidents. However, the pedestrian and PV hazard scores indicate that parking on premises does not increase hazard when pedestrian and pedestrian-vehicle volumes are considered.

Pedestrian Accommodations and Lighting

Table 53 depicts the role of pedestrian accommodations, curbs and lighting in determining the relative hazardousness of locations. Although sites with no sidewalks (or pathways) or sidewalks on only one side are underrepresented in the accident population (site scores are -1.6 and -1.9 respectively), the pedestrian volume and PV exposure hazard scores indicate an increase in hazard associated with no sidewalks. The pedestrian hazard score (-2.6) and the PV exposure hazard score (+2.2) indicate that accidents are more than two times more likely to occur at these places than would be expected on the basis of exposure. Although the pedestrian vol-

TABLE 53: HAZARD SCORE– PEDESTRIAN ACCOMMODATIONS, CURBS & LIGHTING

VARIABLE	% OF NATIONAL PROJECTIONS OF: ACCI-DENTS	SITES	PEDS	P x V	HAZARD SCORE: SITES less ±1	SITES more	PEDS less ±1	PEDS more	P x V less ±1	P x V more
PEDESTRIAN ACCOMMODATIONS										
NO SIDEWALKS OR PATHWAYS	23.3	36.8	9.0	10.7	-1.6			2.6		2.1
SIDEWALK-ONE SIDE	9.5	18.0	7.8	8.3	-1.9			1.2		1.1
SIDEWALK-BOTH SIDES	67.2	45.2	83.2	81.0		1.5	-1.2		-1.2	
CURBS										
NONE	15.0	26.2	4.6	2.2	-1.8			3.3		6 8
ONE SIDE ONLY	4.3	3.0	1.5	0.9		1.4		2.9		4 8
BOTH SIDES	80.7	70.8	93.9	96.9		1.1	-1.2		-1.2	
STREET LIGHTING										
NONE	14.5	12.0	2.2	1.2		1.2		6 6		12 1
REGULARLY SPACED	78.7	71.2	89.9	94.6		1.1	-1.1		-1.2	
NOT REGULARLY SPACED	6.8	16.8	7.9	4.2	-2.5		-1.2			1.6
COMMERCIAL LIGHTING										
NONE	62.1	89.8	63.9	34.1	-1.5		-1.0			1.8
CONTINUOUS	17.5	3.8	23.0	43.0		4 6	-1.3		-2.5	
NOT CONTINUOUS	20.4	6.4	13.1	22.9		3.2		1.6	-1.1	

ume and PV exposure hazard scores associated with sidewalks on one side versus sidewalks on two sides are very small, they are consistent and in the predicted direction. Sites with no sidewalks are the most dangerous, sites with one sidewalk are less hazardous and those with two sidewalks are the least hazardous. Clearly, providing sidewalks results in an increase in pedestrian safety.

The presence of curbs on one or both sides of the roadway has a similar effect on hazardousness. This is not surprising since curbs and sidewalks tend to occur together. Sites with no curbs are underrepresented in the accident population (site hazard score -1.8). However, on the basis of the pedestrian volume hazard score (+3.3) and the PV exposure hazard score (+6.8), sites with no curbs are far more hazardous. Sites with curbs on one side are also hazardous, although the absolute hazard score values are only slightly less. The hazard scores for locations with curbs on both sides do not indicate either more or less hazard.

The hazard scores for street lighting and commercial lighting provide comparable results. Sites with no street lighting and regularly spaced street lighting are both only very slightly overrepresented in the accident population (site hazard scores +1.2 and +1.1 respectively). However, when pedestrian exposure is considered, sites with no street lighting become more hazardous (pedestrian volume hazard score +6.6) and when PV exposure is considered sites with no street lighting become far more hazardous (PV exposure hazard score +12.1).

Places with regularly spaced street lighting are neither hazardous nor safe with site, pedestrian volume and PV exposure hazard scores of +1.1, -1.1 and -1.2 respectively. Locations with not regularly spaced street lighting are underrepresented in the accident population (site hazard score +2.4), however, the PV exposure hazard score of +1.6 indicates some degree of hazardousness, although not as much as that associated with locations with no street lighting. Regularly spaced street lighting apparently results in an improvement in pedestrian safety.

Artificial lighting from signs and/or businesses was identified as "commercial lighting". Places with commercial lighting may be safe because the commercial lighting increases the pedestrian's visibility or they may be unsafe because the commercial establishments serve as pedestrian generators. Sites with no commercial lighting are slightly underrepresented in the accident population (site hazard score -1.5). In terms of pedestrian exposure such sites are neither safe nor unsafe (pedestrian volume hazard score 1.0). However, in terms of pedestrian-vehicle exposure, these sites are hazardous (PV exposure hazard score +1.8).

Thus, it appears that although these locations do not attract a disproportionate number of pedestrians, the vehicle volumes pose a threat to pedestrian safety. On the other hand, sites with continuous commercial lighting are considerably overrepresented in the accident population (site hazard score +4.6). Although the pedestrian volume hazard score (-1.3) indicates a slight reduction in hazard, the PV exposure hazard score indicates a sizeable (-2.5) reduction in hazard. There are far fewer accidents than would be expected on the basis of the PV exposure interactions occurring at these locations. Sites with "not continuous" commercial lighting had a PV exposure hazard score of -1.1. In terms of hazard to pedestrians, such sites fall between those with no commercial lighting (+1.8) and those with continuous commercial lighting (-2.5). Apparently commercial lighting, like roadway lighting, does have a positive effect on pedestrian safety.

Intersection Characteristics

Tables 54, 55 and 56 describe the hazard scores associated with various intersection characteristics.

Land Use

Table 56 shows the hazard scores associated with the adjoining land use categories found at the intersections. The data is broken down into nine categories in the upper portion of the exhibit. The lower portion combines these nine categories into three more general categories. Note that 100% residential sites are underrepresented in the accident population (site hazard score -2.6), yet are quite hazardous (+3.3) in terms of the PV exposure measure. With the exception of the 75-99% residential (PV exposure hazard score -2.2) areas, all other areas also have relatively high positive PV hazard scores. Thus, 100% residential areas are the most hazardous, mixed residential areas are slightly hazardous, while commercial and industrial areas are the safest--in terms of PV exposure. Thus, where PV interactions occur least frequently, accidents are most likely to happen.

Intersection Type, Signalization and Turning Prohibitions

Table 57 offers hazard score information on intersection type, lane configuration, signalization and turning prohibitions. Four-leg intersections apparently do not contribute to

TABLE 54: HAZARD SCORE- LAND USE AT INTERSECTION

VARIABLE	% OF NATIONAL PROJECTIONS OF: ACCI-DENTS	SITES	PEDS	P x V	HAZARD SCORE: SITE less ±1	SITE more	PEDS less ±1	PEDS more	P x V less ±1	P x V more
LAND USE: AT INTERSECTION										
100% RESIDENTIAL	21.7	55.8	22.4	6.5	-2.6		-1.0			3.3
RESIDENTIAL WITH PARKS, SCHOOLS,etc	10.0	6.5	7.9	6.2		1.5		1.3		1.6
RESIDENTIAL & OPEN	6.1	10.3	4.3	1.6	-1.7			1.4		3.8
OPEN ONLY/UNDEVELOPED	2.7	3.1	1.0	0.5	-1.2			2.7		5.4
75-99% RESIDENTIAL	6.4	3.6	7.7	9.6		1.8	-1.2		-1.5	
51-74% RESIDENTIAL	5.4	4.2	7.8	3.8		1.3	-1.4			1.4
50-75%COMMERCIAL	16.8	6.3	10.1	9.3		2.7		1.7		1.8
76-100% COMMERCIAL	28.7	8.8	37.0	62.0		3.3	-1.3		-2.2	
51-100% INDUSTRIAL	2.2	1.6	1.7	0.5		1.4		1.3		4.0
LAND USE: AT INTERSECTION										
100% RESIDENTIAL	21.7	55.8	22.4	6.5	-2.6		-1.0			3.3
COMMERCIAL & INDUSTRIAL	47.7	16.6	48.8	71.8		2.9		1.0	-1.5	
MIXED RESIDENTIAL	30.6	27.6	28.8	21.6		1.1		1.1		1.4

TABLE 55 : HAZARD SCORE- INTERSECTION TYPE,CONFIGURATION, AND SIGNALIZATION

VARIABLE	% OF NATIONAL PROJECTIONS OF: ACCI-DENTS	SITES	PEDS	P x V	HAZARD SCORE: SITES less ±1	SITES more	PEDS less ±1	PEDS more	P x V less ±1	P x V more
INTERSECTION TYPE										
4-LEG	53.9	38.8	70.1	74.9		1.4	-1.3		-1.4	
"T"	35.9	52.3	17.0	9.2	-1.5			2.1		3.9
MULTI-LEG	2.8	3.8	9.3	13.8	-1.4		-3.3		-4.9	
ALL OTHER INT TYPES	7.4	5.1	3.6	2.1						
LANE CONFIGURATION										
2x2	48.7	82.2	59.9	29.0	-1.7		-1.2			1.7
2x4	34.2	12.5	15.1	19.3		2.7		2.3		1.8
4x4	17.0	5.2	25.0	51.7		3.3	-1.5		-3.0	
SIGNALIZATION										
NO SIGNALIZATION	63.3	93.1	59.8	31.8	-1.5			1.1		2.0
RED,GREEN,AMBER	12.1	3.4	7.2	10.1		3.6		1.7		1.2
RGA & PEDESTRIAN SIGNAL	24.7	3.5	33.0	58.2		7.1	-1.3		-2.4	
RIGHT TURN ON RED										
RTOR ALLOWED	72.8	81.3	57.9	69.1	-1.1			1.3		1.1
RTOR NOT ALLOWED	24.9	18.7	42.1	30.9		1.3	-1.7		-1.2	
RTOR NOT ALLOWED AT CERTAIN TIMES	2.3	0	0	0						
LEFT TURNING										
ALLOWED	73.1	77.2	56.3	60.3	-1.1			1.3		1.2
SPECIFICALLY PROHIBITED	20.5	15.6	41.7	37.4		1.3	-2.0		-1.8	
PROHIBITED AT CERTAIN TIMES	6.5	7.2	2.0	2.3	-1.1			3.3		2.8

or detract from safe pedestrian crossing. Although there is a small negative PV exposure hazard score (-1.4), the value is relatively small. "T" intersections, on the other hand, are underrepresented in the accident population (site hazard score -1.5), yet in terms of both pedestrian volume hazard score (+2.1) and PV exposure hazard score (+3.9) indicate a sizeable increase in pedestrian hazard. Perhaps through drivers at "T" intersections do not perceive the situations as requiring any decision-making, while drivers on the leg of the "T" are more concerned about their turning maneuver. Surprisingly, multiple leg intersections--with their increased complexity--do not pose a threat to pedestrians. In terms of both the pedestrian volume hazard score (-3.3) and the PV exposure hazard score (-4.9), multiple leg intersections have greatly reduced pedestrian hazard. This is due to the fact that both pedestrian volumes and vehicle volumes are relatively high at these locations.

The lane configuration hazard scores are interesting. Both the 2 x 2 and 2 x 4 configurations offer a modest hazard to pedestrians (PV exposure scores of +1.7 and +1.8 respectively). However, the 4 x 4 configuration shows a relatively large decrease in pedestrian hazard (PV exposure score of -3.0). This suggests that wider streets are not necessarily more dangerous to cross when the larger traffic volumes they carry are considered. This effect is probably influenced by the presence of signalization. Most 4 x 4 intersections are signalized.

Intersections with no signalization are the most hazardous (PV exposure score +2.0), those with a RGA signal only show no major effect (PV exposure score of +1.2), while those with a RGA signal and a pedestrian signal are quite a bit safer (PV exposure hazard score -2.4). (Note: the interactions between lane configuration and signalization should be further evaluated.)

The data on right-turn-on-red (RTOR) is also illustrated in Table 55. There is a slight trend for less hazard at RTOR-prohibited locations in terms of pedestrian volume hazard score (-1.7) and in terms of PV exposure hazard score (-1.2). However, these values are not very large, particularly the PV exposure score, and do not strongly suggest that RTOR prohibitions increase pedestrian safety. However, the hazards associated with RTOR as a vehicle action do suggest that RTOR does decrease pedestrian safety. This data is presented later in Table 56. (Note: the interaction between RTOR prohibitions and the presence of pedestrian signals should be examined.)

The data on left turn prohibitions indicate a similar effect but the differences are somewhat larger. At intersections where left turning is prohibited, a decrease in hazard was found in the PV exposure hazard score (-1.8). Where left turning is always allowed, a positive, but very small increase in PV exposure hazard (+1.2) was found. Where left turning is prohibited at certain times, a much larger increase in the PV hazard score (+2.8) was found. It is apparent that prohibiting left turns does result in a decrease in hazard to pedestrians. However, this effect may be confounded by the fact that left-turn prohibitions may be most frequently applied at commercial locations which have low PV hazard scores. (Note: The interaction between left turn prohibitions and pedestrian signals should be examined.)

Crosswalks, Markings and Signs

Table 54 shows the hazard scores for crosswalks, crosswalk markings and signs at intersection locations. Although sites with no marked crosswalks are slightly underrepresented in the accident population (site hazard score -1.3) and there is very slightly more hazard in the pedestrian volume hazard measure (+1.2), these locations had a PV exposure hazard score of +2.5, indicating that unmarked crosswalk locations have an increased level of hazard. Although locations with marked crosswalks on only one roadway do not show any hazard reduction, a reasonable level of hazard reduction is associated with sites with all the crosswalks marked. These locations are overrepresented in the accident population in terms of number of sites (site hazard score +2.5). However, locations with both crosswalks marked are far less hazardous when pedestrian and vehicle volumes are considered (PV hazard score -2.5). Providing marked crosswalks does result in an increase in pedestrian safety.

Interestingly, the type of crosswalk marking does not appear to make any difference. Sites with lines only and lines with diagonal stripes had nearly identical negative PV hazard scores (-1.9 and -1.8 respectively).

Sites with stop signs and sites with no signs both occurred in nearly identical proportions in the accident and site populations. However, the pedestrian volume hazard score for sites with no signs was +1.4 and the PV exposure hazard score for these locations was +2.3. This indicates that the lack of signing increases hazards for pedestrians. Conversely, locations with a stop sign showed a small decrease in hazard for pedestrians (PV hazard score -1.3). Interestingly, locations with four-way stops presented less hazard as indicated by both the pedestrian volume hazard score (-1.8) and the PV exposure hazard score (-2.1). Apparently one stop sign is better than no sign and a four-way stop results in the greatest improvement in pedestrian safety.

TABLE 56: HAZARD SCORE– CROSSWALKS, CROSSWALK MARKINGS & SIGNS

VARIABLE	% OF NATIONAL PROJECTIONS OF:				HAZARD SCORE		
	ACCIDENTS	SITES	PEDS	P x V	SITES (less ±1 more)	PEDS (less -1 more)	P x V (less ±1 more)
CROSSWALKS							
NONE	61.2	81.2	51.4	24.8	-1.3	1.2	2.5
MARKED-ONE ROADWAY	12.0	8.1	12.4	12.2	1.5	1.0	1.0
MARKED-BOTH ROADWAYS	26.8	10.7	36.2	63.0	2.5	-1.4	-2.4
CROSSWALK MARKINGS							
NONE	61.9	81.9	54.3	27.7	-1.3	1.1	2.2
LINES ONLY	27.1	13.5	37.1	52.7	2.0	-1.4	-1.9
LINE WITH DIAGONAL STRIPE	10.4	3.8	8.1	19.1	2.7	1.3	-1.8
OTHER	0.6	0.7	0.6	0.4			
SIGNS							
NONE	37.4	41.4	27.2	16.0	-1.1	1.4	2.3
STOP SIGN	58.4	55.8	66.0	78.1	1.1	-1.1	-1.3
4-WAY STOP	3.5	2.4	6.4	7.5	1.5	-1.8	-2.1
YIELD SIGN, OTHER	0.6	0.4	0.4	0.3			

Pedestrian, Vehicle and Accident Characteristics

This section focuses on the relative hazardousness of various pedestrian, vehicle and accident characteristics. Since we are not dealing here with the characteristics of specific locations, it is not possible to generate three different hazard scores for each characteristic. Instead, a single hazard score has been computed. This hazard score is generated by determining the relationship between the percentage of the pedestrian accidents and the percentage of the pedestrians (or vehicles) observed. As was the case for the site, pedestrian volume, and PV exposure hazard scores, the larger percentage is always divided by the smaller percentage. A negative value is assigned if the accident percent is smaller (i.e., the hazard is less). A positive value is assigned if the accident percent is larger (i.e., the hazard is greater).

Pedestrian Characteristics

Table 57 illustrates the relative hazardousness of various pedestrian charcteristics including age, sex, accompaniment, mode, crossing location and signal response. The over-involvement of the very young and the very old in pedestrian accidents has been long established. It is now apparent that the young and old are also over-involved on the basis of their exposure. The 0-4 age group was involved in accidents over eight times more often than they were observed as pedestrians. The 5-9 age group was involved in four times more accidents than would be expected on the basis of the exposure observations. The 10-14 age group was very slightly over-involved while the 15-19 and the 20-29 age groups were very slightly under-involved. On the other hand, the 30-59 age group was 2.6 times less involved in accidents than would be expected on the basis of their exposure. The expected trend returns to the 60+ age group who are involved in accidents 1.7 times more often than expected, based on their exposure. It is apparent that the young and the old are over-involved in pedestrian accidents not because of increased exposure.

It has been frequently reported that males are involved in approximately 60% of the pedestrian accidents. The exposure data also indicates that approximately 60% of the pedestrians observed are male. It is evident that males are involved in 60% of the pedestrian accidents because of their exposure. It is somewhat surprising that males are not over-involved relative to their exposure. The preceeding section discussing pedestrian characteristics found that males are over-involved in certain apparently hazardous activities, i.e., crossing midblock and crossing against the signal.

Somewhat less than half of the pedestrians were walking with other pedestrians. It has been suggested that here is "safety in numbers"--specifically that it is safer to walk with other pedestrians than it is to walk alone. Based on the exposure data, such does not appear to be the case. The pedestrians struck were found to be alone in very nearly the same ratio as the pedestrians observed.

Running has long been identified as a precipitating factor in pedestrian accidents. Slightly more than half of the accidents in the present sample involved running. However, only 11.2% of the pedestrians observed were running. Thus, a hazard score of +4.7 was obtained for pedestrians running. The relative hazardousness of pedestrian behavior is increased when they are running.

TABLE 57: HAZARD SCORE–
RELATIVE HAZARDOUSNESS:PEDESTRIAN CHARACTERISTICS

VARIABLE	PERCENTAGE OF: PEDESTRIAN ACCIDENTS	PEDESTRIANS OBSERVED	HAZARD SCORE (less ±1 more)
PEDESTRIAN AGE			
1-4	8.3	1.0	8.3
5-9	21.6	5.4	4.0
10-14	12.2	10.1	1.2
15-19	10.9	11.5	-1.1
20-29	18.4	22.6	-1.2
30-59	15.8	41.7	-2.6
60 & over	12.8	7.7	1.7
PEDESTRIAN SEX			
MALE	60.4	59.7	1.0
FEMALE	39.6	40.3	-1.0
PEDESTRIAN ACCOMPANIMENT			
ALONE	53.1	58.9	-1.1
WITH OTHER PEDESTRIANS	46.9	41.1	1.1
PEDESTRIAN MODE			
WALKING	47.1	88.8	-1.9
RUNNING	52.9	11.2	4.7
CROSSING LOCATION			
CROSSWALK	24.0	54.3	-2.3
WITHIN 50' OF INTERSECTION	24.1	9.4	2.6
DIAGONALLY ACROSS INTERSECTION	0.9	1.7	-1.9
MIDBLOCK	51.0	34.6	1.5
SIGNAL RESPONSES (If crossed at signal)			
WITH SIGNAL: GREEN	51.3	90.4	-1.8
AGAINST SIGNAL: RED	48.7	9.6	5.1

Running, particularly running out into the roadway of midblock, has been one of the most frequently occurring accident situations. The hazard scores for pedestrian crossing location generally supports these findings. Crossing in a crosswalk (marked or unmarked) had a hazard score of -2.3 while crossing midblock had a score of +1.5. Interestingly, crossing within 50 feet of an intersection, with a hazard score of +2.6, is even more hazardous than crossing midblock. Surprisingly, the hazard ratio for crossing an intersection diagonally was -1.9, as "safe" as crossing at the intersection. Such behavior occurred relatively infrequently, .9% of the accidents and 1.7% of the pedestrians observed, so the hazard score should be considered accordingly.

Approximately half of the pedestrian accidents occuring at signalized intersections involved pedestrians crossing with the green light; over 90% of the pedestrians observed crossed with the green. Thus a negative hazard score of -1.8 is obtained, indicating that it is safer to cross with the green light. Although almost half of the pedestrians struck at signalized intersections were crossing against the light, only 9.6% of the pedestrians observed at signalized intersections crossed against the light. Thus, it is more than five times more hazardous to cross against the light. It is encouraging to find positive proof supporting what has long been believed to be true, namely, that it is safer to cross in a crosswalk and that it is safer to cross with the light.

Vehicle Action and Type

Table 56 provides the hazard scores for vehicle action and vehicle type. Vehicles proceeding straight accounted for 90.0% of the accidents and 84.6% of the vehicles observed. Although vehicles proceeding straight are very slightly over-represented in the accident population, the hazard score is only -1.1 and should not be considered a major effect. Turning vehicles, on the other hand, are involved in accidents about half as often as they were observed. Hazard scores of -2.0 for turning right and -1.6 for turning left indicate that turning results in less hazard.

The involvement rates for right turn on red (RTOR) are very interesting. Previous discussions of Table 55 noted an indication of slightly increased hazard at locations where RTOR is allowed. The data on vehicle action indicates a large increase in hazard associated with RTOR vehicles. A total of 1.6% of the accidents involved RTOR vehicles while only 0.5% of the vehicles observed were RTOR. The resulting hazard score of +3.2 indicates a sizeable increase in hazard associated with RTOR. The effect is especially dramatic when compared with the reduction in hazard associated with non-RTOR right turning (hazard score -2.0). Apparently turning right alone is not hazardous to pedestrians yet RTOR activity does increase pedestrian hazard.

The data on vehicle type indicates that cars, vans and pickups, trucks and taxis are involved in accidents in very much the same proportion as they were found in the exposure data. However, large positive hazard scores were found to be associated with buses (+2.9) and with motorcycles (+3.3). Both buses and motorcycles strike pedestrians about three times more often that would be expected based on exposure.

Time of Day

Table 59 charts pedestrian exposure, pedestrian-vehicle (PV) exposure and the occurrence of pedestrian accidents by time of day. The exhibit portrays the hazard associated with being a pedestrian during the hours of the day. The

TABLE 58: HAZARD SCORE–
RELATIVE HAZARDOUSNESS:VEHICLE CHARACTERISTICS

VARIABLE	PERCENTAGE OF: VEHICLES IN ACCIDENTS	VEHICLES OBSERVED	HAZARD SCORE less	±1	more
VEHICLE ACTION					
GOING STRAIGHT	90.0	84.6			1.1
TURNING RIGHT	3.8	7.7	-2.0		
TURNING LEFT	4.6	7.2	-1.6		
RIGHT TURN ON RED	1.5	0.5			3.2
VEHICLE TYPE					
CARS	79.3	83.5	-1.1		
VANS,PICK-UPS	12.4	11.6			1.1
TRUCKS,OTHER	2.3	2.4	-1.0		
BUSES	2.0	0.7			2.9
TAXIS	0.7	0.8	-1.1		
MOTORCYCLES	3.3	1.0			3.3

TABLE 59: HAZARD SCORE–TIME OF DAY

VARIABLE	% OF NATIONAL PROJECTIONS OF: ACCIDENTS	* SITES	PEDS	P x V	HAZARD SCORE: SITES * less	SITES * more	PEDS less	PEDS more	P x V less	P x V more
TIME OF DAY										
7 AM-8 AM	0.4	6.2	4.2	4.3	-15.5		-10.5		-10.8	
8 AM-9 AM	5.4	6.2	5.1	4.7	-1.2			1.1		1.2
9 AM-10 AM	4.6	6.2	5.2	4.7	-1.4		-1.1		-1.0	
10 AM-11 AM	3.9	6.2	5.5	5.2	-1.6		-1.4		-1.3	
11 AM-12 NOON	4.7	6.2	7.0	7.0	-1.3		-1.5		-1.5	
12 NOON-1 PM	4.6	6.2	8.4	8.2	-1.4		-1.8		-1.8	
1 PM-2 PM	4.3	6.2	7.5	8.2	-1.4		-1.7		-1.9	
2 PM-3 PM	8.5	6.2	6.9	7.6		1.4		1.2		1.1
3 PM-4 PM	10.0	6.2	7.7	10.7		1.6		1.3	-1.1	
4 PM-5 PM	10.7	6.2	8.8	8.9		1.7		1.2		1.2
5 PM-6 PM	13.0	6.2	7.5	11.6		2.1		1.7		1.1
6 PM-7 PM	6.1	6.2	7.1	7.5	-1.0		-1.2		-1.2	
7 PM-8 PM	5.8	6.2	7.6	4.6	-1.1		-1.3			1.3
8 PM-9 PM	5.8	6.2	5.2	3.1	-1.1			1.1		1.9
9 PM-10 PM	7.5	6.2	3.6	2.3		1.2		2.1		3.3
10 PM-11 PM	4.7	6.2	2.7	1.4	-1.3			1.7		3.4
TIME OF DAY										
7-9 AM	5.8	12.5	9.3	9.0	-2.2		-1.6		-1.6	
11-1 PM	9.2	12.5	15.4	15.2	-1.4		-1.7		-1.7	
4-6 PM	23.7	12.5	16.3	20.5		1.9		1.5		1.2
REST OF DAY	61.2	62.5	59.0	55.2	-1.0			1.0		1.1

*SITES CONSIDERED TO BE DISTRIBUTED EVENLY BY HOUR

exhibit, with one notable exception, uses the same format that was used to present roadway and intersection characteristics earlier in this chapter. Since it is not possible to plot the occurrence of "sites" by time of day, the sites column is used to indicate the distribution if the events occurred equally during the 16 hours of data collection. The site hazard score column, therefore, shows the ratios between the percentage of accidents and the percentage that would be expected if they were equally distributed during the day. The score shows how the "curve" of accidents by time of day deviates from a straight-line distribution.

The site hazard score column shows the traditional peak of an increase in pedestrian accidents in the afternoon. Between 2 PM and 6 PM there are more accidents than would be expected. The pedestrian volume hazard score column compares the accident distribution with the distribution of pedestrians observed. The afternoon continues to be a time of increased hazard even when pedestrian volume is considered. There is also an increase in hazard after 8 PM.

The PV hazard score column reveals the comparison of accident occurrence and the PV exposure measure. The distributions are very similar to those of the pedestrian exposure measure with two notable exceptions. The increase in hazard in the afternoon has almost vanished. When both vehicle volumes and pedestrian volumes are considered, it is not more hazardous to be a pedestrian in the afternoon. An opposite effect is seen in the evening. When vehicle and pedestrian volumes are considered, there is a further increase in hazard to pedestrians starting at 7 PM and continuing until 11 PM. By far the most hazardous time to be a pedestrian is between 9 PM and 11 PM.

An interesting and yet not totally understood characteristic of the time of day data involves the apparently great reduction in hazard associated with the 7-8 AM time period. Very few accidents occurred at that time, only 0.4% of the total; and yet pedestrian and pedestrian-vehicle exposure is surprisingly high, representing 4.2% and 4.3%, respectively, of the total. These values produce very high negative pedestrian volume hazard scores (-10.5) and PV exposure hazard scores (-10.8). Perhaps this effect is partially due to the fact that the more over-involved age groups, 0-4 and 5-9 are not up and around so early in the morning. The data base could be further analyzed to confirm or refute this hypothesis.

Figure 9 graphically depicts the time of day data previously presented in Table 59. The trends discussed in the preceding paragraph are pictorially highlighted. Both pedestrian and PV exposure tend to mirror each other throughout the day. Accidents tend to be under-represented in the morning hours, particularly the first hour shown--7 AM. This corresponds to the times when there are negative hazard scores. There is a slight over-representation of accidents in the late afternoon and a more major over-representation later in the evening. This corresponds to the times when there are positive hazard scores.

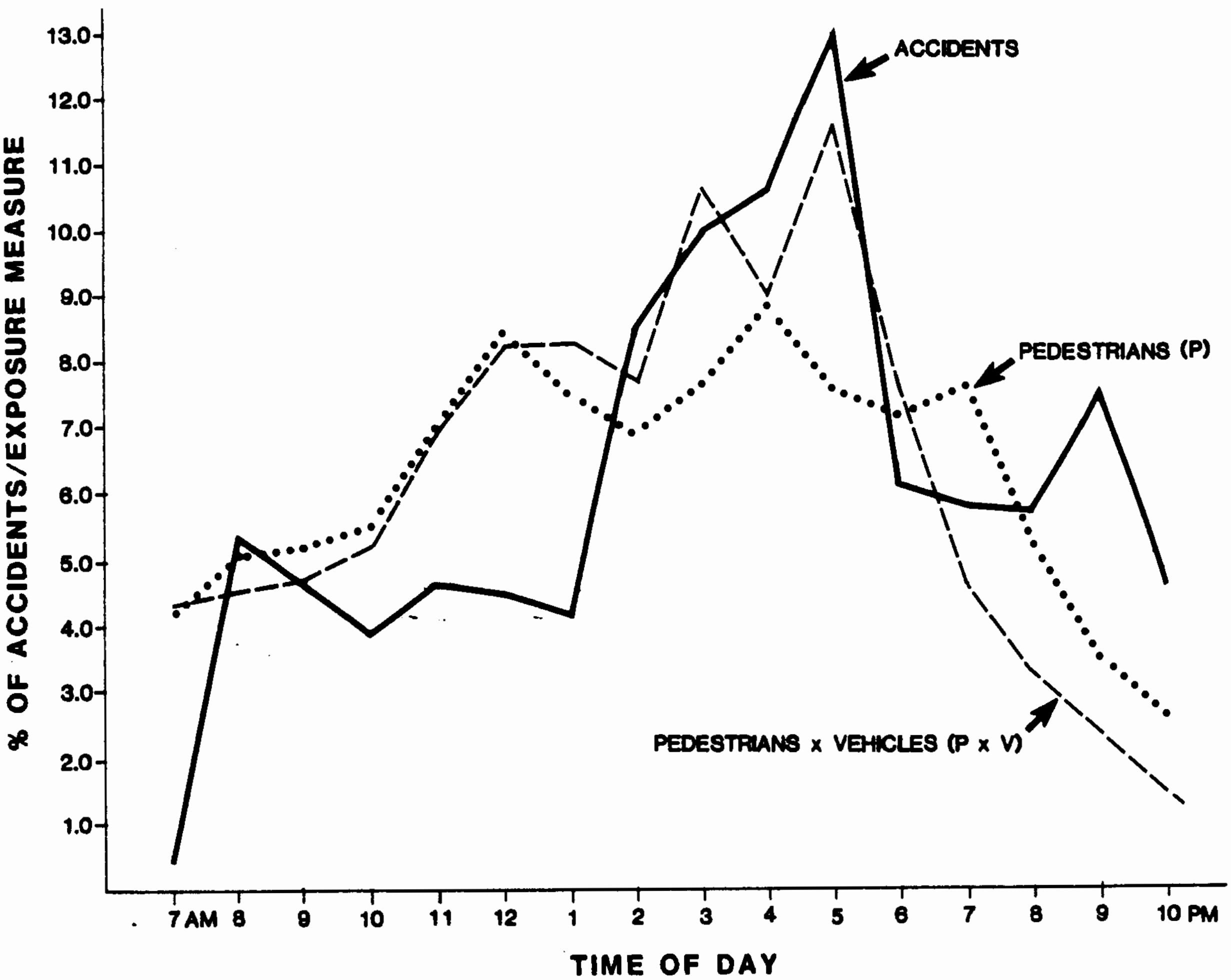

FIGURE 9 : HAZARD SCORE-ACCIDENTS
PEDESTRIAN & PEDESTRIAN-VEHICLE EXPOSURE BY TIME OF DAY

Accident Type

Table 60 shows the data that was collected on accident type. An accident type was assigned to each accident report that was reviewed. The accident types were based on the behavioral activities of the pedestrian when they were struck. A complete set of definitions for the various accident types is presented in Appendix B. In addition, during the pedestrian activity sampling portion of the exposure data collection, the field crew also coded the "accident type" for each pedestrian observed. In this case, "accident type" was also based on the behavioral activities of the pedestrian. The field researchers simply coded the appropriate accident type in response to the question: "If the pedestrian had been struck during the time that he/she was being observed, into what type would the accident have been classified?". The relative frequency of the accident types in the accident population and in the exposure population were used to generate a hazard score. A negative hazard score was assigned when the frequency in the accident population was smaller, indicating that there is less hazard associated with the particular pedestrian behavior. A positive hazard score was assigned when the frequency in the accident population was larger, indicating that there is more hazard associated with the particular pedestrian behavior.

Large negative hazard scores were found to be associated with four accident types. This indicates that the behaviors associated with these four accident types are exhibited by pedestrians who are not involved in accidents more often than they are by pedestrians who are involved in accidents. These behaviors are relatively "safe". Not surprisingly, walking on

TABLE 60: HAZARD SCORE-RELATIVE HAZARDOUSNESS:ACCIDENT TYPES

VARIABLE	PERCENTAGE OF: PEDESTRIAN ACCIDENTS	PERCENTAGE OF: PEDESTRIANS OBSERVED	HAZARD SCORE (less ±1 more)
ACCIDENT TYPE			
PEDESTRIAN ON SIDEWALK-NOT CROSSING	3.3	16.5	-5.0
INTERSECTION CROSSING-WALKING	12.1	52.5	-4.4
TRAPPED: CHANGING LIGHT	0.6	2.2	-3.7
EXITING-ENTERING PARKED VEHICLES	3.2	6.8	-2.1
MIDBLOCK DART-OUT	33.0	1.2	27.5
BUS STOP RELATED	1.9	0.1	19.0
VEHICLE TURN-MERGE	4.9	0.4	12.3
VENDOR, ICE CREAM TRUCK RELATED	1.7	0.2	8.5
RIGHT TURN ON RED	1.4	0.2	7.0
DISABLED VEHICLE RELATED	1.7	0.3	5.7
CROSSING EXPRESSWAY	0.4	0.1	4.0
MULTIPLE THREAT	2.3	0.8	2.9
INTERSECTION DASH	11.1	5.4	2.1
PLAYING IN ROADWAY	3.7	1.8	2.1
WALKING ALONG ROADWAY	8.9	4.6	1.9
MIDBLOCK CROSSING-WALKING	9.4	6.3	1.5
HITCHIKING	0.1	0.1	1.0
SCHOOL BUS RELATED	0.2	0.0	1.0
MAILBOX RELATED	0.0	0.5	1.0

the sidewalk and not crossing was the safest pedestrian behavior observed. It occurred five times more often in the exposure data than it did in the accidents. Walking across the roadway at an intersection was the second most safe activity. Slightly over half of the pedestrians observed were involved in this activity while only 12.1% of the pedestrian accidents involved this behavior. Two other accident types, exiting-entering a parked vehicle and trapped by a changing light, occurred far less frequently but were found to have negative hazard scores.

Three of the accident types (school bus-related, hitchhiking and mailbox-related) occurred so infrequently in either the accident or exposure populations that it was not possible to compute a hazard score. The remaining 12 accident types were found to have positive hazard scores of varying magnitudes. By far, the most hazardous pedestrian behavior was found to be associated with the midblock dart-out. Running into the roadway at midblock accounted for 33.0% of the accidents. Only 1.2% of the pedestrians observed displayed this behavior. This produces a hazard score of +27.5, by far the largest hazard score computed for any of the variables analyzed in this chapter. Pedestrians rarely exhibit darting-out behavior, but when they do, it is far more likely to result in an accident. The second most hazardous accident typology involved bus-stop related activity--crossing in front of a stopped bus at a bus stop. It accounted for 1.9% of the accidents and only 0.1% of the pedestrians observed. With a hazard score of +19.0, a very high degree of hazard is associated with this behavior. The third most hazardous accident type was the vehicle turn-merge situation. This involves a vehicle preparing to turn, change lanes, or pull-out into the roadway and a pedestrian walking in front of the vehicle. Although this situation accounted for 4.9% of the accidents, only 0.4% of the pedestrians observed were involved in this accident precipitating scenario. A hazard score of +12.0 is associated with this accident type.

Four accident types produced very high hazard scores that were larger than 5. Vendor-ice cream truck accidents involve a pedestrian going to or from a street vendor. A hazard score of +8.5 was computed. Right turn on red accidents involve a pedestrian being struck by a vehicle involved in a RTOR maneuver. Accounting for 1.4% of the accidents and 0.2% of the behavior observed, this type produced a hazard score of 7.0. The hazardousness indicated for this pedestrian activity is supported by the high hazard associated with RTOR as a vehicle action (Table 58). Disabled vehicle accidents involve a pedestrian struck while working on, or in the vicinity of, a disabled vehicle. Since 1.7% of the accidents and 0.3 % of the pedestrians observed were so involved, a hazard score of 5.7 was calculated. Crossing an expressway was rarely reported as an accident type (0.4%) and even more rarely (0.1%) reported as an observed behavior. The hazard score, +4.0, supports the obvious conclusion that such behavior is indeed hazardous.

Five accident types resulted in hazard scores that ranged from +2.9 to +1.5. Although these scores are not as large as those for the accident types just discussed, they are for the most part based on much higher percentages of the accident and/or exposure populations. Because of this, they deserve as much or more attention as some of the other accident types with even higher hazard scores that were just discussed.

The multiple threat situation involves a pedestrian crossing the road in front of a standing vehicle and being struck by another vehicle traveling in the same direction as the standing vehicle. This situation accounts for 2.3% of the accident population, 0.8% of the exposure population, and a hazard score of +2.9.

The intersection dash involves a pedestrian running across the roadway at an intersection. It accounts for 11.1% of the accidents, and 5.4% of the exposure. The hazard score of +2.1 is in contrast to the -4.4 score for the similar accident type involving walking across the roadway at an intersection. Again, the hazard associated with running is clearly demonstrated.

Playing in the roadway has long been assumed to be a hazardous activity, accounting for 3.7% of the accidents. Since 1.8% of the pedestrians observed were playing in the roadway, a hazard score of +2.1 results. Thus, playing in the roadway is not as hazardous as many other pedestrian behaviors.

Walking along the roadway accidents involve pedestrians who are struck while walking along the traveled way or shoulder--not on a sidewalk or pathway. It is a particularly common accident type in rural and suburban areas, accounting for 8.9% of the accident population. Pedestrians tend to walk along the roadway relatively often: 4.6% of the exposure population exhibited this behavior. The hazard score of +1.9 indicates that walking along the roadway is a hazardous activity, but not as hazardous as a great many other activities.

Walking across the roadway at midblock accounted for 9.4% of the accidents and 6.3% of the exposure behavior. The hazard score of +1.5 indicates that this behavior is only slightly hazardous. The +1.5 hazard score stands in sharp contrast to the +27.5 score associated with running across the roadway at midblock. It is a great deal more hazardous to run across the roadway, either midblock or at an intersection, than it is to walk across the roadway at those locations.

Summary and Conclusions

In this chapter, the relative hazardousness of various roadway, intersection, pedestrian, vehicle and accident characteristics have been described. This was done by comparing the characteristics of accident locations and accident-involved pedestrians and vehicles with the characteristics of locations, pedestrians and vehicles in the general population at risk. Hazard scores were computed for each of these characteristics. These scores are the ratios of the percentage of the accident population to the percentage of the exposure population, or vice versa. The larger percentage was always divided by the smaller percentage. For example, if one percentage was twice the other, a hazard score of 2.0 was computed. If the accident population had the larger percentage, a positive value was assigned (i.e., +2.0). If the accident population had the smaller percentage, a negative value was assigned (i.e., -2.0). Thus, a positive hazard score indicates that a characteristic is relatively hazardous while a negative hazard score indicates that a characteristic is relatively safe.

The major findings from this chapter are summarized in three tables: 61, 62, 63. These contain the findings on the relative hazardousness of roadway characteristics, intersection characteristics and pedestrian, vehicle and accident characteristics. Each of the variables that was examined are listed in the left-hand column of the tables. The remaining three columns are used to indicate which of the characteristics associated with the variable are either relatively "safe", not relatively hazardous or relatively safe, or relatively hazardous. In order for a characteristic to be considered relatively hazardous, it had to have a positive hazard score of +1.4 or greater. These characteristics are listed in the fourth column. In order for a characteristic to be considered relatively safe, it had to have a negative hazard score of -1.4 or less. They are listed in the second column. Characteristics which had hazard scores ranging from +1.3 to -1.3 are considered to be neither relatively hazardous or relatively safe and are listed in the third column.

Recommended Research

The project achieved its stated objectives of identifying pedestrian trip making characteristics, developing pedestrian exposure measures, and determining the relative hazard associated with various characteristics and behaviors. A very large and potentially, very useful, data base describing pedestrian behavior was collected. A great deal has been learned about the nature of pedestrians and of pedestrian exposure. Even more can be readily extracted from the data tapes. The reader was previously cautioned against interpreting high correlations between two factors as indicating a causative effect. The bivariate analyses presented in this report readily lend themselves to a confusion between correlation and causation. Further analyses need to be done to extricate all of the factors involved in some of the results presented. Also, further analyses could be done on some data that was collected but not analyzed in this report. The remainder of this section will be devoted to a listing of examples of the kinds of additional analyses that could be performed on the data base.

- Counts were made of bicyclists, joggers, skaters, blind pedestrians and transportation handicapped pedestrians. This data could be tabulated to determine how these individuals contribute to pedestrian exposure.

- Information on roadway, sidewalk, shoulder and median width was recorded. This data could be examined to determine how it affects pedestrian exposure.

- Data on area density as it related to various land use categories was recorded at all sites (accident and exposure sites). This information could be further analyzed to determine how the amount of the various types of land use affects pedestrian exposure.

- The hazard scores described in this report were based on P x V exposure, for all pedestrians crossing the street. Similar analyses could be conducted based on the various subgroupings of pedestrian exposure i.e. midblock crossing, crossing at an intersection, crossing in the crosswalk, etc.

- Most of the results presented were bivariate analyses of the entire data base, across all sites. For example, we found that major arterials were more hazardous than other roadway classifications and 100% residential areas were more hazardous than other land use classifications. It would be useful to examine any interactions that may exist between land use and roadway classification. These effects could be found by looking at the various roadway classifications in areas of a particular land use, or, by looking at land use across each roadway classification.

- Before any of the results presented in this document are used for rule-making and/or countermeasure development, the influence of potentially confounding effects should be examined. For example, painted edge lines were found to be associated with increased hazard to pedestrians. This conclusion was based on a comparison between all sites with edgelines and all sites with no edgelines. The potential interactive effects of roadway classification, vehicle speed, land use, etc. should be examined. For example, the apparent edgeline effect could result from the fact that edgelines tend to be used on roadways with higher vehicle speeds and the higher vehicle speeds result in increased hazard to pedestrians.

TABLE 61
Relative Hazardousness: Roadway Characteristics

Variable	Relatively Safe	Not Relatively Hazardousness or Relatively Safe	Relatively Hazardous
Roadway Classification	Collector Distributors	---	Major Arterials; Local Streets
Number of Lanes	More than 2	---	2 or less
Length of Block	251' to 499'	Greater than 500'	Less than 250'
Road Surface Material	Concrete	---	Bituminous; Gravel, Dirt, Sand
Road Surface Condition	Good	---	Fair and Poor
Shoulder Material	---	None	Concrete; bituminous and gravel, shell
Median	Painted pavement	No median curb or island	Barrier, grass
Center Markings	No center markings	Double solid lines Single dashed line	---
Roadway Edge Markings	---	None	Painted edge line
Roadway lane markings	Dashed and solid	Dashed solid	None
Channelization	Right turn	None Both right and left turn	Left turn
Parking Restrictions	Prohibited, one side	Permitted both sides; prohibited both sides; restrictions very by time of day	Width restricts parking on one or both sides
Parking Meters	One or both sides	---	None
Parking on Premises	---	All conditions	---
Pedestrian Accommodations	---	Sidewalks on one or both sides	No sidewalks or pathways
Curbs	---	Both sides	No curbs; curbs on one side
Street lighting	---	Regularly spaced	None; Not regularly spaced
Commercial lighting	Continuous	Not continuous	None

TABLE 62

Relative Hazardousness: Intersection Characteristics

Variable	Relatively Safe	Not Relatively Hazardous or Relatively Safe	Relatively Hazardous
Adjoining land use	Commercial and industrial	---	100% Residential; Mixed residential
Intersection type	4-leg; Multi-leg	---	"T"
Lane Configuration	4 x 4	---	2 x 2, 2 x 4
Signalization	RGA and ped signal	Red, Green, Amber	None
Right turn on red	---	RTOR allowed; RTOR not allowed	---
Left turning	Specifically prohibited	Allowed	Prohibited certain times
Crosswalks	Marked crosswalks both roadways	Marked crosswalks one roadway only	No crosswalks
Crosswalk markings	Crosswalk lines only; Crosswalk lines and diagonal stripe	---	No crosswalk markings
Signs	4-way stop	Stop sign	No sign

TABLE 63
Relative Hazardousness - Pedestrian, Vehicle and Accident Characteristics

Variable	Relatively Safe	Not Relatively Hazardous or Relatively Safe	Relatively Hazardous
Pedestrian age	30-59 Years	10-14 years old; 15-19 years old; 20-29 years old	1-4 years old; 5-9 years old; 60+ years old
Pedestrian sex	----	Male; Female	----
Pedestrian accompaniment	----	Being alone; With others	----
Pedestrian mode	Walking		Running
Crossing location	Crosswalk; Diagonally across intersection		Within 50' of intersection; midblock
Signal response	With signal		Against signal
Vehicle action	Turning right Turning left	Going straight	Right turn on red
Vehicle type	----	Cars, vans & pick-ups, trucks and taxis	Motorcycles
Time of day	7-8 AM 10 AM to 2 PM	8-10 AM 3-8 PM	8 PM to 11 PM
Accident type	On sidewalk-not crossing; Intersection crossing-Walking; Trapped-changing light; Exiting/entering parked vehicle	Hitchhiking; School-related; Mailbox-related	Midblock dart-out; Bus stop related; Vehicle turn-merge; Vendor, ice cream truck; RTOR; Disabled vehicle; Crossing expressway; Multiple threat; Inter-section dash; Playing in the roadway; Walking along roadway; Midblock crossing-walking

APPENDIX A

A REVIEW OF PEDESTRIAN RISK EXPOSURE MEASURES

CONTENTS

Page

INTRODUCTION

Police and other public safety agencies regularly compile statistics on pedestrian-vehicle accidents and the resulting pedestrian injuries. Pedestrian deaths represent approximately 18% of all traffic fatalities. Pedestrian accidents account for 5% of traffic accidents.

The accumulation and analysis of accident statistics are clearly important tasks for they indicate changes in accident patterns over time and the categories of pedestrian severely affected by traffic accidents. This information serves an important alerting function, but it is misused when it is the sole source of data examined in the consideration of safety countermeasures. Missing from analysis of most accident statistics, though, are comparisons of accident-involved behavior with normal, non-accident pedestrian behaviors which would permit a determination of relative hazardousness of various pedestrian behaviors. This normal, non-accident baseline data is referred to as pedestrian exposure information.

Exposure data is critical if accurate assessments of relative hazardousness are to be derived. From accident files, it is known that the most common category of pedestrian accidents is a "dart-out" at a midblock location. What exposure data contributes is information indicating how often dart-outs occur in the course of normal non-accident walking.

CONCEPTS OF EXPOSURE

Work on accident risk has been performed over the past two decades in Great Britain, Australia and this country and researchers have recognized the necessity of using exposure measures to correctly assess accident risk in context. Without considering exposure, for example, looking at motor vehicle accident rates is misleading. More people have accidents during the day than at night, which would indicate that daytime driving is more hazardous than nighttime driving. But once exposure is considered, it is obvious that while there are more daytime accidents than nighttime accidents, the proportion of nighttime accidents to nighttime exposure is considerably greater than the proportion of daytime accidents to daytime exposure - and therefore, nighttime drivers are more at risk.

In looking at pedestrian risk, then, exposure measures are important because they assist in identifying which pedestrian activities are risky and they help identify the characteristics of those pedestrians who perform high risk activities.

The research in pedestrian risk defines basic exposure and then looks at how it varies, given various pedestrian tripmaking characteristics - age, sex, time of day, etc. - and given various vehicle behaviors - turning movements, speed, etc. The following discussion reviews general concepts and definitions of exposure in the literature and how various researchers have measured exposure.

Definitions of Exposure

Hauer (1980) has discussed the problem of defining "exposure" and differentiating it from the concepts of conflict, risk, and hazard. He recognizes the problem of the tautological relationship of the concept of risk and exposure: Risk is defined in terms of exposure and exposure is defined in terms of risk. Hauer's clarification of the definition of exposure is expressed in the language of probability:

> "A unit of exposure corresponds to a trial. The result of such a trial is the occurrence or non-occurrence of an accident (by type, severity, etc.). The chance set-up is the transportation system (physical facilities, users, and the environment), which is being examined, and risk is the probability (chance of an accident occurrence in a trial) and thus describes the safety property of the transportation system examined."

Hauer's formulation of risk (or system safety) as

SAFETY = PROBABILITY OF AN ACCIDENT x EXPOSURE

expresses, in slightly different terms, the same idea that Cameron, Jacobs and Wilson, and others have used, that

$$\text{Risk} = \frac{\text{Accidents}}{\text{Exposure}}$$

Although there is basic agreement on the relationship of exposure to risk, various researchers have used different language in defining exposure:

- "an event which precedes an accident"
- "frequency of traffic events which create the risk of accident"
- "Potential accident events"

While language differs, however, all definitions are consistent with the idea that exposure is related to a condition that must be present in order to have an accident.

Exposure Measurements and Techniques

There are several exposure measures that have been employed in pedestrian risk research, and several methods used to measure exposure. These measures, ranging from the general to the specific, are:

1) time spent walking
2) distance travelled when walking
3) the number of trips made by walking
4) the number of roads crossed
5) time spent crossing a road
6) the number of pedestrians at a given location
7) the product of pedestrians and vehicles (P x V) at a given location

The more general of these measures have been used to give an indication of what segment of the pedestrian population is most exposed, whereas the more specific measures have been used both to determine the exposure of various segments of the population and to compare the exposure at different locations in a roadway system.

Todd and Walker (1980) defined pedestrian exposure as "the exposure to the risk of being involved in a road accident while on foot on the public highway" and sought to measure this in very general terms in order to compare the distribution of those pedestrians exposed with the distribution of those pedestrians involved in accidents.

To measure this, they used a combination of various exposure measures:

- time spent walking (because the degree of risk a pedestrian might be exposed to may vary with the length of time he is on foot, especially if he is walking in the roadway)

- distance walked

- number of roads crossed (they noted that 84% of pedestrian accidents in 1975 occurred when a pedestrian was crossing a road)

- number of safe points when crossing (for example, pedestrian refuges)

- number of paces needed to cross the road (because a person is more exposed to traffic the longer he is in the road, and a major determinant of "time in roadway" is the width of roadway)

By using these exposure measures, Todd and Walker were able to develop mean pedestrian activity measures by age and sex of their sample population in Great Britain, which was selected from the voting register. Measurement was made by an initial home interview to obtain information on all walking done on a selected sample day and then having an interviewer "retrace" the steps taken by the sampled person.

Brög and Küffner (1981) in their general discussion on relating accident frequency to travel exposure, also used several exposure measures to describe total travel exposure. They, like Todd and Walker, considered distance travelled and time spent travelling as measures of exposure, but they also considered the number of trips a person made as a measure. They used a trip diary technique to draw this information from their sample respondents. While we may believe that number of trips is irrelevant to pedestrian exposure, Brög and Küffner were working to determine the comparative risks of different groups of people using different modes of transportation, and it is perhaps a good measure of exposure for some modes. Brög and Küffner's work emphasizes that the choice of exposure measure affects the conclusion. For example, using "miles travelled" as the main indicator shows that the risk of having an accident is least for those travelling by car, whereas using "number of trips" and "time spent travelling" show least risk for a pedestrian.

Hillman and Whalley (1979) also compare pedestrian accident rates with those of other modes, and estimated for Great Britain's National Travel Survey rates of accident by number of trips, time spent travelling and distance travelled. (Their results differed from those of Brög and Küffner - possibly because they were considering Great Britain instead of Germany, and possibly because of the way the rates were calculated.)

Researchers, working on very specific problems, approached exposure from a less general viewpoint and have used relatively simple measures of exposure. They have been primarily concerned with measuring exposure at a given site or set of sites, rather than making conclusions about exposure for the population in general.

Mackie and Older (1965) were not looking to develop broad estimates of relative risks of one mode versus another, nor were they specifically looking to differentiate risk by demographic or tripmaking characteristics, although they did separate their data by age and sex. In studying pedestrian risk in crossing busy roads in Inner London suburbs, they were concerned with the relative risk in crossing at various sites on the road (i.e., at the crossing, midblock, within 50 yards of the crossing, etc.). To ascertain the relative levels of risk they merely used the number of pedestrians as a measure of exposure in their formula:

$$\text{RISK} = \frac{\text{ACCIDENTS (2 years)}}{\text{PEDESTRIANS (12-minute sample)}}$$

They arbitrarily assigned a risk value of 1.00 to "elsewhere" (i.e. not at junction or near a crossing) crossings and were thus able to develop relative risk measurements for the other crossing locations.

While they did not consider vehicle volumes in their formula, they did measure road width and vehicle volumes at the sites and their conclusions state that these are important to exposure. For example, they concluded that roadway width is a variable related to risk in that "when crossing a wide roadway pedestrians are exposed to risk for greater length of time than when crossing a narrow street". They also recognized that in some area types risk increased with total vehicle flow, and they recognized that turning traffic and pedestrian density are related to risk. As numbers of turning vehicles increase, risk increases; as pedestrian density increases, risk decreases.
Jacobs and Wilson (1967), in their study of pedestrian risk in crossing busy roads in four towns in Great Britian, used the same equation that Mackie and Older did.

$$Risk = \frac{\text{Accidents (2 1/2 years)}}{\text{Pedestrians (12-minute sample)}}$$

They realized that a serious problem with this sampling technique is that pedestrian observations are made during the daytime only but that accidents cover a twenty-four-hour period.

Jacobs and Wilson also developed a set of factors affecting risk:

- type of area--at a zebra crossing (a pedestrian-priority crossing), within 20 yards of a junction, at a light-controlled crossing, etc.
- age and sex of pedestrians
- characteristics of the various towns
- roadway geometrics (including one-way streets)
- vehicle flow

It is clear that they saw vehicle flow as more than just a "variable affecting risk" such as age and sex, because they controlled for this variable in looking at differences between the various crossing locations. When comparing the four towns they studied, they found that differences in vehicle flows in the towns largely accounted for the differences in risk in the four towns.

Howarth et al.(1974) acknowledged the value of the Mackie and Older and Jacobs and Wilson research, but found it lacking in that the studies had been concerned with the relative risk for pedestrians crossing at particular types of locations, rather than on identifying pedestrians who are most at risk overall. They also stressed the importance of including an assessment of potential encounters with vehicles in an exposure measure. Their work aimed to establish a conceptual framework and develop a breakdown of risk estimates within the under 16 years of age category.

Howarth's equation for risk--

$$\text{probability of selecting a child of given characteristics who will have an accident} = \frac{\text{number of accidents occurring in a given time period}}{\text{number of pedestrians of this type in the population and days over which the accident statistic has been collected.}}$$

for accidents per pedestrian day enables comparison of risks run by different age groups of pedestrians in different cities or at different times of the year merely by using accident data. However, Howarth et al also considered two other statistics to calculate risk:

- accidents per road crossing
- accidents per encounter with a vehicle

Their method of calculating the accidents per encounter with a vehicle is interesting because they consider traffic density and traffic speed, as well as the amount of time a child is in the roadway. The calculation is based on average lengths of vehicles, the average velocity of vehicles, and the average time taken by the pedestrian to cross the path of a vehicle. This assumed "heedless" behavior-- that is, that neither the vehicle nor the pedestrian would engage in adaptive behavior.

To measure exposure, Howarth et al. conducted an interview study of Nottingham school children aged 5-11 years from three different types of areas - city, suburban, and rural. A diary of road crossings was obtained for the previous day, and traffic counts were taken at each of the roads crossed. From the questionnaire they estimated for the children number of roads crossed and the probability of encountering a vehicle at each road crossing.

Routledge, Repetto-Wright and Howarth (1976) elaborated on their earlier work by discussing four techniques to measure exposure for the statistics they used, which were a measure of average risk (given present patterns of road crossing) and a measure of risk per encounter with a vehicle. The four methods Routledge, Repetto-Wright and Howarth experimented with in their child pedestrian risk studies are:

- interviews with the children, which enabled precise identification of child's age and discussion with the child about his attitudes on safety. Interviewing children instead of parents provides a much more accurate picture of their journeys. However, this method underestimates the exposure of playing in the road. Also, using this technique precludes taking traffic density counts on the day the child is actually making his trips, because the interview asks about the activities of the previous day.

- interviews with the parents of children, which provided more accurate information about weekend journeys (because children had difficulty remembering on Monday what they did on Saturday). However, parents tend to underestimate their child's exposure and, like interviewing children, this method precludes taking traffic density counts on the day the child is actually exposed.

- "following study", where an observer followed the child and records his activity. This method provides very accurate information on exposure - especially for playing in the road. Accompaniment is accurately reported in this method, as is the exact location of every crossing. However, the method is impractical for obtaining a large sample of children and, like the interview studies, traffic density counts must be taken on days other than those on which the children were followed.

- random site observations, where selected sites were observed and road crossings, sex and age of pedestrians, and vehicle density counts were recorded all at the same time. This method has the advantage of fast and flexible sampling, greater possibility for observing pedestrians, and the ability to conduct traffic density counts simultaneously with the observation of pedestrians. The limitation of the method is that the age of the pedestrians observed must be estimated, but it is an extremely cost-effective way to collect data.

In their work Howarth, Repetto-Wright, and Routledge recognized the importance of potential conflict with a vehicle as an important aspect of exposure, but it was Cameron's work in Australia which fully involved the "pedestrian x vehicles" exposure measure. Cameron (1967) makes a very simple argument that pedestrians are simply not exposed to the risk of being hit by a car unless they are in an area where cars travel. This is a strong argument against using "time" or "distance" or "number of journeys" as exposure measures.

The important difference between Howarth, Repetto-Wright and Routledge's "conflict with a vehicle" exposure measure and Cameron's is that their measure considered vehicle density and the probability that a pedestrian would encounter a vehicle, while Cameron's measure was more simply the product of the number of pedestrians and vehicles observed in the same section in the same five-minute interval. To determine PV, Cameron et al. (1976) calculated the product of five-minute pedestrian and vehicle counts in each road section and then summed these over all locations and times to obtain a total measure of pedestrian risk exposure. Cameron uses the simpler measure because he sees gap acceptance as a component of pedestrian decision-making affecting risk -- not as a part of exposure itself. Cameron (1981) cites two desirable features of the use of P x V as an exposure measure:

- it is the number of intersecting pedestrian and vehicle paths (which has intuitive appeal)
- it is consistently summable when partitioned by descriptors of pedestrians and/or vehicles.

While seeing P x V as the best exposure measure, he believes that it could give a distorted result in conditions of high vehicle flow when gap acceptance will be different than it is in lower volume flows. Cameron (1976) noted, however that correction for gap acceptance under conditions of high vehicle flow does not appear to more adequately explain frequencies of pedestrian accidents than the simple P x V measure, according to conclusions in a study made by the Transport Road and Research Laboratory.

Summary

What is obvious from the preceding discussion is that there is no clear "best" definition of exposure or a "best" technique for measuring it. In the past two decades, researchers in different countries, with different data bases and different research goals, have obviously different concepts of exposure and have used different exposure measures. While there is a considerable body of literature treating pedestrian exposure, the contexts of the studies are very different, so the effectiveness of the measures cannot be compared. An exposure measure used to determine relative exposure of pedestrians against exposure of auto users, for example, will not be useful in determining pedestrian risk at a midblock crossing versus that at an intersection crossing.

Regardless of how they defined or measured exposure, all researchers agree on the importance of considering it when making any conclusions about pedestrian behavior and risk. However, as Todd and Walker (1980) point out, it is easy to overlook the actual numbers involved when looking at risk based on exposure. An individual crossing midblock may be more at risk than a person crossing at an intersection, but there are more accidents at intersections. So, even though it is safer to cross at an intersection, more accidents occur at intersections than at any other location. Todd and Walker caution that those responsible for safety campaigns must be aware of both kinds of situations - those that are high risk and those that are low risk but have a high frequency of accidents.

TRIPMAKING CHARACTERISTICS

Pedestrian risk researchers, regardless of how they measure exposure, have been concerned with identifying tripmaking characteristics that help explain which segment of the population is most exposed or help explain which segment of the population is most at risk and why. For example, looking at sex of pedestrians shows that women are generally more exposed, but that men are more at risk than women - as shown by their greater involvement in accidents relative to their exposure. By looking at other tripmaking characteristics and using them as controlling variables, some of this variation can be explained. For example, Todd and Walker (1980) found that nighttime walking was more hazardous than daytime walking and concluded the difference in risk between the sexes can partially be explained by the fact that men cross more roads at night than women do.

Thus, in an effort to describe the characteristics of pedestrians at risk and what conditions promote risk, researchers have examined:

- pedestrian characteristics (age, sex, clothing color, demographics)
- pedestrian behavior (accompaniment by others, walking versus running, decision-making strategies)
- environmental characteristics (time of day, time of year, weather, surrounding land use, type of crossing)
- trip characteristics (purpose, length)
- and, to a lesser degree, driver behavior and vehicle characteristics.

This section will briefly summarize the pertinent findings of these studies. With few exceptions, use of different exposure measures does not affect the conclusions regarding risk, so the literature will be considered as one body.

Pedestrian Characteristics

Virtually all research in the pedestrian risk literature deals with the role of sex and age in determining the population most exposed and that most at risk. Other demographic characteristics have only been briefly examined in the literature.

Sex: The findings are generally consistent that women have greater exposure than men but incur less risk. Brög and Küffner (1981), for all three of their exposure measures - number of trips, time spent walking, and distance travelled - saw German women considerably more exposed than men but saw their injury and fatality rate only slightly higher than that of men. Hillman and Whalley (1979), using Britain's 1975 National Travel Survey data, concluded that men make about one-third fewer journeys than women but their pedestrian casualty rate is one-third higher. Todd and Walker (1980), using a sample in England, looked at the general characteristics of the walking population and found that women under 60 are more exposed than men under 60 in terms of the travel exposure measures they used - distance travelled, mean time spent walking, and number of roads crossed. One demographic characteristic that helps explain the greater exposure of women is auto availability. Todd and Walker found that men crossed roads more than women when they controlled for auto availability in examining the relationship between sex and exposure.

The findings of Cameron et al.(1976), studying a sample of road sections in Sydney, Australia, contradict these general findings, showing women less exposed than men. He suggests that this may be caused by some unknown situation peculiar to Australia.

Cameron does, however, agree with the conclusions of the main body of research in showing a higher risk for young (0-10 years) and older (61+ years) males than for their female counterparts.

Jacobs and Wilson (1967) show higher risk for older males, but their research concludes that females under 16 years of age are more at risk than males under 16: the differences, however, were not statistically significant. Mackie and Older (1965) cite an overall higher risk for men than women, with little difference between the sexes for the under-sixteen age category.

Differences in behavior have generally been cited to explain the different risk rates of men and women pedestrians. Jacobs and Wilson (1967) noted in their study of four English towns that 35% of women crossed roads in the pedestrian crossings, while only 27% of the men did. Mackie and Older (1965) found a greater general adherence to crossings in Inner London suburbs, but their findings also show that men are less likely to use crosswalks than women - 56% of men compared with 66% of females used the crosswalks, with the 16 to 60 age group's male behavior largely accounting for this difference. Routledge et al. (1974) when looking at children's risk, found a higher accident rate for boys; they attributed this to differences in crossing behavior - boys ran more and played in the street more than girls. Cameron et al.(1976) also had the same explanation for the high risk of young boys and they suggested that the higher risk of older men is explained by the fact that men may walk more in the road than women, as well as the fact that older men tend to use pedestrian crossways less than older women. Todd and Walker (1980), when questioning their sample, found men take more risks and are generally less cautious about crossing than women are.

But Todd and Walker also made an important finding on the differences between the sexes in terms of exposure: the differences in casualty rates between men and women is largely explained by the difference in the casualty rates late at night. Men cross twice as many roads at night than women do, and hence are more exposed to the dangers associated with darkness. They found no significant difference between casualty rates for men and women during daylight hours after taking exposure into account.

Age: Safety of children has been of particular concern to pedestrian risk researchers, and they have studied how exposure and risk vary with age. Jacobs and Wilson (1967) saw a marked relationship between age and risk of injury. They found risk of young males under 16 to be twice that of 16 to 60 year olds, and risk to elderly males was four times that of the middle-aged group. For women, risk to those under 16 was six times that of the 16 to 60 year olds, and risk to those over 60 was four times that of the middle-aged group. Mackie and Older (1965) also found that the under-16 and over-60 age groups were the population groups most at risk.

Hillman and Whalley (1979) differentiated their sample population more than these researchers and used a lower limit threshold of five years age. They found children five to nine years of age have a much higher risk than any other age group in their sample when considering a casualty rate per journey on foot. Cameron et al.(1976), using more complete age breakdown and controlling for exposure, showed a very high risk for pedestrians under four years of age and over 61 years of age.

Routledge, Repetto-Wright, and Howarth (1974), whose main interest was identifying risk to children, studied children's exposure extensively. They found a very marked increase in exposure for children between age five and eleven and concluded, therefore, that the very young children (those under five) have a much greater risk than would appear to be the case just by looking at raw accident statistics. The findings of Cameron et al. (1976) support this, showing that pedestrians under four years of age have an almost four times greater risk than children five to ten years of age. They also conclude that the relative risk of 61 year olds is about half that of the youngest pedestrian, as shown in the table* below from their study in Sydney, Australia:

Pedestrian Age	Accidents	Exposure	Estimated Relative Risk*
0-4	70	.7	11.00 (High)
5-10	184	5.4	3.72 (High)
11-20	153	18.2	.92
21-40	164	53.7	.34 (Low)
41-60	190	18.8	1.11 (High)
61+	152	3.2	5.17 (High)

Various factors may explain why the young and elderly are more at risk than middle-aged people. Researchers have suggested that physical and mental impairments contribute to this risk. Todd and Walker (1980) looked at how health problems affect how much one walks and concluded that health reasons were not the main factor in why old people walk less than young people. They also discovered that the elderly do not consider good hearing to be important for safe street crossing. They suggest that the elderly may <u>know</u> what to do when faced with a problem, but they may not be able to react quickly enough to cope with modern-day traffic. Howarth et al.(1974) cite the work of Sandels, who suggested that children under ten years of age do not have the sensory or cognitive abilities to cope with traffic. Older and Grayson (1974) cite a study by Eysenck which indicates that children and the elderly need more information to cross the street, as compared with adults who combine location selection and observation tasks.

*Source: Cameron et al. p.1B5.

Older's research has focused on pedestrians' behavior when crossing streets, and his results indicate that age plays an important part in behavioral differences. Older and Grayson (1974) noted that older pedestrians make more head movements than younger pedestrians do. Grayson (1975) noted that the behavior of child pedestrians also varies by sex, with young boys more likely to exhibit "adult" crossing behavior. The adult's behavior involved making head movements on approach to a crossing, whereas children did not look until stopping at the curb.

Other physical characteristics: Snyder and Knoblauch (1971) considered the role of alcohol involvement in pedestrian accidents, but found that it is difficult to get accurate information on this because often this is not measured, and even if it is, the results are confidential information.

Other demographic factors: Several studies in the field of pedestrian research have aimed to identify and describe the characteristics of the walking population. Hillman and Whalley (1979) were concerned with describing characteristics of English pedestrians, using information from Britain's 1975-76 National Travel Survey. They looked at distance of journeys by foot by age and by sex, journey rates and mode split by household income, journey rates and mode split by car ownership. Their findings confirm what would be expected: people with low incomes walk more than people with high incomes, people without cars make more journeys by foot than people with cars, people living in densely populated areas make more trips by foot than people living in less densely populated areas. Todd and Walker (1980), also working to describe the general pedestrian population (using a sample in England), again confirmed what would be expected: part-time workers walk more than full-time workers, people with a driver's license walk less than people without a driver's license, single people walk more than married people. These differences are largely accounted for by differences in auto availability, age, and sex.

Pedestrian Behavior

Pedestrian behavior is related to age and sex, as Cameron, Grayson, and others have pointed out; various pedestrian behaviors are also related to other behaviors. For example, Grayson (1975) compared pedestrians' head movements on approach to a curb, at the curb, and during crossing. Whether a person was alone or with another pedestrian affected these head movement patterns, which is understandable because of shared decisionmaking. Following is a brief summary of work sought to describe pedestrian behavior and relate it to risk.

Mode: Running versus walking is probably one of the most important pedestrian behavior parameters. Cameron et al. (1976) observed that most people (85%) walk when they cross a road, but those who run have a much higher risk of accident - more than twice that of those who walk. Rose et al. (1976) considered pedestrian velocity, direction and acceleration important pedestrian behaviors to consider in accident risk research. The Institute of Transportation Engineers' handbook (1976) cites a study by Sleight which shows that children generally move more rapidly than adults. It also cites a study by Weiner which associates accompaniment with walking speed: When groups of pedestrians walk together, the walking speed is lower. Grayson (1975) sees pedestrian mode choice as a factor in risk to young boys: primary school boys are more likely to run across the road than other groups in the population. Hillman and Whalley (1979) note that the accident rate among boys is two-thirds higher than that of girls, even though they walk only slightly more; Grayson's concept that boys run across roads more than girls may help explain this difference in risk.

Accompaniment: While accompaniment generally slows down the walking speed of pedestrians, it has other effects on behavior as well-- some not beneficial. Grayson (1975) found that children in groups were more likely to cross the road before it was clear than children alone. Older and Grayson (1974) found that children alone make more head movements than children in groups - indicating that accompaniment can be a distraction. Snyder and Knoblauch (1971) considered distraction due to accompaniment a predisposing condition to pedestrian accidents.

Routledge, Reppetto-Wright, and Howarth (1976) were very concerned about the effect of accompaniment - especially adult accompaniment - on child pedestrian risk. They saw accompaniment as important in determining what person takes the responsibility to insure that a crossing is safe. In one of their studies (Howarth et al., 1974) they modified their exposure measure to account for this ignoring all child pedestrians accompanied by adults (as this is really an "adult" crossing) and considering 50% exposure for a child accompanied by another child (expecting that the second child would accept responsibility for crossing on half the occasions).

In general it seems that accompaniment reduces accident risk. Cameron et al in their study in Sydney, Australia found this to be the case. Todd and Walker's (1980) findings suggest that accompaniment may be one of the several factors that account for the higher risk of older people and males: They found that people over 60 years of age cross 70% of the roads alone, as compared with people 18-59 who cross 59% of the roads alone. Men cross 67% of the roads alone, as compared with women, who cross 57% of the roads alone.

Decisionmaking strategies: As mentioned earlier, different pedestrians use different decisionmaking techniques in crossing a road, and these can vary by age and sex. Grayson (1975) Older and Grayson (1974), and Mackie and Older (1965) in particular have looked carefully at pedestrian decisionmaking strategies and behavior in crossing streets. This involved observing the way pedestrians approach an intersection, where they look, whether they stop at the curb before crossing, where they choose to cross (midblock or at an intersection), etc. Rose, et al. (1976), while primarily interested in establishing a method to observe pedestrian behavior in order to evaluate countermeasures, defined five parameters of pedestrian searching behavior used in decisionmaking:

- object - those threats the pedestrian is searching for, which could be vehicles which do not pose a threat, threatening vehicles, and non-vehicular objects;
- direction- which way the pedestrian looks;
- duration - an estimate of whether the search lasted long enough to be adequate;
- location - where the pedestrian was when he made his search;
- sequence - the order of search.

Snyder and Knoblauch's (1971) work in detailing the causes of a sample of accidents in twelve American cities thoroughly analyzed the components of the pedestrian's decisionmaking process. They recognized certain pedestrian decisionmaking strategies and behaviors as important predisposing factors in causing certain types of accidents, and grouped these into five types:

- pedestrian course failures: i.e., crossing in an unexpected place, running, crossing against light, back to traffic, crossing unusually slowly
- pedestrian search failures: i.e., distraction, inadequate search, overload, playing in the road
- pedestrian detection failures: i.e., vision blocked by parked cars, street furniture, traffic, sun, poor lighting
- pedestrian evaluation failure: misperception of driver's intent, poor prediction of vehicle/pedestrian path
- pedestrian avoidance action failure

Adherence to control device: Fleig and Duffy (1967) conducted an early study of the adherence to a flashing "Walk - Don't Walk" sign. They observed unsafe road crossing behaviors before and after installation of the device and found no significant change. They indicated that pedestrians more often look at available gaps than at the sign's message when deciding whether or not to cross.

Environmental Characteristics

It is obvious that certain environmental conditions increase the probability of pedestrian risk. Most research considers time of day as such a factor, and much of the work also considers the surrounding land use and location of crossing to be important environmental determinants.

Time of day: Cameron et al. (1976) in their work in Australia observed high risk in the night time hours - especially 10 p.m. to 1 a.m. It is fairly clear that risk would be higher in the dark due to decreased visibility, but Cameron (1967) did find that crossing at a zebra crossing from 5 p.m. to 6 p.m. (in the dark) did not have the dangers associated with night time crossings in general. It is possible that the safety associated with pedestrian density at this time (evening peak) accounts for there being less risk than would be expected. Cameron (1967) in looking at time of day and lighting also considered the orientation of the road and how this affects whether the pedestrian is looking into the sun and having his vision blocked because of that. The OECD report on pedestrian safety (1977) cited Smeed's work which concluded that a combination of dark and rain increased the risk of accident by as much as twelve times. Other studies cited by OECD show that dark alone can increase the risk of accidents as much as twice of that in daylight. Todd and Walker's (1980) work shows a greater difference. They found that twice as many accidents occurred during the day as the night, but when the amount of pedestrian activity was taken into account (using distance and number of roads crossed as exposure measures) the pedestrian was three times as much at risk of being a casualty in the dark as he was in the light. They saw 10 p.m. to 12 midnight as the highest risk hours. Of course, other factors besides visibility are responsible for increased nighttime risk. Alcohol involvement, for example, could be expected to be higher at night.

Lighting reduces the risk of night time accidents, of course. Cameron (1967) discussed the very noticeable reduction in nighttime accidents after installing street lights: Hartford experienced a 69% reduction, London a 45% reduction, and Trenton a 53% reduction.

Hillman and Whalley (1979), while not relating their findings to accident risk, quantified pedestrian activity by time of day. They noted that the majority of walk journeys are made between 9:00 a.m. to 12:00 a.m. and 3:00 p.m. to 5:00 p.m., which can be attributed to lack of auto availability for journeys when the main household provider is using a car for the journey to work.

Day of week: Todd and Walker (1980) found that Friday was high risk day, but that this difference could be accounted for by the greater numbers of pedestrians walking in the nighttime hours on Friday than on other days of the week. Hillman and Whalley (1979) found that more and longer journeys are made on the weekend. Todd and Walker (1980), on all indices of exposure, found Friday and Saturday the busiest walking days with Monday through Thursday somewhat lower and Sunday about half as busy as Saturday. On an average Monday through Thursday three-fourths of the sample population did some walking. Cameron et al. (1976) found Friday and Sunday to be the highest risk days.

Time of the year: Hillman and Whalley (1979) found that more and longer walk journeys are made in July and August, which is understandable because weather is good and there are more daylight hours.

Surrounding land use, type of city: Researchers such as Howarth et al. (1974) have recognized the effects of different types of areas on pedestrian activity and have collected data separately for center city areas, suburban areas, and rural areas. However, there is no work that specifically measures the effects of different types of land use on accident risk. It is obvious that in central areas pedestrian density will be higher and it seems reasonable that "area type" differences would be caused by other variables. Jacobs and Wilson (1967) found that risk does vary substantially by type of city but this is almost entirely attributable to differences in traffic volumes in the towns studied. (They also considered differences in vehicle flow to explain the differences in risk between one-way and two-way streets.) Mackie and Older (1965) cite increased risk to pedestrians on wider roads, which would also help explain why risk varies between types of towns.

Crossing facilities and crossing location: Substantial work has been done in England and Australia evaluating various types of crossing facilities. Much of this work is not applicable to America where these types of facilities do not exist. Most research (Jacobs and Wilson, 1967; Cameron, 1967) indicated that risk is higher within 50 yards of a crossing than at a crossing itself. However, Cameron's (1976) work in Sydney contradicted this showing a high risk at the intersection, a lower risk 30-100 feet from the intersection, and highest risk more than 100 feet from an intersection. Jacobs and Wilson (1967) concluded that the area within 50 yards of a crossing was high-risk area whether or not the crossing was within 20 yards of a junction, indicating perhaps that where there is a crosswalk facility visible a driver may not expect a pedestrian to be crossing elsewhere.

Cameron et al. (1976) found pedestrians walking in the road to be at high risk, but those people walking against traffic had considerably lower risk than those walking with the traffic flow.

Trip Characteristics

Todd and Walker (1980), in their general descriptions of pedestrian tripmaking, discussed trip length and purpose by sex and age and day of week. Much of what they document confirms what would be expected: most walking is done for shopping (using all indices of exposure), with women having greater shopping trip exposure than men. Hillman and Whalley (1979), as discussed previously, looked at trip characteristics by time of year, finding that longer journeys are made in the summer. Rutherford (1976), while associating trip characteristics with risk, looked at trip length by purpose, distance walked by purpose, trip length time of day, as well as distribution of trips by time of day. He used Chicago Area Transportation Study data as the basis of his research.

Driver Behavior and Vehicle Characteristics

Snyder and Knoblauch (1971) considered driver behavior to be a very important predisposing condition for accidents. Driver search for pedestrians and control of the vehicle, as well as driver attention are important. Rose et al. (1976) considered driver control of direction and driver control of velocity as two driver behavior parameters. Vehicle speed as well as vehicle path are associated with these parameters.

Mackie and Older (1965) see turning behavior as increasing risk to pedestrians. Jennings et al. (1977) in their study in Portland, Oregon, found that 54% of accidents involved straight travelling vehicles, 40% involved left-turning vehicles, and 6% involved right-turning vehicles. While one can not conclude the relative risk of turning vehicles to straight vehicles without knowing the volumes of each in the traffic stream, this data indicates that left-turning vehicles are a greater risk to pedestrians than right-turning vehicles. Cameron et al. (1976) also saw turning vehicles--especially right-turning vehicles--posing greater risk to pedestrians than straight- travelling vehicles. This is consistent with the American research because Cameron's work was done in Australia where vehicles drive on the opposite side of the road than they do in the United States.

Cameron (1967) notes that vehicle color and lighting may be significant in terms of accident involvement, but these characteristics have received little attention in the literature.

Summary

By conducting studies in these five areas - pedestrian characteristics, pedestrian behavior, environmental characteristics, trip characteristics, and driver behavior/vehicle characteristics - researchers have identified a number of relationships between pedestrian behavior and pedestrian demographic characteristics which are important in formulating accident countermeasures.

As a concluding remark, it should be noted that some research performed in other countries may not be helpful in looking at American pedestrian tripmaking characteristics. The greater auto availability and the less dense population patterns in America would definitely be expected to have an impact on pedestrian tripmaking characteristics.

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APPENDIX B

DATA COLLECTION AND ACCIDENT TYPING FORMS

CONTENTS

PSU ______
F.I. ______

SITE INVENTORY
(intersections and midblocks)

Square # ______
Page # ______

Site No.	Intersection (I) or Midblock (M)	ADDRESS (For intersections indicate: Maple & Main, For midblocks indicate: 1st / Maple & Main, meaning 1st between Maple & Main)	No. of traffic lanes-larger roadway	Mid Block: Segment Length (50' increments)	Inter-section: Signalized? Yes or No	Indicate Appropriate Categorys Check only one: 100% Residential	Residential w. Parks etc.	Residential & Open	Open Only–Undeveloped	75 - 99% Residential	51 - 74% Residential	50 - 75% Commercial	76 - 100% Commercial	51 - 100% Industrial	Other, describe

Card [1]   [ ] PSU   [ ][ ]-[ ][ ][ ] Site

PEDESTRIAN SAFETY STUDY
SITE FORM

1. PSU________________________

2. Field Investigator________________________

3. Site Location____

____

4. Site Type. . . . . [ ]

1. Intersection and midblock   2. Intersection   3. Midblock

5. Type of Coverage. . . . . [ ] 9

1 – Site characteristics only (accident sites)

2 – Site characteristics and exposure data

DEFINITIONS

Roadway	– that portion of the highway, including shoulders, for vehicular use; a divided highway has two or more roadways.
Shoulder	– the roadway edge from traveled way to change in slope, suitable for stopped vehicles, emergency use, or lateral support.
Traveled way	– the portion of the roadway for the movement of vehicles, exclusive of shoulders and parking lanes.
Sidewalk	– the paved section established for pedestrian passage parallel to the roadway. Does not include narrow lawn space between road and sidewalk (the common ground).
Pathway	– where no sidewalk exists, the path taken by pedestrians along the side of the road.
Roadway type	– refers to different highway configurations, determined in this study by the number of lanes.
Marked crosswalk	– pavement markings or paint indicating the pedestrian path across roadways (usually at intersections). Must have dashed or solid line showing pedestrian path. A line indicating where traffic should stop is not, by itself, a marked crosswalk.
Unmarked crosswalk	– the path at intersections connecting two sidewalks on opposite sides of the roadway, but without pavement markings or paint.
Channelization	– Refers to lanes specifically assigned to left turns or right turns. May be indicated by signs and/or pavement markings.

3-8-82

PSU ___ Site ___ ___ ___ ___ ___

SITE FACTORS

1. GENERAL AREA DESCRIPTION: Choose appropriate cell from matrix below and code. ☐☐ 10

	City	Small Town	Suburban	Country
Commercial	01	11	21	31
Industrial	02	12	22	32
Residential	03	13	23	33
School	04	14	24	34
Park, Playground	05	15	25	35
Open Area	06	16	26	36

2. ROADWAY FUNCTIONAL CLASSIFICATION — Site Roadway ☐☐ Cross Roadway ☐☐

Suburban, Small Town, City Locations . . . .

01. Limited access (grade separated intersections only)
02. Controlled access (intersections, but no access to abutting property)
03. Major arterial highway (direct access to abutting property)
04. Collector–Distributor
05. Local street
06. Frontage or service road
09. Other, ______________________

County Locations

11. Limited access (i.e., Interstate)
12. Controlled access
13. Primary highway
14. Secondary highway
15. Improved surface roadway
16. Unimproved surface roadway
17. Frontage or service road
19. Other, ______________________

3. PARKING ON COMMERCIAL PREMISES (Does not refer to on-street parking) . . . . ☐

1. No business with parking on premises (POP)
2. $<\frac{1}{4}$ of frontage has POP
3. $>\frac{1}{4} < \frac{1}{2}$ of frontage has POP
4. $>\frac{1}{2} < \frac{3}{4}$ of frontage has POP
5. $>\frac{3}{4}$ of frontage has POP

4. PARKING RESTRICTIONS (Signs or marking) (Ignore 2-hour residential restrictions). . . . . ☐

1. Permitted, both sides of roadway
2. Permitted, one side of roadway
3. Prohibited, both sides
4. No posted restrictions, roadway width, limited parking, one direction.
5. No posted restrictions, roadway width limits parking, both directions.
6. Restrictions vary by time of day and/or day of week.

5. PARKING METERS . . . . ☐

1. None
2. One Side
3. Both sides

6. ROAD SURFACE MATERIAL. . . . . ☐

1. Concrete
2. Bituminous (Blacktop)
3. Gravel
4. Dirt and Sand

7. ROAD SURFACE CONDITION . . . . ☐

1. Good (no cracks over 1" and no holes or bumps)
2. Fair (some large cracks and small depressions)
3. Poor (potholes, bumps and/or ruts)

8. MEDIAN. . . . . ☐

(The portion of a divided highway separating the traveled ways for traffic in opposite directions)

1. None
2. Barrier (fence, guardrail, New Jersey, etc.)
3. Curb or Island (takes precedence over 5, 6, 7, or 8)
4. Painted Pavement (other than center line markings)
5. Grass
6. Dirt or Sand
7. Gravel
8. Trees and/or Shrubs
9. Other, ______________________

9. SHOULDER SURFACE . . . . ☐ 22

(Roadway edge from traveled way to change in slope, suitable for stopped vehicle, emergency use, or lateral support)

1. None
2. Concrete
3. Bituminous (Blacktop)
4. Gravel, Shell, Shale
5. Dirt or Sand
6. Grass
7. Combination
9. Other ______________________

__ PSU   __ __ __ __ __ Site

SITE FACTORS

1. ROADWAY CENTER MARKINGS . . . . □ 23

(If highway is divided by a median or barrier, code 0.)

1. None
2. Double solid center line
3. Single solid center line
4. 1 Dashed, 1 Solid center line
5. Common left turn-lane markings
6. Single dashed center line
9. Other, ______________

2. ROADWAY EDGE MARKINGS . . . . □

1. None
2. Pavement edge markings (paint only)
3. Roadside delineators (raised and/or reflectorized)
4. Pavement delineators (raised and/or reflectorized)
5. Pavement edge markings and roadside delineators
6. Pavement edge markings and pavement delineators
7. Parking lanes (marked)
9. Other, ______________

3. ROADWAY LANE MARKINGS (2 lane, 2-way roadways have no lane markings; may have center marking). . . . . □

1. None
2. Dashed lane markings
3. Solid lane markings
4. Dashed or solid lane markings with pavement delineators
9. Other, ______________

4. PEDESTRIAN CROSSWALKS . . . . □

1. None
2. Marked pedestrian crosswalk for site roadway
3. Marked pedestrian crosswalk for cross roadways
4. Marked pedestrian crosswalk for both roadways

5. CROSSWALK MARKINGS . . . . □

1. None
2. Crosswalk: Lines only
3. Crosswalk: Lines and diagonal stripes
9. Other, ______________

6. PEDESTRIAN ACCOMMODATIONS . . . . One Side □ Other Side □

1. Unimproved shoulder
2. Improved shoulder
3. Pedestrian pathway (gravel or blacktop)
4. Sidewalk (concrete), with curb
5. Sidewalk (concrete), without curb
6. Curb only, no sidewalk
9. Other, specify ______________

7. STREET LIGHTING (luminares). . . . . □

1. None
2. Regularly spaced
3. Non-Regularly spaced

8. COMMERCIAL LIGHTING (for signs and/or businesses) . . . . □

1. None
2. Through whole site (At least one side)
3. Not whole site

9. INTERSECTION TYPE . . . . □

1. None
2. 4-leg
3. "T"
4. "Y"
5. Multiple leg
6. Jog
7. "L"
8. Interchange
9. Other, ______________

10. SIGNALIZATION . . . . □

1. No signalization
2. Red, Green, Amber (RGA) signal
3. RGA and pedestrian signal
4. Flashing red and/or amber beacon

11. CHANNELIZATION. . . . . □

1. None
2. Left turn channelization
3. Right turn channelization
4. Both right and left turn channelization

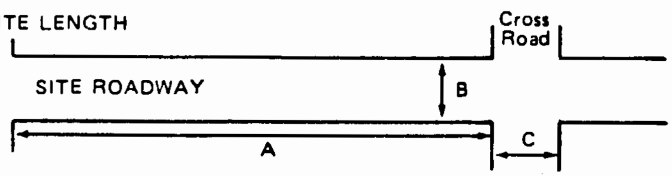
12. ROADWAY SIGNS. . . . . □

If no signalization, does site block have

1. Stop sign
2. 4-way Stop sign
3. Yield sign

13. POSTED OR LEGAL SPEED LIMIT. . . . . □□

14. SITE LENGTH



A . . . . □□□

B . . . . □□

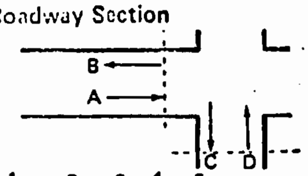
C . . . . □□ 44

Note: Take measurements from curb to curb. If no block at rear end of site, limit site to 500 feet. Truncate sites at visual limits, if necessary.

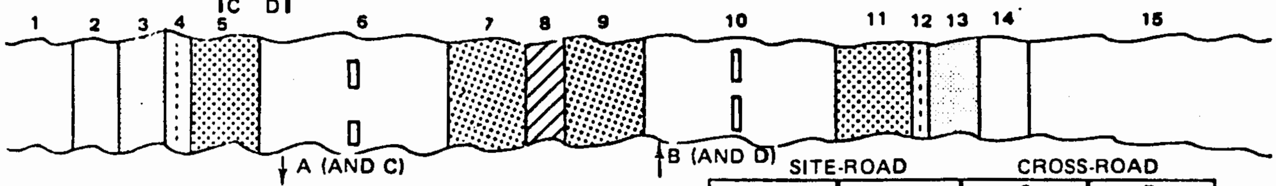
SITE FACTORS

___ PSU ___ ___ ___ ___ Site

1. Roadway Section



THE A-B SECTION SHOULD BE TAKEN AT THE DOTTED VERTICAL LINE.
THE C-D SECTION SHOULD BE TAKEN AT THE DOTTED HORIZONTICAL LINE.



			SITE-ROAD A	SITE-ROAD B	CROSS-ROAD C	CROSS-ROAD D
1	15	Building Setback Distance (from sidewalk edge closest to building) . . . 45				
2	14	Sidewalk or Pedestrian Pathway Width				
3	13	Common Ground Width				
4	12	Curb 1 yes 2 no				
5	11	Shoulder Width				
6	10	Roadway Width (includes shoulder) . . . 8				
6	10	Traveled Way Width (excludes shoulder and parking lanes)				
6	10	No. of Traffic Lanes				
6	10	No. of Parking Lanes				
7	9	Shoulder Width				
8		Median Width				

43

Begin Card 2

[2] ☐ ☐☐ ☐☐☐

Notes

- Provide measurements to nearest foot.
- If two-way unlined roadway, divide total traveled-way width evenly between 6 and 10.
- If an area is not present (e.g., no median, no shoulder), code as 00.
- If one-way street, code 6 or 10 as 0, depending on direction of travel.
- Code 7, 8, 9 for divided roadways only; if undivided, code as 00.
- Sites with curbs typically have no shoulder, if so-code 00.

2. Area Density

Record the percentage of frontage devoted to each of the following land use categories. Use both sides of the road to determine frontage and compute percentage. For 100%, use 99.

	Site-road	Cross-road
Residential (single family & duplexes) . . . 44		
Residential (multi-family)		
Commercial (store, gas stations) (include hospital here)		
Industrial (factories, warehouses, manufacturing, Inc.)		
School		
Church		
Playground or Park		
Open, farm or undeveloped . . . 72		

Begin Card 3

[3] ☐ ☐☐ ☐☐☐

3. Signal Timing

Record the time (in seconds) for the indicated cycle.
Do not code if no signal is present.

	Site Roadway	Cross Roadway
Red . . . 8		
Turning Phase (code 00 if none)		
Green		
Amber		
"Walk" (code 00 if none)		
Flashing "Don't Walk" . . . 28		
Steady "Don't Walk"		
Right Turn on Red (1 - Allowed 2 - Not Allowed 3 - Not Allowed Certain Times)		
Left Turn (1 - Allowed 2 - Specifically Prohibited 3 - Not Allowed Certain Times)		

39

PSU ___ Site ___ ___ ___ ___ ___

SITE DIAGRAM

INDICATE NORTH BY ARROW

SCALE

100 Feet

SITE PHOTOS

Per above from X looking to Right

(Remember to place 5 digit site code on each photo)

Per above from Y looking to Left

SPECIAL PEOPLE COUNT	Site	Bicycles	Jogging	Skaters	Blind	Handicapped
Full 15 minutes count	A					
	B					
	C					

Site Nos. Address

A __ __-__ __ __ ____________________

B __ __-__ __ __ ____________________

C __ __-__ __ __ ____________________

Day of Week ☐

Shift ☐

Hour ☐☐

F.I. __________

FIELD WORKSHEET
VEHICLE VOLUME AND ACTION (6 mins.)

SITE	Weather: 1-clear 2-cloudy 3-lt.rain 4-hv.rain	Light: 1-day 2-night 3-dawn 4-dusk	Start Time / Stop Time	Minutes Counted	Total Vehicles Counted	Vehicle Type Tally: Van Pickup	Other Trucks	Bus	Taxis	Motorcycle	Vehicle Action Tally: Making Left Turn	Making Right Turn (on Green) (or No Signal)	RTOR	Turn in Front of Peds	Turn Thru Peds	Turn Behind Peds	Backing Up	Parking	In/Out Driveway/Alleys	Signal Violation
A Site																				
A Cross																				
B Site																				
B Cross																				
C Site																				
C Cross																				

Location:

1. Sidewalk
2. Shoulder w/traffic
3. Shoulder a/traffic
4. Roadway w/traffic
5. Roadway a/traffic
6. Standing in road
7. Just across

Crossed:

1. No
2. Site St.–Crosswalk
3. Site St.–W/I 50' X-walk
4. Cross St.–Crosswalk
5. Cross St.–W/I 50' X-walk
6. Midblock
7. Diagonally at intersection

Obstruction: Crossed Next To or Between

1. None
2. Parked or stopped car
3. Car in traffic lane
4. Parked or stopped truck or van
5. Truck or van in traffic lane
6. Bus at curb
7. Bus in traffic lane
8. Other

Accident Type:

1. On sidewalk, no cross
2. Midblock cross—normal speed
3. Intersection—normal speed
4. Midblock dart-out
5. Intersection dash
6. Right turn on red
7. Vehicle turn-merge
8. Multiple threat
9. Bus-stop related
10. Exiting/entering parked vehicles
11. Trapped by changing light
12. Disabled vehicle
13. School bus related
14. Hitchhiking
15. Walking along roadway
16. Playing in roadway
17. Vendor, ice cream truck
18. Expressway crossing
19. Mailbox related

Distance:

1. Intersection only
2. Full block including intersection crossing
3. Full block but no intersection crossing
4. Partial block—more than half block
5. Partial block—half block or less

Signal:

1. Not at signal
2. Green—No ped head
3. Green & Walk
4. Green & Don't Walk
5. Red
6. Changed G to R

Vehicles Turning as Peds Cross at Intersection

1. No vehicle turned
2. Left turn in front of ped
3. Left turn behind ped
4. Right turn in front of ped (Green or No Signal)
5. Right turn behind ped
6. RTOR in front of ped
7. RTOR behind ped

PEDESTRIAN ACTIVITY SAMPLING (4 mins.)

SITE	Hour, military time	Pedestrian Number	Age: estimate	Sex: 1-male 2-female 3-unknown	Grouping:	Location: (icon)	Distance: (icon)	If Partial Block: 1. If enter/exited building 2. If entered/exited vehicle 3. Both of above	Crossed: (icon)	Obstruction Crossed Next to or Between: (icon)	Encroachment: 1. No 2. Yes	Signal: (icon)	Mode: 1. Walk 2. Run	Time Exposed in Roadway:	Gap (in sec.) to approaching vehicle (max: 9 sec.)	Vehicles Turning as Peds Cross at Intersection: (icon)	Vehicle Adaptation to Ped (1. No adaption 2. Slowed 3. Stopped 4. Speeded up 5. Move Over a lane): Turning Vehicle	Vehicle Adaptation to Ped: Straight Vehicle	Ped Adaptation to Vehicle (1. No adaption 2. Slowed 3. Stopped in street 4. Speeded up 5. Stopped at sidewalk): Turning Vehicle	Ped Adaptation to Vehicle: Straight Vehicle	Accident Type (icon)
A		1																			
		2																			
		3																			
		4																			
		5																			
B		1																			
		2																			
		3																			
		4																			
		5																			
C		1																			
		2																			
		3																			
		4																			
		5																			

PEDESTRIAN VOLUMES (5 mins.)

SITE	Start Time / Stop Time	Minutes Counted	Number of Roadway Crossings: Site Street: Crosswalk	Site Street: within 50'	Cross Street: Crosswalk	Cross Street: within 50'	Midblock	Diagonally Across Intersection	Number of Pedestrians Who: Intersection Only	Do Not Cross (Rounders)	Cross More Than Once
A											
B											
C											

POLICE ACCIDENT REPORT FORM

7 ☐ ☐☐☐
FORM PSU 3 DIGIT ID

1. Site Location: ______________________________

2. Date of Accident: ______________________________

3. Day of Accident . . . . . ☐
   1. Sunday 2. Monday 3. Tuesday 4. Wednesday 5. Thursday 6. Friday 7. Saturday

4. Time of Accident (Round to nearest hour, military time) . . . . . ☐☐

5. Accident was . . . . . ☐
   1. At Intersection 2. Not at Intersection

6. Number of Pedestrians Injured . . . . . ☐

7. Injury to Pedestrian (Most severe injury if more than one pedestrian) . . . . . ☐
   1. Fatal 2. Disabling/Hospitalization 3. Non-Disabling 4. None

8. Pedestrian Age . . . . . ☐☐

9. Pedestrian Sex . . . . . ☐
   1. Male 2. Female

10. Road Condition . . . . . ☐
    1. Dry 2. Wet 3. Ice/Snow

11. Light Condition . . . . . ☐
    1. Daylight 2. Night 3. Dawn 4. Dusk

12. Vehicle Type . . . . . ☐
    1. Passenger Car 2. Taxi 3. Van, Pickup 4. Other Truck 5. Bus 6. Motorcycle

13. Pedestrian Location . . . . . ☐
    1. In Marked Crosswalk 2. In Unmarked Crosswalk 3. Within 50' of Intersection (not in X-walk) 4. More than 50' from Intersection 5. Diagonally Across Intersection 6. On Sidewalk

14. Pedestrian Crossing . . . . . ☐
    1. With Signal (Green)
    2. Against Signal (Red)
    3. Mid block
    4. Between Parked Cars
    5. Intersection with No Signal
    6. At Signal but No Info. Green or Red

15. Pedestrian Grouping . . . . . ☐
    1. Alone
    2. With Others

16. Pedestrian Sobriety . . . . . ☐
    1. Had not been drinking (sober)
    2. Had been drinking

17. Driver Action . . . . . ☐
    1. Going straight
    2. Backing up, parallel parking
    3. Turning right
    4. Right turn on red
    5. Turning left
    6. Entering, exiting roadway
    7. Other

18. Driver Sobriety . . . . . ☐
    1. Had not been drinking (sober)
    2. Had been drinking

19. Accident Type . . . . . ☐☐
    1. On sidewalk, no cross
    2. Midblock cross—normal speed
    3. Intersection—normal speed
    4. Midblock dart-out
    5. Intersection dash
    6. Right turn on red
    7. Vehicle turn-merge
    8. Multiple threat
    9. Bus-stop related
    10. Exiting/entering parked vehicles
    11. Trapped by changing light
    12. Disabled vehicle
    13. School bus related
    14. Hitchhiking
    15. Walking along roadway
    16. Playing in roadway
    17. Vendor, ice cream truck
    18. Expressway crossing
    19. Mailbox related

20. Traffic Condition . . . . . ☐
    1. Heavy 2. Medium 3. Light

21. Pedestrian Mode . . . . . ☐
    1. Walking 2. Running 3. Jogging
    4. Other

8																			

FORM PSU 3 DIGIT ID

ACCIDENT TYPE DEFINITIONS

1. On sidewalk–No cross.
2. Midblock cross–Normal speed.
3. Intersection cross–Normal speed.
4. Midblock dart-out–The pedestrian is crossing midblock and is struck by a vehicle, or walks and runs into a moving vehicle. Although the driver usually detects the pedestrian, this occurs too late for effective action by the driver. The pedestrian is often running and often appears from between parked cars or from behind another obstruction.
5. Intersection dash–The pedestrian is crossing at an intersection (marked or unmarked crosswalk), is not seen by the driver of a vehicle, or is seen too late, or is running and is struck by the vehicle (or hits a moving vehicle).
6. Right turn on red–Pedestrian is struck by vehicle turning right at a red traffic signal.
7. Vehicle turn-merge–The driver is turning into and merging with traffic. The driver's attention is diverted from the pedestrian, usually in order to find an acceptable gap in the traffic flow. The driver's vehicle strikes a pedestrian who is generally in a different direction from the driver's focus of attention.
8. Multiple threat–The pedestrian, crossing a multi-lane street, is permitted to cross by one or more vehicles that stop, remain stopped, or slow to yield to the pedestrian. He is hit by another vehicle which passes the yielding vehicle(s). The pedestrian is hidden by the yielding vehicle(s) from the view of the driver of the collision vehicle.
9. Bus-stop related–The pedestrian is struck by a vehicle while crossing in front of a bus that is stopped at a bus stop. The bus blocks both the pedestrian's view of oncoming traffic and the vehicle driver's view of the pedestrian.
10. Exiting/entering parked vehicle–The pedestrian was in the process of exiting or entering a parked or stopped vehicle when struck. He/she was in the traffic lane next to the stopped vehicle.
11. Trapped by changing light–The pedestrian was struck at a signalized intersection when the light changed and traffic started to move.
12. Disabled vehicle–Pedestrian is struck while working on or next to a disabled vehicle.
13. School bus related–The pedestrian is struck while going to or from a school bus or a school bus stop.
14. Hitchhiking–The pedestrian is struck while hitchhiking, either while walking or stationary at the side of the road.
15. Walking along roadway–The pedestrian is struck while walking along a roadway, either on the edge of the roadway or on the shoulder.
16. Playing in roadway–The pedestrian was struck while playing on foot in the roadway.
17. Vendor, ice cream truck–The pedestrian is struck going to or from a vending vehicle in the street, usually an ice cream vendor.
18. Expressway crossing–The pedestrian was struck while attempting to cross a limited access expressway or expressway ramp.
19. Mailbox related–The pedestrian is struck going to or from a mailbox or newspaper box.

APPENDIX C

EXPOSURE MEASURES CALCULATION FORMULAE

DOCUMENTATION OF CALCULATION OF EXPOSURE MEASURE FORMULAE

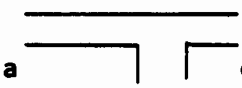
Using the data items entered on the field observation sheet, calculations were performed to derive the exposure measures as defined in the observed Pedestrian Exposure chapter. These calculations are listed on the following pages.

Because street configurations affect the calculations of exposure measures, the exposure measure formulae have been listed by the 36 possible street configurations. These are:

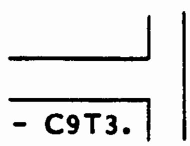
- For 4-leg intersections:

	Cross Street 2-Way	Cross Street 1-Way "North"*	Cross Street 1-Way "South"*
Site Street 2-Way	C1	C2	C3
Site Street 1-Way to Nub	C4	C5	C6
Site Street 1-from Nub	C7	C8	C9

* "North" and "South" refer to the directions on the classic site diagram, not compass directions.

- For T-junctions with a  configuration the naming system is C1T1 - C9T1 using the same one-way/two-way "C" codes as for a 4-leg intersection.

- For T-junctions with a  configuration, the naming system is C1T2 - C9T2.

- For T-junctions with a  configuration, the naming system is C1T3 - C9T3.