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PROJECT REPORT

October 1978

UNC HSRC
University of North Carolina
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Chapel Hill, N.C.

AN ANALYSIS OF BICYCLE ACCIDENTS IN NORTH CAROLINA: 1974-1976

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October 1978

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This report was prepared by the University of North Carolina Highway Safety Research Center for the North Carolina Governor's Highway Safety Program in cooperation with the N.C. Department of Transportation Bicycle Program.

ABSTRACT

An analysis of the current North Carolina bicycle accident problem was conducted in order to: (1) initiate a continuing program of accident data retrieval and analysis for the N.C. Bicycle Program (BP), (2) update previous N.C. bicycle accident studies by analyzing the latest three years of available data, and (3) examine the utility of other existing sources of enriched bicycle-related information. A special HSRC RAPID data set was developed to provide the BP with quick, economical access to bicycle accident data from 1974 through 1976. The RAPID system will allow the BP to make regular data comparisons and will provide periodic input to ongoing research, rapid response to data requests and day-to-day technical assistance to local areas.

Other data sources were used to accomplish the second and third objectives. First, three years of bicycle accident data (1974-1976) were examined and compared with previous data (1965-1968) from an earlier HSRC study in order to update the N.C. bicycle accident experience. Two other classes of vehicles (motorcycles and passenger cars) were also compared with bicycles to determine differences in accident patterns.

Secondly, the HSRC Narrative Search System was utilized to extract crash descriptions of 1976 bicycle accidents taken from the N.C. traffic accident report form. Over 800 bicycle-related narratives were read, coded, keypunched and stored for analysis so that information not found on the standard report form could be examined (e.g., use of special clothing and equipment). Unfortunately, the narratives were typically so brief that many variable items could not be coded.

Finally, combining accident and roadway characteristics for the N.C. rural primary system, the N.C. Board of Transportation Merged System was examined

to obtain results about geometric variables not contained on the basic accident form. Results from the analysis indicated that, for these rural accidents, many bicycle crashes were in rural areas with partial or no development and on routes with 55 mile-per-hour speed limits.

In general, many bicycle accidents occur as a result of difficulty in seeing the bicyclist and his vehicle. Frequent accident sites are intersections, driveways and alleys. Special bicycle equipment and clothing worn by the rider could be highly effective in alleviating the visibility problem. Recent bicycle data indicate changes in the population of riders since more females and bicyclists older than 25 are involved in accidents than previously. There is no indication that bicycle injuries are more severe than before.

Considerable underreporting of accident information is apparent. Causal factors are rarely identified since investigating officers usually fail to report pre-crash variables such as bicycle maneuver. The narrative description is a convenient section of the accident report form for officers to mention such pre-crash factors and other information that characterize bicycle crashes more accurately.

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CHAPTER 1. INTRODUCTION AND TASK DESCRIPTION

As bicycle usage continues to increase both in North Carolina and in the United States, bicycle accidents are occurring with more frequency. Little is known about the underlying causes or circumstances associated with these accidents; however, programs at all levels are being planned and executed to investigate this situation. In order that North Carolina Department of Transportation Bicycle Program (BP) funds be spent in a cost-effective manner, it is necessary that a current analysis of the North Carolina bicycle accident problem be undertaken.

With little current data existing on the bicycle accident situation, it is difficult to develop a comprehensive program to improve the traffic environment of the bicyclist. In recent years, an average of well over 1000 bicycle accidents and approximately 30 bicycle fatalities per year have been reported by investigating officers to the North Carolina Department of Motor Vehicles. By examining various kinds of N.C. bicycle accident data, this project report will attempt to identify bicycle problem areas and proposed countermeasures and provide recommendations for subsequent efforts.

This study is a joint effort between the N.C. Department of Transportation Bicycle Program and the University of North Carolina Highway Safety Research Center (HSRC). The objectives of this updated bicycle accident study are to: (1) initiate a continuing program of accident data retrieval and analysis for the N.C. Bicycle Program, (2) update previous N.C. bicycle accident studies using the latest 3 years of available accident data, and (3) examine other data sets for enriched bicycle-related information (i.e., narrative descriptions from the N.C. traffic accident report and the computerized system of merged accident and roadway data developed by HSRC for the N.C. Division of

Highways[1]). Attainment of these objectives will hopefully lead to more efficient and effective bicycle programming at the state and local level.

This project consisted of a series of tasks for which some discussion would be appropriate. The first task was concerned with assessing the capability of the data processing branch of the North Carolina Department of Transportation to provide the required project data. This branch is most closely concerned with processing and storing the huge amount of accident data reported to the N.C. Department of Motor Vehicles, what might typically be termed a maintenance activity. As such, programming personnel are familiar with the data items appearing on the N.C. accident report form. However, the maintenance type of activity generally occupies the majority of staff time so that additional analytical or developmental efforts are infrequent. Since the current project required the development of a special data set and an extensive analysis of other N.C. data sets, it was decided that it would be most appropriate for HSRC to perform the required data processing.

The second task was concerned with the development of a special RAPID data set for the latest three years of N.C. bicycle accident data and also a means to access the data by the BP. RAPID is an HSRC interactive computer system whereby a potential user located anywhere in the United States can interrogate an accident file by means of a telephone and a standard computer terminal. The strength of the system is the very quick access to the accident file of interest. The RAPID system was designed so that users are able to retrieve data in both tabular and cross-tabular form quickly, economically and without recourse to a programmer. All that is required by a user are rudimentary typing skills and a few minutes of instruction.

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[1]This study, entitled "Highway Safety Improvements Through Utilization of Merged Accident and Roadway Data," was supported by the N.C. Governor's Highway Safety Program.

The BP has a need for ready access to bicycle accident data for the following reasons:

1. Regular data comparisons.
2. Periodic input to ongoing research.
3. Provide rapid response to data requests.
4. Use in day-to-day technical assistance to local areas.

To fill this need, HSRC stored N.C. bicycle accident data for 1974, 1975 and 1976 on the RAPID system. This required a series of steps, the first of which was pulling together the raw accident files for 1974-1976. Next, a subset of bicycle accidents was developed. The special accident supplement information (e.g., vehicle identifiers, restraint usage, vehicle damage, information on additional occupants, etc.) was then added to the raw files. Next, the HSRC vehicle identification package was added, which includes items like make, model, vehicle size and weight, and engine size. At this point, the format for storing the data in this particular RAPID file was developed and the data copied to disk. Subsequent steps included: (1) the creating of modules to read the bicycle records and to build a table of all the available accident variables and their appropriate ranges of values, (2) adding the new file to the HSRC RAPID system, and (3) testing and updating the production system to include the bike file.

The entire process was completed around February 1, 1978. HSRC personnel then trained BP staff to use the system. The BP had an in-house terminal suitable for use so that a rented terminal was not needed.

The next two project tasks involved the updating of an earlier HSRC bicycle accident study and the examination of other existing data--the narrative description of bicycle accidents appearing on the standard accident report and the computerized system of merged accident and roadway data developed by HSRC for the N.C. Division of Highways. The next few chapters in this report refer to these efforts.

The final task involved the preparation of this project report, including the identification of bicycle accident countermeasures and recommendations for direction of the Bicycle Program. The report is basically a reflection of the results obtained from the analyses performed in this project effort.

CHAPTER 2. AN UPDATED ANALYSIS OF BICYCLE ACCIDENTS IN NORTH CAROLINA

Introduction

Waller and Reinfurt (1969) examined bicycle accidents occurring in North Carolina over a three-year period from July, 1965 through June, 1968, each accident involving at least one motor vehicle. Of these, 109 (4 percent) involved fatalities, 2,054 (84 percent) involved Class A or B injuries, 282 (11.5 percent) involved Class C injuries, and 8 (less than 0.33 percent) involved property damage only. During this time period, the reportable accidents were those involving personal injury or $100 of property damage. Injury definitions were:

Class A - Visible injury such as bleeding wound, distorted member, or had to be carried from the scene.

Class B - Visible injury such as bruises, abrasions, swelling, limping, etc.

Class C - No visible injury but complaint of pain or momentary loss of consciousness.

The low incidence of bicycle accidents involving property damage only may be attributed to the fact that non-injury accidents with total damage less than $100 were quite often not reported.

The data were divided into two major categories, fatal and nonfatal accidents. The latter category included Class A, B and C injuries as well as a small portion of property damage accidents which did not aprreciably affect the findings.

The fatal and nonfatal accidents were further compared with a sample of fatal and injury-producing motor vehicle accidents in the State of North Carolina for the year 1966.

In order to update this report, a similar analysis was conducted in the present study using bicycle-motor vehicle accidents for the three-year period 1974-1976. The fatal and non-fatal bicycle accidents for this interval were compared with bicycle data from the previous three-year period (July 1965 - June 1968). The variables that will be discussed in this comparison are the ones examined in the previous study. To facilitate the old and new comparisons, the later variables were formed in the same fashion as the earlier ones. Since the year-to-year comparisons of bicycle accident variables were consistent, it was felt that combining the three years into a single data set was appropriate.

In addition, accidents involving motorcycles from 1974-1976 and accidents involving passenger cars from 1976 were contrasted with the bicycle accident data. Additional variables were examined in these comparisons that were not available in the previous report (e.g., violation indicated, city size, sobriety, etc.) but which have relevance to the understanding of bicycle accidents. For the data involving bicycles and motorcycles, the injury outcome (non-fatal or fatal) was determined from the status of the bicycle or motorcycle rider involved (or in some comparisons, the drivers of the motor vehicles striking these two-wheeled vehicles). For the passenger car sample, the injury outcome was derived from the status of the drivers of all passenger cars involved in N.C. accidents for 1976 only. In this fashion, the non-fatal and fatal injury distributions could be compared for a large number of variables.

For the 1974-1976 data, reportable accidents were those involving personal injury or $200 worth of property damage. Injury definitions were:

Class A - Injury obviously serious enough to prevent the person injured from performing his normal activities for at least one day beyond the day of the accident. Massive loss of blood, broken bone, unconsciousness of more than momentary duration are examples.

Class B - Obvious injury which is evident at the scene. Bruises, swelling, limping, soreness are examples. Class B injury would not necessarily prevent the person from carrying on his normal activities.

Class C - No visible injury, but person complains of pain, or has been momentarily unconscious.

This change in injury definition has tended to produce fewer reportable Class A injuries, in the order of a 50 percent decrease. Since all non-fatal injuries were combined in this analysis, this change should have little effect. Overall, from 1974-1976, there were 84 (2.4 percent) fatalities, 2,525 (73.4 percent) A or B injuries, 720 (20.9 percent) C injuries, and 112 (3.3 percent) property damage only crashes.

As mentioned in the earlier report, there was no way to control for the important exposure information, and certainly some of the differences reported here were attributable to differences in exposure. Lacking such information, it was felt that comparisons with motorcycle and passenger car accidents would be meaningful.

Several statistical tests were used to test for significant differences. As in the previous study, all tables presented in this section were used to examine the distributions of fatal and non-fatal accidents. Chi-square (χ^2) tests of independence were used to test for overall differences, such as comparing the fatal and non-fatal bicycle accidents when distributed by a variable like time of day. When ordering of the variable of interest was important (e.g., bicycle speed), the Rank Analysis of Variance (RANOVA) F statistic was calculated (Quade, 1968). When both table components were ordered (e.g., bicycle speed versus injury severity), the Goodman-Kruskal rank correlation coefficient (G) and accompanying standard error (s(G)) were computed. The G index is used to determine the strength of association between two variables and the direction of the association.

In the following text, tables will be presented with frequencies and percentages for the variable of interest distributed by fatality (F) or non-fatality (NF). The following notation will be used:

Test Statistics:

χ^2 ( ) = calculated Chi-square statistic with ( ) degrees of freedom (d.f.).

F (,) = RANOVA F statistic with (,) d.f. for testing homogeneity of the distributions over the variable under consideration.

$G \pm s(G)$ = Goodman-Kruškal index of association and standard error of the variable under consideration.

A number of comparisons will be made utilizing the test statistics, including:

1. Old (then) versus new (now) distribution of bicycle non-fatalities -- Bi NF (i.e., $NF_{Then:Now}$, χ^2 (d.f.)).
2. Old (then) versus new (now) distribution of bicycle fatalities -- Bi F (i.e., $F_{Then:Now}$, χ^2 (d.f.)).

For recent data only:

3. Non-fatal versus fatal bicycle distributions (i.e., $NF\text{-}F_{Now}$, χ^2 (d.f.)).
4. Non-fatal bicycle versus non-fatal motorcycle distributions.
5. Fatal bicycle versus fatal motorcycle distributions.
6. Non-fatal bicycle versus non-fatal passenger car distributions.
7. Fatal bicycle versus fatal passenger car distributions.

The appropriate test statistics will be shown under each table, along with the corresponding p-value. Where significant differences are indicated in the text, they are significant at the α = .05 level.

Five categories of accident variables will be discussed by comparing recent bicycle data (1974-1976) with three groups -- bicycle accidents (1965-1968), motorcycle accidents (1974-1976) and passenger car accidents (1976). As in the earlier study, the analyses of these variables partition the data into fatal and non-fatal injury classes.

I. Features of the Accident Situation

A. Month of year
B. Day of week
C. Hour of day
D. Locality
E. Highway class
F. Road feature
G. Road condition
H. Road surface
I. Road defect
J. Weather condition
K. Light condition
L. Speed limit
M. Traffic control type
N. Object struck
O. City size

II. Characteristics of the Accident

A. Bicycle maneuver
B. Motor vehicle maneuver
C. Point of contact on bicycle
D. Point of contact on motor vehicle
E. Approximate speed of bicycle
F. Approximate speed of motor vehicle

III. Motor Vehicle Defects and Driver Violations

A. Motor vehicle defects
B. Violations and charges

IV. Characteristics of the Motor Vehicle Driver

A. Sex
B. Age
C. Race
D. Restrictions
E. Sobriety
F. Physical condition

V. Characteristics of the Bicyclist

A. Sex
B. Age
C. Race
D. Sobriety

Features of the Accident Situation

Month of Year

The earlier report by Waller and Reinfurt showed that the frequency of bicycle accidents, both fatal and non-fatal, increases during the months when the weather is favorable, especially the summer. A comparison with the later data does not indicate any significant changes in the trend (Table 2.1).

When bicycle accidents are compared with motorcycle accidents for the period 1974-1976 (Table 2.2), significant differences are found for non-fatal accidents between the two groups ($p <.005$), but for fatal accidents the distributions are not significantly different ($.25 < p <.75$). A similar finding is noted for bicycle versus passenger car accidents (Table 2.3). The bicycle-passenger car comparison simply reflects the more frequent occurrences of non-fatal bicycle accidents during the warmer months. Table 2.2 indicates that slightly more motorcycle non-fatal accidents than bicycle accidents occur during the warmer months.

Day of Week

A comparison of old data and new indicates that there are significant differences ($.025 < p <.05$) in the day of week distributions of non-fatal bicycle accidents (Table 2.4). In general, slightly higher percentages of accidents occur during weekdays in the more recent data for both non-fatal and fatal crashes. Overall, Friday and Saturday continue to be the days of highest frequency.

When bicycles were compared with motorcycles and passenger cars, there were significant differences only between the non-fatal groups. Non-fatal bicycle accidents occur on weekdays slightly more often than motorcycle accidents, while the latter occur more frequently on weekends (Table 2.5). Non-fatal passenger

Table 2.1. Month by injury class of bicyclist. Then (1965-1968) now (1974-1976) data.

	Bi NF				Bi F			
	Then		Now		Then		Now	
	N	%	N	%	N	%	N	%
January	97	(4.17)	172	(5.1)	9	(8.26)	4	(4.8)
February	123	(5.29)	152	(4.5)	4	(3.67)	4	(4.8)
March	148	(6.36)	245	(7.3)	5	(4.59)	10	(11.9)
April	200	(8.60)	325	(9.7)	10	(9.17)	8	(9.5)
May	221	(9.50)	342	(10.2)	6	(5.50)	7	(8.3)
June	312	(13.41)	412	(12.3)	15	(13.76)	8	(9.5)
July	288	(12.38)	438	(13.0)	13	(11.93)	14	(16.7)
August	307	(13.20)	431	(12.8)	11	(10.09)	10	(11.9)
September	237	(10.19)	353	(10.5)	10	(9.17)	6	(7.1)
October	178	(7.65)	240	(7.1)	9	(8.26)	5	(6.0)
November	117	(5.03)	134	(4.0)	8	(7.34)	2	(2.4)
December	98	(4.22)	113	(3.4)	9	(8.26)	6	(7.1)
Total	2326		3357		109		84	
(%)	(95.5)		(97.6)		(4.5)		(2.4)	

	χ^2 (d.f.)
$NF_{Then:Now}$	17.06 (d.f. = 11) ($.10 < p < .25$)
$F_{Then:Now}$	9.37 (d.f. = 11) ($.25 < p < .75$)
$NF\text{-}F_{Now}$	9.01 (d.f. = 11) ($.25 < p < .75$)

Table 2.2. Month by injury class: bicycles versus motorcycles (1974-1976).

	Bicycle				Motorcycle			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
January	172	(5.1)	4	(4.8)	253	(3.0)	1	(0.6)
February	152	(4.5)	4	(4.8)	349	(4.1)	5	(2.9)
March	245	(7.3)	10	(11.9)	615	(7.3)	14	(8.2)
April	325	(9.7)	8	(9.5)	879	(10.4)	14	(8.2)
May	342	(10.2)	7	(8.3)	971	(11.5)	16	(9.4)
June	412	(12.3)	8	(9.5)	1131	(13.4)	23	(13.5)
July	438	(13.0)	14	(16.7)	1105	(13.0)	22	(12.9)
August	431	(12.8)	10	(11.9)	1111	(13.1)	24	(14.0)
September	353	(10.5)	6	(7.1)	768	(9.1)	19	(11.1)
October	240	(7.1)	5	(6.0)	615	(7.3)	14	(8.2)
November	134	(4.0)	2	(2.4)	425	(5.0)	12	(7.0)
December	113	(3.4)	6	(7.1)	248	(2.9)	7	(4.1)
Total	3357		84		8470		171	
(%)	(97.6)		(2.4)		(98.0)		(2.0)	

	Non-Fatal	Fatal
χ^2(d.f.)	50.68 (d.f. = 11) ($p < .005$)	12.56 (d.f. = 11) ($.25 < p < .75$)

Table 2.3. Month by injury class: bicycles (1974-1976) versus passenger cars (1976).

	Bicycles				Passenger Cars			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
January	172	(5.1)	4	(4.8)	16910	(8.3)	37	(6.4)
February	152	(4.5)	4	(4.8)	13732	(6.7)	47	(8.2)
March	245	(7.3)	10	(11.9)	15821	(7.7)	40	(7.0)
April	325	(9.7)	8	(9.5)	15895	(7.8)	39	(6.8)
May	342	(10.2)	7	(8.3)	17948	(8.8)	43	(7.5)
June	412	(12.3)	8	(9.5)	16372	(8.0)	53	(9.2)
July	438	(13.0)	14	(16.7)	16283	(8.0)	53	(9.2)
August	431	(12.8)	10	(11.9)	16846	(8.2)	52	(9.0)
September	353	(10.5)	6	(7.1)	16692	(8.2)	44	(7.7)
October	240	(7.1)	5	(6.0)	20052	(9.8)	55	(9.6)
November	134	(4.0)	2	(2.4)	17789	(8.7)	47	(8.2)
December	113	(3.4)	6	(7.1)	20099	(9.8)	65	(11.3)
Total	3357		84		204439		575	
(%)	(97.6)		(2.4)		(99.7)		(0.3)	

	Non-Fatal	Fatal
χ^2(d.f.)	624.58 (d.f. = 11) ($p < .005$)	14.85 (d.f. = 11) ($.10 < p < .25$)

Table 2.4. Day of week by injury class of bicyclist: then versus now.

	Bi NF				Bi F			
	Then		Now		Then		Now	
	N	%	N	%	N	%	N	%
Monday	301	(12.8)	493	(14.7)	14	(12.8)	10	(11.9)
Tuesday	325	(13.9)	482	(14.4)	16	(14.7)	13	(15.5)
Wednesday	304	(13.0)	447	(13.3)	8	(7.3)	12	(14.3)
Thursday	314	(13.4)	488	(14.5)	12	(11.0)	10	(11.9)
Friday	386	(16.5)	557	(16.6)	15	(13.8)	13	(15.5)
Saturday	435	(18.6)	533	(15.9)	28	(25.7)	14	(16.7)
Sunday	279	(11.9)	357	(10.6)	16	(14.7)	12	(14.3)
Total	2344		3357		109		84	
(%)	(95.6)		(97.6)		(4.4)		(2.4)	

	χ^2(d.f.)
$NF_{Then:Now}$	12.86 (d.f. = 6) ($.025 < p < .05$)
$F_{Then:Now}$	4.17 (d.f. = 6) ($.25 < p < .75$)
$NF\text{-}F_{Now}$	2.07 (d.f. = 6) ($.90 < p < .95$)

Table 2.5. Day of week by injury class: bicycles versus motorcycles.

	Bicycles				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Monday	493	(14.7)	10	(11.9)	966	(11.4)	23	(13.5)
Tuesday	482	(14.4)	13	(15.5)	1000	(11.8)	18	(10.5)
Wednesday	447	(13.3)	12	(14.3)	942	(11.1)	21	(12.3)
Thursday	488	(14.5)	10	(11.9)	1029	(12.1)	18	(10.5)
Friday	557	(16.6)	13	(15.5)	1279	(15.1)	29	(17.0)
Saturday	533	(15.9)	14	(16.7)	1738	(20.5)	41	(24.0)
Sunday	357	(10.6)	12	(14.3)	1516	(17.9)	21	(12.3)
Total	3357		84		8470		171	
(%)	(97.6)		(2.4)		(98.0)		(2.0)	

	Non-fatal	Fatal
χ^2(d.f.)	164.54 (d.f. = 6) ($p < .005$)	3.16 (d.f. = 6) ($.75 < p < .90$)

car accidents also occur with a higher frequency than bicycle accidents on weekends (Table 2.6).

Hour of Day

The distributions for hour of day were significantly different ($p < .005$) in the non-fatal accidents of all three groups: bicycles (then) versus bicycles (now) (Table 2.7), bicycles versus motorcycles (Table 2.8) and bicycles versus passenger cars (Table 2.9). Table 2.7 shows that the proportion of recent nighttime bicycle accidents was slightly higher than in the previous period of bicycle crashes. The afternoon and early evening time periods (2 p.m. - 9 p.m.) continued to account for the majority of bicycle accidents in both the fatal and non-fatal injury classes. The latter statement was also true for both motorcycle and passenger car accidents.

In terms of the fatal crashes, there were no differences between the old and new bicycle distributions, but significant differences did occur when the bicycle fatal crashes were compared with both motorcycles and passenger cars. These differences were attributable to much higher proportions of fatal crashes at nighttime for the motorcycles and passenger cars and, conversely, the higher proportion of fatal bicycle crashes during the afternoon and early evening. It should be noted that a fourth of all passenger car fatalities occur between midnight and 7 a.m., compared to 12.4 percent of the motorcycle fatalities and only 1.2 percent of the bicycle fatalities. These differences are certainly reflective of riding and driving exposure patterns.

Locality

Previous data showed that there were differences in the locations of bicycle accidents as opposed to other motor vehicle accidents. The results for the current analysis were similar.

Table 2.6. Day of week by injury class: bicycles versus passenger cars.

	Bicycles				Passenger cars			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Monday	493	(14.7)	10	(11.9)	26973	(13.2)	75	(13.0)
Tuesday	482	(14.4)	13	(15.5)	25037	(12.2)	58	(10.1)
Wednesday	447	(13.3)	12	(14.3)	26869	(13.1)	65	(11.3)
Thursday	488	(14.5)	10	(11.9)	27319	(13.4)	67	(11.7)
Friday	557	(16.6)	13	(15.5)	39181	(19.2)	91	(15.8)
Saturday	533	(15.9)	14	(16.7)	34751	(17.0)	134	(23.3)
Sunday	357	(10.6)	12	(14.3)	24309	(11.9)	85	(14.8)
Total	3357		84		204439		575	
(%)	(97.6)		(2.4)		(99.7)		(0.3)	

	Non-fatal	Fatal
χ^2(d.f.)	39.30 (d.f. = 6) ($p < .005$)	4.07 (d.f. = 6) ($.25 < p < .75$)

Table 2.7. Hour of day by injury class of bicyclist: then versus now.

	Bi NF				Bi F			
	Then		Now		Then		Now	
	N	%	N	%	N	%	N	%
7 AM - 9:59 AM	166	(7.2)	197	(6.0)	8	(7.5)	2	(2.4)
10 AM - 1:59 PM	432	(18.8)	585	(17.8)	22	(20.6)	15	(17.9)
2 PM - 8:59 PM	1606	(69.9)	2282	(69.4)	67	(62.6)	58	(69.0)
9 PM - 11:59 PM	75	(3.3)	161	(4.9)	9	(8.4)	8	(9.5)
Midnight-6:59 AM	20	(0.9)	61	(1.9)	1	(0.9)	1	(1.2)
Total	2299		3286		107		84	
(%)	(95.6)		(97.5)		(4.4)		(2.5)	

	χ^2(d.f.)
$NF_{Then:Now}$	21.54 (d.f. = 4) ($p < .005$)
$F_{Then:Now}$	2.90 (d.f. = 4) ($.25 < p < .75$)
$NF\text{-}F_{Now}$	5.50 (d.f. = 4) ($.10 < p < .25$)

Table 2.8. Hour of day by injury class: bicycles versus motorcycles.

	Bicycles				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
7 AM - 9:59 AM	197	(6.0)	2	(2.4)	467	(5.6)	9	(5.3)
10 AM - 1:59 PM	585	(17.8)	15	(17.9)	1447	(17.3)	23	(13.5)
2 PM - 8:59 PM	2282	(69.4)	58	(69.0)	4840	(58.0)	75	(44.1)
9 PM - 11:59 PM	161	(4.9)	8	(9.5)	1028	(12.3)	42	(24.7)
Midnight-6:59 AM	61	(1.9)	1	(1.2)	565	(6.8)	21	(12.4)
Total	3286		84		8347		170	
(%)	(97.5)		(2.5)		(90.8)		(2.0)	

	Non-fatal	Fatal
χ^2(d.f.)	284.16 (d.f. = 4) ($p < .005$)	23.15 (d.f. = 4) ($p < .005$)

Table 2.9. Hour of day by injury class: bicycles versus passenger cars.

	Bicycles				Passenger Cars			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
7 AM - 9:59 AM	197	(6.0)	2	(2.4)	25244	(12.5)	43	(7.5)
10 AM - 1:59 PM	585	(17.8)	15	(17.9)	39770	(19.7)	55	(9.6)
2 PM - 8:59 PM	2282	(69.4)	58	(69.0)	98073	(48.6)	218	(38.1)
9 PM - 11:59 PM	161	(4.9)	8	(9.5)	27330	(10.3)	108	(18.9)
Midnight-6:59 AM	61	(1.9)	1	(1.2)	17917	(8.9)	148	(25.9)
Total	3286		84		201734		572	
(%)	(97.5)		(2.5)		(99.7)		(0.3)	

	Non-fatal	Fatal
χ^2 (d.f.)	677.05 (d.f. = 4) (p <.005)	47.41 (d.f. = 4) (p <.005)

In comparing bicycles (then) versus bicycles (now), a higher percentage of non-fatal accidents has recently occurred in business or playground/school areas than in previous years, and slightly fewer non-fatal accidents have been noted in residential areas (Table 2.10). These differences were significant. No significant differences were detected for the fatal accident groups. For the recent data, proportionately fewer fatal than non-fatal bicycle accidents occurred in these two areas, and the differences were significant. The majority of non-fatal bicycle accidents still occur in residential areas, but most of the fatals appear in the open country where speeds are higher.

The breakdown of the locality variable for bicycle-motorcycle and bicycle-passenger car comparisons was different from the first comparison (bicycles-then versus now) in that business and school/playground categories were separated (Table 2.11). The only significant difference for the bicycle-motorcycle comparison was between the non-fatal crashes, where a higher proportion of bicycle accidents occurred in the residential areas and a lesser proportion in the open country. Again, this trend reflects the differences in riding habits between bicycles and motorcycles in these localities.

In comparing bicycles and passenger cars by locality (Table 2.12), both the non-fatal and fatal distributions were highly significantly different ($p < .005$). In both cases, the differences were due to a higher proportion of bicycle crashes in the residential area and a higher proportion of passenger car crashes in the open country. As expected, more fatals occurred in the open country.

One interesting finding that emerged from this group of tables was that very few bicycle accidents occurred around school or playground areas, where bicycle exposure might be high. This finding is in agreement with recent federal studies and possibly indicates that drivers are more attentive in these areas.

Table 2.10. Locality by injury class of bicyclist: then versus now.

	Bi NF				Bi F			
	Then		Now		Then		Now	
	N	%	N	%	N	%	N	%
Residential	1367	(58.3)	1708	(51.1)	28	(25.7)	26	(31.0)
Open Country	606	(25.9)	828	(24.8)	76	(69.7)	52	(61.9)
Business or School/ Playground	371	(15.8)	806	(24.1)	5	(4.6)	6	(7.1)
Total	2344		3343		109		84	
(%)	(95.6)		(97.5)		(4.4)		(2.5)	

	χ^2(d.f.)
$NF_{Then:Now}$	59.92 (d.f. = 2) ($p < .005$)
$F_{Then:Now}$	1.45 (d.f. = 2) ($.25 < p < .75$)
$NF\text{-}F_{Now}$	60.56 (d.f. = 2) ($p < .005$)

Table 2.11. Locality by injury class: bicycles versus motorcycles

	Bicycles				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Business	737	(22.0)	6	(7.1)	2110	(24.9)	21	(12.3)
Residential	1708	(51.1)	26	(31.0)	2407	(28.4)	36	(21.1)
School/Playground	70	(2.1)	0	(0.0)	94	(1.1)	2	(1.2)
Open Country	828	(24.8)	52	(61.9)	3853	(45.5)	112	(65.5)
Total	3343		84		8464		171	
(%)	(97.5)		(2.5)		(98.0)		(2.0)	

	Non-fatal	Fatal
χ^2(d.f.)	638.18 (d.f. = 3) ($p < .005$)	4.77 (d.f. = 3) ($.10 < p < .25$)

Table 2.12. Locality by injury class: bicycles versus passenger cars.

	Bicycles				Passenger Cars			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Business	737	(22.0)	6	(7.1)	71001	(34.7)	33	(5.7)
Residential	1708	(51.1)	26	(31.0)	55072	(26.9)	65	(11.3)
School/Playground	70	(2.1)	0	(0.0)	2297	(1.1)	2	(0.3)
Open Country	828	(24.8)	52	(61.9)	75997	(37.2)	475	(82.6)
Total	3343		84		204367		575	
(%)	(97.5)		(2.5)		(99.7)		(0.3)	

	Non-fatal	Fatal
χ^2(d.f.)	1019.224 (d.f. = 3) ($p < .005$)	24.955 (d.f. = 3) ($p < .005$)

Highway Class

As was seen in the earlier data, rural roads accounted for most bicycle fatalities; however, this was true to a lesser extent in the later data (Table 2.13). In the more recent data, the proportion of fatal bicycle crashes occurring on city streets doubled (23.2 percent now versus 11.9 percent then). Nonetheless, the differences were not significant. This change in proportion may reflect more commuting to and from work by the bicyclists on city streets.

When recent fatal and non-fatal bicycle accidents were compared with each other, there were marked differences associated with highway class ($p < .005$). Both Chi-square and Ranova-F statistics substantiate this conclusion. Proportionately more fatal crashes occurred on major (U.S. and N.C.) and rural roads than non-fatals, while a higher percentage of non-fatal bicycle accidents appeared on city streets. The index G (-0.63) indicates that there was a moderate association between the bicyclist's use of highway type and his injury. The proportion of non-fatal bicycle accidents increased from less than one percent on Interstate highways (virtually untraveled by bicyclists) to 64.2 percent on city streets (where one would expect to find the largest population of bicycle riders). In contrast, the magnitude of the proportions of fatal accidents on different highway types was in the opposite direction: most fatal bicycle crashes occurred on major roads (39 percent), closely followed by rural roads (38 percent), with a smaller percentage on city streets (23.2 percent). Undoubtedly, the higher speeds on major and rural roads contributed to the greater proportion of serious accidents.

There were differences between bicycles and motorcycles in non-fatal crashes but not in fatal crashes (Table 2.14). The non-fatal differences were largely due to the higher proportion of bicycle accidents on the city streets and the higher proportion of motorcycle accidents on the rural roads.

Table 2.13. Highway class by injury class of bicyclist: then versus now.

	Bi NF				Bi F			
	Then		Now		Then		Now	
	N	%	N	%	N	%	N	%
Interstate	5	(0.2)	5	(0.1)	0	(0.0)	0	(0.0)
U.S. Route, N.C. Route	353	(15.1)	436	(13.0)	41	(37.6)	32	(39.0)
Rural Road	558	(23.8)	758	(22.6)	55	(50.5)	31	(37.8)
City Street	1428	(60.9)	2151	(64.2)	13	(11.9)	19	(23.2)
Total (%)	2344 (95.6)		3350 (97.6)		109 (4.4)		82 (2.4)	

	χ^2 (d.f.)	Ranova-F (d.f.)	G-Index + s(G)
$NF_{Then:Now}$	7.68 (d.f. = 3) (.05 < p <.10)	--	--
$F_{Then:Now}$	5.22 (d.f. = 3) (.10 < p <.25)	--	--
$NF\text{-}F_{Now}$	69.17 (d.f. = 3) (p <.005)	67.14 (d.f. = 1,3429) (p <.005)	-0.63 ± 0.05

Table 2.14. Highway class by injury class: bicycles versus motorcycles

	Bicycles				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Interstate	5	(0.1)	0	(0.0)	103	(1.2)	0	(0.0)
U.S. Route	196	(5.9)	24	(29.3)	1181	(14.0)	29	(17.0)
N.C. Route	240	(7.2)	8	(9.8)	953	(11.3)	26	(15.2)
Rural Road	758	(22.6)	31	(37.8)	2683	(31.7)	77	(45.0)
City Street	2151	(64.2)	19	(23.2)	3537	(41.8)	39	(22.8)
Total	3350		82		8457		171	
(%)	(97.6)		(2.4)		(98.0)		(2.0)	

	Non-fatal	Fatal
χ^2(d.f.)	523.187 (d.f. = 4) ($p < .005$)	5.914 (d.f. = 4) ($.10 < p < .25$)

For the bicycle-passenger car comparisons (Table 2.15), the non-fatal differences were similar to the motorcycle comparisons, although the differences in the proportions on the U.S. routes had a larger contribution. The fatal distributions also differed, with the largest discrepancies occurring on the N.C. routes and the city streets. For both bicycle and passenger cars, more fatal accidents occurred on rural roads than other highway types. This finding was also consistent with comparisons of fatal accidents between bicycles and motorcycles and between the "new" and "old" bicycle accidents.

Road Feature

Road feature is an important factor in bicycle accidents, and many studies have indicated that accidents are frequent at intersections (e.g., intersection of two roadways, or intersection of a roadway with an alley or driveway). To facilitate comparison with the earlier HSRC study, driveway and intersection accidents were combined and examined against all other types of road features (Table 2.16). When the old and new bicycle data were compared, significant non-fatal differences were found, the trend being slightly less for driveway and intersection accidents than in the past. In recent bicycle accidents, significant differences were seen between non-fatal and fatal accidents ($p < .005$). As in the old data, intersections and driveways contributed to a higher proportion of non-fatal bicycle accidents, whereas these features are less involved in fatal accidents.

Tables 2.17 and 2.18 compare bicycles with motorcycles and passenger cars and differentiate between accidents at intersections and at driveways or alleys. Concerning bicycles versus motorcycles, significant differences were noted ($p < .005$), and the proportion of non-fatal bicycle accidents occurring at intersections was greater than the one for motorcycles (Table 2.17). There were no significant differences between the fatal accident groups. In the bicycle/passenger

Table 2.15. Highway class by injury class: bicycles versus passenger cars.

	Bicycles				Passenger Cars			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Interstate	5	(0.1)	0	(0.0)	3912	(1.9)	20	(3.5)
U.S. Route	196	(5.9)	24	(29.3)	32770	(16.0)	158	(27.5)
N.C. Route	240	(7.2)	8	(9.8)	21534	(10.5)	120	(20.9)
Rural Road	758	(22.6)	31	(37.8)	39813	(19.5)	212	(36.9)
City Street	2151	(64.2)	19	(23.2)	106311	(52.0)	65	(11.3)
Total	3350		82		204340		575	
(%)	(97.6)		(2.4)		(99.7)		(0.3)	

	Non-fatal	Fatal
χ^2 (d.f.)	416.04 (d.f. = 4) (p <.005)	15.41 (d.f. = 4) (p <.005)

Table 2.16. Road feature by injury class of bicyclist: then versus now.

	Bi NF		Bi F	
	Then	Now	Then	Now
	N (%)	N (%)	N (%)	N (%)
Intersection, Driveway, Alley	1455 (62.9)	1982 (59.8)	62 (56.9)	35 (41.6)
Other	857 (37.1)	1332 (40.2)	47 (43.1)	49 (58.3)
Total (%)	2312 (95.5)	3314 (97.5)	109 (4.5)	84 (2.5)

	χ^2 (d.f.)
$NF_{Then:Now}$	5.47 (d.f. = 1) (.01 < p <.025)
$F_{Then:Now}$	3.81 (d.f. = 1) (Fisher's p = 0.04)
$NF\text{-}F_{Now}$	10.44 (d.f. = 1) (p <.005)

Table 2.17. Road feature by injury class: bicycles versus motorcycles.

	Bicycles				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Intersection	1463	(44.1)	16	(19.0)	2990	(36.1)	39	(23.5)
Driveway or Alley	519	(15.7)	19	(22.6)	1580	(19.1)	34	(20.5)
Other	1332	(40.2)	49	(58.3)	3720	(44.9)	93	(56.0)
Total	3314		84		8290		166	
(%)	(97.5)		(2.5)		(98.0)		(2.0)	

	Non-fatal	Fatal
χ^2(d.f.)	67.291 (d.f. = 2) ($p < .005$)	0.674 (d.f. = 2) ($.25 < p < .75$)

Table 2.18. Road feature by injury class: bicycles versus passenger cars.

	Bicycles NF N	Bicycles NF %	Bicycles F N	Bicycles F %	Passenger Cars NF N	Passenger Cars NF %	Passenger Cars F N	Passenger Cars F %
Intersection	1463	(44.1)	16	(19.0)	85586	(42.6)	106	(19.1)
Driveway or Alley	519	(15.7)	19	(22.6)	31612	(15.7)	27	(4.9)
Other	1332	(40.2)	49	(58.3)	83568	(41.6)	423	(76.1)
Total	3314		84		200766		556	
(%)	(97.5)		(2.5)		(99.7)		(0.3)	

	Non-fatal	Fatal
χ^2(d.f.)	3.378 (d.f. = 2) (.10 < p <.25)	35.151 (d.f. = 2) (p <.005)

car comparison, differences were found in the fatal accident distributions (Table 2.18) but not in the non-fatal accident distributions. Here, fatal bicycle accidents occurred four times more often than fatal passenger car accidents at driveways or alleys. The incidence of fatal accidents at intersections was proportionately the same for bicycles and passenger cars.

Road Condition

Bicycle, motorcycle and passenger car accidents are most likely to occur on dry pavement. No differences were seen in the comparison of the old and new bicycle data (Table 2.19). The bicycle-motorcycle comparisons in Table 2.20 showed non-fatal accident differences, but these differences merely reflect the slight differences in the "other" category (i.e., the two distributions are in reality almost identical if we exclude the "other" category).

Significant differences were seen (Table 2.21) between bicycle accidents and passenger car accidents: fatal and non-fatal bicycle accidents were more likely to be associated with dry roads. As stated in the earlier report, bicycles tend to be used primarily in good weather. Consequently, these differences were exposure-related.

Table 2.19. Road condition by injury class of bicyclist: then versus now.

	Bi NF				Bi F			
	Then		Now		Then		Now	
	N	%	N	%	N	%	N	%
Dry	2152	(93.1)	3079	(92.7)	102	(94.4)	79	(94.0)
Wet	154	(6.7)	235	(7.1)	6	(5.6)	5	(6.0)
Other	6	(0.3)	6	(0.2)	0	(0.0)	0	(0.0)
Total (%)	2312 (95.5)		3320 (97.5)		108 (4.5)		84 (2.5)	

χ^2 (d.f.)

$NF_{Then:Now}$	0.758 (d.f. = 2) (.25 < p <.75)
$F_{Then:Now}$	0.014 (d.f. = 1) (.90 < p <.95)
$NF\text{-}F_{Now}$	0.314 (d.f. = 2) (.75 < p <.90)

Table 2.20. Road condition by injury class: bicycles versus motorcycles.

	Bicycles				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Dry	3079	(92.7)	79	(94.0)	7818	(92.7)	159	(93.5)
Wet	235	(7.1)	5	(6.0)	571	(6.8)	11	(6.5)
Other	6	(0.2)	0	(0.0)	47	(0.6)	0	(0.0)
Total (%)	3320 (97.5)		84 (2.5)		8436 (98.0)		170 (2.0)	

	Non-fatal	Fatal
χ^2(d.f.)	7.822 (d.f. = 2) ($.01 < p < .025$)	0.026 (d.f. = 1) ($.75 < p < .90$)

Table 2.21. Road condition by injury class: bicycles versus passenger cars.

	Bicycles				Passenger Cars			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Dry	3079	(92.7)	79	(94.0)	160886	(79.1)	454	(79.8)
Wet	235	(7.1)	5	(6.0)	38754	(19.1)	113	(19.9)
Other	6	(0.2)	0	(0.0)	3688	(1.8)	2	(0.4)
Total (%)	3320 (97.5)		84 (2.5)		203328 (99.7)		569 (0.3)	

	Non-fatal	Fatal
χ^2(d.f.)	373.602 (d.f. = 2) ($p <.005$)	9.952 (d.f. = 2) ($.005 < p <.01$)

Road Surface

The road surface variable was analyzed in the earlier report and indicated differences undoubtedly related to expsoure. The majority of bicycle accidents occur on asphalt pavement. Tables 2.22 - 2.24 show some non-fatal accident differences, but these can only be theorized to again relate to exposure.

Road Defect

When the road defect variable was examined, there were no significant differences found in any of the old versus new data comparisons (Table 2.25). It should be noted that when defects were present, loose material on the surface was most often involved.

When bicycles and motorcycles were compared, there were significant non-fatal differences (Table 2.26), but no differences in the fatals. In the case of the non-fatals, road defects were present twice as often in the motorcycle crashes. No significant differences were detected in the bicycle/passenger car comparisons.

Weather Condition

Considering weather conditions, a comparison of recent bicycle data with old data showed that there was a significant difference in the non-fatal accident group (Table 2.28). A larger proportion of the present (1974-76) bicycle non-fatals occurred during unfavorable weather conditions than in the past. The comparison of recent non-fatal and fatal bicycle accidents was similar.

No differences were seen in the bicycle/motorcycle comparisons (Table 2.29). For the bicycle/passenger car comparisons, however, both the non-fatal and fatal distributions were significantly different (Table 2.30). In both cases, the trend was for more bicycle accidents in clear weather and more passenger car accidents when conditions were not as favorable. This is again an exposure effect.

Table 2.22. Road surface by injury class of bicyclist: then versus now.

	Bi NF				Bi F			
	Then		Now		Then		Now	
	N	%	N	%	N	%	N	%
Concrete	95	(4.1)	84	(2.5)	5	(4.6)	2	(2.4)
Smooth Asphalt	1464	(62.5)	2096	(63.2)	59	(54.1)	50	(59.5)
Coarse Asphalt	662	(28.2)	1069	(32.2)	37	(33.9)	30	(35.7)
Other	123	(5.3)	68	(2.1)	8	(7.3)	2	(2.4)
Total	2344		3317		109		84	
(%)	(95.6)		(97.5)		(4.4)		(2.5)	

	χ^2 (d.f.)
$NF_{Then:Now}$	58.91 (d.f. = 3) ($p < .005$)
$F_{Then:Now}$	3.18 (d.f. = 3) ($.25 < p < .75$)
$NF\text{-}F_{Now}$	0.53 (d.f. = 3) ($.90 < p < .95$)

Table 2.23. Road surface by injury class: bicycles versus motorcycles.

	Bicycles NF N	Bicycles NF %	Bicycles F N	Bicycles F %	Motorcycles NF N	Motorcycles NF %	Motorcycles F N	Motorcycles F %
Concrete	84	(2.5)	2	(2.4)	347	(4.1)	4	(2.4)
Smooth Asphalt	2096	(63.2)	50	(59.5)	5077	(60.2)	88	(51.8)
Coarse Asphalt	1069	(32.2)	30	(35.7)	2756	(32.7)	75	(44.1)
Other	68	(2.1)	2	(2.4)	253	(3.0)	3	(1.8)
Total	3317		84		8433		170	
(%)	(97.5)		(2.5)		(98.0)		(2.0)	

	Non-fatal	Fatal
χ^2(d.f.)	27.74 (d.f. = 3) ($p < .005$)	1.69 (d.f. = 3) ($.25 < p < .75$)

Table 2.24. Road surface by injury class: bicycles versus passenger cars.

	Bicycles				Passenger Cars			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Concrete	84	(2.5)	2	(2.4)	9976	(4.9)	27	(4.7)
Smooth Asphalt	2096	(63.2)	50	(59.5)	134565	(66.1)	365	(63.5)
Coarse Asphalt	1069	(32.2)	30	(35.7)	54614	(26.8)	173	(30.1)
Other	68	(2.1)	2	(2.4)	4438	(2.2)	10	(1.7)
Total	3317		84		203593		575	
(%)	(97.5)		(2.5)		(99.7)		(0.3)	

	Non-fatal	Fatal
χ^2(d.f.)	77.45 (d.f. = 3) ($p < .005$)	1.99 (d.f. = 3) ($.25 < p < .75$)

Table 2.25. Road defect by injury class of bicyclist: then versus now.

	Bi NF				Bi F			
	Then		Now		Then		Now	
	N	%	N	%	N	%	N	%
No Defects	2208	(96.3)	3197	(96.5)	103	(95.4)	83	(98.8)
Defects	85	(3.7)	116	(3.5)	5	(4.6)	1	(1.2)
Total	2293		3313		108		84	
(%)	(95.5)		(97.5)		(4.5)		(2.5)	

	χ^2 (d.f.) (with Yates correction)
$NF_{Then:Now}$	0.11 (d.f. = 1) (.25 < p <.75)
$F_{Then:Now}$	0.89 (d.f. = 1) (Fisher's p = 0.23)
$NF\text{-}F_{Now}$	0.71 (d.f. = 1) (.25 < p <.75)

Table 2.26. Road defect by injury class: bicycles versus motorcycles.

	Bicycles				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
No Defects	3197	(96.5)	83	(98.8)	7790	(92.3)	165	(96.5)
Defects	116	(3.5)	1	(1.2)	649	(7.7)	6	(3.5)
Total	3313		84		8439		171	
(%)	(97.5)		(2.5)		(98.0)		(2.0)	

	Non-fatal	Fatal
χ^2(d.f.)	67.91 (d.f. = 1) (p <.005)	0.43 (d.f. = 1) (Fisher's p = 0.43)

(with Yates Correction)

Table 2.27. Road defect by injury class: bicycles versus passenger cars.

	Bicycles				Passenger Cars			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
No Defects	3197	(96.5)	83	(98.8)	195147	(95.9)	546	(95.1)
Defects	116	(3.5)	1	(1.2)	8424	(4.1)	28	(4.9)
Total	3313		84		203571		574	
(%)	(97.5)		(2.5)		(99.7)		(0.3)	

	Non-fatal	Fatal
χ^2(d.f.)	3.18 (d.f. = 1) (.05 < p <.10)	1.57 (d.f. = 1) (Fisher's p = 0.16)

Table 2.28. Weather condition by injury class of bicyclist: then versus now.

	Bi NF				Bi F			
	Then		Now		Then		Now	
	N	%	N	%	N	%	N	%
Clear	1911	(82.2)	2634	(79.6)	93	(86.1)	63	(75.9)
Cloudy	325	(14.0)	513	(15.5)	12	(11.1)	16	(19.3)
Other	89	(3.8)	160	(4.8)	3	(2.8)	4	(4.8)
Total	2325		3307		108		83	
(%)	(95.6)		(97.6)		(4.4)		(2.4)	

	χ^2 (d.f.)
$NF_{Then:Now}$	6.41 (d.f. = 2) ($.025 < p < .05$)
$F_{Then:Now}$	3.27 (d.f. = 2) ($.10 < p < .25$)
$NF\text{-}F_{Now}$	0.88 (d.f. = 2) ($.25 < p < .75$)

Table 2.29. Weather condition by injury class: bicycles versus motorcycles.

	Bicycles				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Clear	2634	(79.6)	63	(75.9)	6853	(81.4)	132	(77.6)
Cloudy	513	(15.5)	16	(19.3)	1206	(14.3)	30	(17.6)
Other	160	(4.8)	4	(4.8)	361	(4.3)	8	(4.7)
Total	3307		83		8420		170	
(%)	(97.6)		(2.4)		(98.0)		(2.0)	

	Non-fatal	Fatal
χ^2(d.f.)	4.80 (d.f. = 2) (.05 < p <.10)	0.11 (d.f. = 2) (.90 < p <.95)

Table 2.30. Weather condition by injury class: bicycles versus passenger cars.

	Bicycles				Passenger Cars			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Clear	2634	(79.6)	63	(75.9)	138641	(68.2)	379	(66.6)
Cloudy	513	(15.5)	16	(19.3)	31136	(15.3)	94	(16.5)
Other	160	(4.8)	4	(4.8)	33463	(16.5)	96	(16.9)
Total	3307		83		203240		569	
(%)	(97.6)		(2.4)		(99.7)		(0.3)	

	Non-fatal	Fatal
χ^2(d.f.)	332.49 (d.f. = 2) ($p < .005$)	8.11 (d.f. = 2) ($.01 < p < .025$)

Light Condition

As discussed in the previous report, the largest portion of all accidents occur during daylight hours, but for bicycles the proportion is larger. When recent fatal and non-fatal bicycle accidents were compared (Table 2.31), the difference was highly significant ($p < .005$). This is explained by the fact that if a bicycle accident occurs in darkness or on an unlighted road, there is a much higher probability of the accident being fatal. Speed differential is likely to be a factor here, but much more important would be the ability to perceive and recognize the bicyclist under these conditions.

The bicycle/motorcycle (Table 2.32) and bicycle/passenger car (Table 2.33) comparisons revealed differences for both the non-fatal and fatal distributions, and the trends were the same in both cases. Proportionately more bicycle accidents occurred during the day, while more motorcycle and passenger car accidents occurred under conditions of darkness.

Speed Limit

Starting with this variable, the remainder of this section will be concerned with variables that were not present in the earlier Waller-Reinfurt study but which are considered useful. These tables will be concerned only with the bicycle/motorcycle and bicycle/passenger car comparisons.

Non-fatal differences were shown in the bicycle/motorcycle comparisons (Table 2.34), primarily attributable to the presence of motorcycles on higher speed facilities. The same was true for passenger cars (Table 2.35), where differences in both fatal and non-fatal distributions were found significant by both chi-square and Ranova-F statistical tests.

When fatal and non-fatal bicycle accidents were compared, the computed index G (0.64) revealed a moderate degree of association between speed limit and bicyclist injury, with most serious bicycle accidents occurring in high speed

Table 2.31. Light condition by injury class of bicyclist: then versus now.

	Bi NF				Bi F			
	Then		Now		Then		Now	
	N	%	N	%	N	%	N	%
Daylight	1911	(81.7)	2748	(82.9)	75	(68.8)	58	(69.0)
Dusk or dawn	116	(5.0)	165	(5.0)	6	(5.5)	6	(7.1)
Dark (street lights)	180	(7.7)	244	(7.4)	2	(1.8)	3	(3.6)
Dark (no street lights)	132	(5.6)	159	(4.8)	26	(23.9)	17	(20.2)
Total	2339		3316		109		84	
(%)	(95.5)		(97.5)		(4.5)		(2.5)	

	χ^2 (d.f.)
$NF_{\text{Then:Now}}$	2.36 (d.f. = 3) ($.25 < p < .75$)
$F_{\text{Then:Now}}$	1.04 (d.f. = 3) ($.75 < p < .90$)
$NF\text{-}F_{\text{Now}}$	42.02 (d.f. = 3) ($p < .005$)

Table 2.32. Light condition by injury class: bicycles versus motorcycles.

	Bicyclists				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Daylight	2748	(82.9)	58	(69.0)	5954	(70.5)	79	(46.5)
Dusk or dawn	165	(5.0)	6	(7.1)	382	(4.5)	12	(7.1)
Dark (street lights)	244	(7.4)	3	(3.6)	949	(11.2)	19	(11.2)
Dark (no street lights)	159	(4.8)	17	(20.2)	1156	(13.7)	60	(35.3)
Total	3316		84		8441		170	
(%)	(97.5)		(2.5)		(98.0)		(2.0)	

	Non-fatal	Fatal
χ^2(d.f.)	253.98 (d.f. = 3) (p <.005)	13.27 (d.f. = 3) (p <.005)

Table 2.33. Light condition by injury class: bicycles versus passenger cars.

	Bicyclists				Passenger Cars			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Daylight	2748	(82.9)	58	(69.0)	144004	(70.7)	242	(42.4)
Dusk or dawn	165	(5.0)	6	(7.1)	7730	(3.8)	25	(4.4)
Dark (street lights)	244	(7.4)	3	(3.6)	23859	(11.7)	45	(7.9)
Dark (no street lights)	159	(4.8)	17	(20.2)	28145	(13.8)	259	(45.4)
Total	3316		84		203738		571	
(%)	(97.5)		(2.5)		(99.7)		(0.3)	

	Non-fatal	Fatal
χ^2(d.f.)	327.63 (d.f. = 3) ($p < .005$)	25.37 (d.f. = 3) ($p < .005$)

Table 2.34. Speed limit by injury class: bicycles versus motorcycles.

	Bicyclists				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
0-35	2205	(66.9)	20	(24.7)	3643	(43.4)	38	(22.4)
36-45	363	(11.0)	16	(19.8)	1455	(17.3)	29	(17.1)
46-55	728	(22.1)	45	(55.6)	3296	(39.3)	103	(60.6)
Total	3296		81		8394		170	
(%)	(97.6)		(2.4)		(98.0)		(2.0)	

	Non-fatal	Fatal
χ^2(d.f.)	524.94 (d.f. = 2) (p <.005)	0.59 (d.f. = 2) (.25 < p <.75)
Ranova-F (d.f.)	513.94 (d.f. = 1, 1687) (p <.005)	0.49 (d.f. = 1, 248) (.25 < p <.75)
G$\pm$s(G)	--	--

NF:F

	Bicycles	Motorcycles
χ^2(d.f.)	65.44 (d.f. = 2) (p <.005)	36.27 (d.f. = 2) (p <.005)
Ranova-F (d.f.)	66.69 (d.f. = 1, 3374) (p <.005)	36.34 (d.f. = 1, 8561) (p <.005)
G+s(G)	0.64 $\pm$ 0.06	0.39 $\pm$ 0.06

Table 2.35. Speed limit by injury class: bicycles versus passenger cars.

	Bicyclists				Passenger Cars			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
0-35	2205	(66.9)	20	(24.7)	101379	(50.1)	65	(11.3)
36-45	363	(11.0)	16	(19.8)	37605	(18.6)	60	(10.4)
46-55	728	(22.1)	45	(55.6)	63419	(31.3)	450	(78.3)
Total	3296		81		202403		575	
(%)	(97.6)		(2.4)		(99.7)		(0.3)	

	Non-fatal	Fatal
χ^2(d.f.)	371.50 (d.f. = 2) (p <.005)	19.99 (d.f. = 2) (p <.005)
Ranova-F (d.f.)	304.44 (d.f. = 1, 5696) (p <.005)	20.53 (d.f. = 1, 653) (p <.005)
G $\pm$ s(G)	--	--

NF:F

	Bicycles	Motorcycles
χ^2(d.f.)	65.44 (d.f. = 2) (p <.005)	594.35 (d.f. = 2) (p <.005)
Ranova-F (d.f.)	66.69 (d.f. = 1, 3374) (p <.005)	515.81 (d.f. = 1, 2975) (p <.005)
G $\pm$ s(G)	0.64 $\pm$ 0.06	0.74 $\pm$ 0.02

zones (46-55). The magnitude of association was somewhat higher (G = 0.74) for passenger car accidents and only slight for motorcycles (G = 0.39).

Traffic Control Type

Stop or yield signs were found to a larger degree in the non-fatal bicycle accidents than in those of motorcycles (Table 2.36) and passenger cars (Table 2.37), which matches the earlier finding concerning intersections. This does not appear to be a factor in any of the fatal accidents.

Object Struck

When bicycle accidents were compared with motorcycle accidents (Table 2.38), non-fatal significant differences occurred, and, unlike the motorcycles, a larger proportion of the bicycles hit some object. There was no difference between the bicycle and motorcycle fatal accidents in contrast to the fatal bicycle/passenger car comparisons, where a significant difference was found ($.01 < p < .025$) (Table 2.39). Proportionately more passenger cars than bicyclists hit objects in fatal accidents.

City Size

Information concerning city size is largely unknown for the bicycle fatal accidents, but more data are available for the non-fatals, where the majority occur in cities with a population of greater than 25,000 (Table 2.40). In the bicycle/motorcycle comparisons, non-fatal differences were found. The variation appeared to occur in the cities under 20,000 population, which contained 43 percent of the bicycle non-fatals and 33 percent of the motorcycle non-fatals. The recent non-fatal versus fatal comparisons for bicycles were also significantly different. Much variation can be seen in both distributions. There were no differences in the fatal crashes.

Table 2.36. Traffic control type by injury class: bicycles versus motorcycles.

	Bicycles				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Stop or yield sign	736	(67.9)	11	(78.6)	1234	(59.6)	14	(56.0)
Other	348	(32.1)	3	(21.4)	837	(40.4)	11	(1.3)
Total	1084		14		2071		25	
(%)	(97.7)		(1.3)		(98.8)		(1.2)	

	Non-fatal	Fatal
χ^2(d.f.)	20.61 (d.f. = 1) (p <.005)	1.13 (d.f. = 1) (Fisher's p = 0.19)

(with Yates Correction)

Table 2.37. Traffic control type by injury class: bicycles versus passenger cars.

	Bicycles				Passenger Cars			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Stop or yield sign	736	(67.9)	11	(78.6)	35268	(48.7)	50	(55.6)
Other	348	(32.1)	3	(21.4)	37154	(51.3)	40	(44.4)
Total	1084		14		72422		90	
(%)	(97.7)		(1.3)		(99.9)		(0.1)	

	Non-fatal	Fatal
χ^2(d.f.)	156.76 (d.f. = 1) ($p < .005$)	1.78 (d.f. = 1) (Fisher's $p = 0.15$)

(with Yates Correction)

Table 2.38. Object struck by injury class: bicycles versus motorcycles.

	Bicycles				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Some	1530	(47.7)	43	(53.1)	3304	(40.4)	87	(53.0)
No object	1678	(52.3)	38	(46.9)	4870	(59.6)	77	(47.0)
Total	3208		81		8174		164	
(%)	(97.5)		(2.5)		(98.0)		(2.0)	

	Non-fatal	Fatal
χ^2(d.f.)	9.87 (d.f. = 1) (p <.005)	0.00 (d.f. = 1) (Fisher's p = 0.99)

(with Yates Correction)

Table 2.39. Object struck by injury class: bicycles versus passenger cars.

	Bicycles				Passenger Cars			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Some	1530	(47.7)	43	(53.1)	62799	(48.8)	315	(66.9)
No object	1678	(52.3)	38	(46.9)	66004	(51.2)	156	(33.1)
Total	3208		81		128803		471	
(%)	(97.5)		(2.5)		(99.6)		(0.4)	

	Non-fatal	Fatal
χ^2(d.f.)	1.37 (d.f. = 1) (.10 < p <.25)	5.18 (d.f. = 1) (.01 < p <.025)

(with Yates Correction)

Table 2.40. City size by injury class: bicycles versus motorcycles.

	Bicycles				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Over 75,000	854	(38.2)	6	(28.6)	1572	(39.9)	19	(37.3)
50,000-75,000	144	(6.4)	2	(9.5)	369	(9.4)	8	(15.7)
35,000-49,999	175	(7.8)	1	(4.8)	300	(7.6)	2	(3.9)
25,000-34,999	271	(12.1)	2	(9.5)	287	(7.3)	6	(11.8)
20,000-24,999	80	(3.6)	1	(4.8)	102	(2.6)	0	(0.0)
15,000-19,999	145	(6.5)	0	(0.0)	260	(6.6)	2	(3.9)
10,000-14,999	152	(6.8)	3	(14.3)	268	(6.8)	1	(2.0)
5,000- 9,999	198	(8.9)	0	(0.0)	334	(8.5)	3	(5.9)
1,000- 4,999	181	(8.1)	3	(14.3)	346	(8.8)	6	(11.8)
Under 1,000	36	(1.6)	3	(14.3)	99	(2.5)	4	(7.8)
Total	2236		21		3937		51	
(%)	(99.1)		(0.9)		(98.7)		(1.3)	

	Non-fatal	Fatal
χ^2(d.f.)	63.85 (d.f. = 9) ($p < .005$)	10.09 (d.f. = 9) ($.25 < p < .75$)
Ranova-F (d.f.)	0.92 (d.f. = 1, 6170) ($.25 < p < .75$)	1.20 (d.f. = 1, 69) ($.25 < p < .50$)
G$\pm$s(G)	--	--

NF:F

	Bicycles	Motorcycles
χ^2(d.f.)	26.50 (d.f. = 9) ($p < .005$)	14.56 (d.f. = 9) ($.10 < p < .25$)
Ranova-F (d.f.)	2.27 (d.f. = 1, 2254) ($.10 < p < .25$)	0.16 (d.f. = 1, 3985) ($.25 < p < .75$)
G$\pm$s(G)	0.22 $\pm$ 0.15	0.04 $\pm$ 0.10

The results were similar for the passenger car comparisons (Table 2.41). For the non-fatals, more passenger car accidents occurred in cities of greater than 50,000, while more bicycle non-fatals occurred in cities of 25,000 to 35,000.

Characteristics of the Accident

Bicycle Maneuver

Bicycle accidents appeared to be different from motorcycle and passenger car accidents with regard to vehicle action. There was no comparison of old and new data, since the earlier report did not examine this variable. Tables 2.42 and 2.43 reveal that going straight was the maneuver most often executed by all three groups with the exception of fatal bicycle accidents. The data indicate that bicycles changed lanes more often than motorcycles or passenger cars in non-fatal accidents. Proportionately more non-fatal accidents involved bicycles starting in the road than motorcycles or passenger cars. This may be explained by the fact that bicyclists frequently enter traffic from the side of the road. These non-fatal differences were significant ($p < .005$). When bicycles were compared with motorcycles and passenger cars, significant fatal differences were also found, but interpreting the differences was difficult since bicycle maneuvers were reported in only 3 fatal cases. Better reporting of this variable by the investigating officer would improve future analyses of bicycle data.

Motor Vehicle Maneuver

Waller and Reinfurt state that the majority of all highway accidents involve a vehicle going straight ahead. The earlier bicycle data also followed this trend. In fact, all the earlier bicycle fatalities involved a motor

Table 2.41. City size by injury class: bicycles versus passenger cars.

	Bicycles				Passenger Cars			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Over 75,000	854	(38.2)	6	(28.6)	48056	(40.0)	26	(31.3)
50,000-75,000	144	(6.4)	2	(9.5)	11370	(9.5)	9	(10.8)
35,000-49,999	175	(7.8)	1	(4.8)	8434	(7.0)	5	(6.0)
25,000-34,999	271	(12.1)	2	(9.5)	8423	(7.0)	5	(6.0)
20,000-24,999	80	(3.6)	1	(4.8)	4350	(3.6)	3	(3.6)
15,000-19,999	145	(6.5)	0	(0.0)	6762	(5.6)	4	(4.8)
10,000-14,999	152	(6.8)	3	(14.3)	7993	(6.7)	10	(12.0)
5,000- 9,999	198	(8.9)	0	(0.0)	9959	(8.3)	7	(8.4)
1,000- 4,999	181	(8.1)	3	(14.3)	11748	(9.8)	9	(10.8)
Under 1,000	36	(1.6)	3	(14.3)	3037	(2.5)	5	(6.0)
Total	2236		21		120,132		83	
(%)	(99.1)		(0.9)		(99.9)		(0.1)	

	Non-fatal	Fatal
χ^2(d.f.)	123.32 (d.f. = 9) ($p < .005$)	4.99 (d.f. = 9) ($.75 < p < .90$)
Ranova-F (d.f.)	0.61 (d.f. = 1, 2365) ($.25 < p < .75$)	0.33 (d.f. = 1, 101) ($p < .50$)
$G \pm s(G)$	--	--

NF:F

	Bicycles	Passenger Cars
χ^2(d.f.)	26.50 (d.f. = 9) ($p < .005$)	9.79 (d.f. = 9) ($.25 < p < .75$)
Ranova-F (d.f.)	2.27 (d.f. = 1, 2254) ($.10 < p < .25$)	3.66 (d.f. = 1, 212)
$G \pm s(G)$	0.22 ± 0.15	0.14 ± 0.07

Table 2.42. Maneuver of bicycle versus motorcycle by injury class.

	Bicycles				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Going straight	57	(54.3)	1	(33.3)	6770	(80.0)	148	(86.5)
Changing lanes	15	(14.3)	0	(0.0)	93	(1.1)	2	(1.2)
Left turn	10	(9.5)	0	(0.0)	392	(4.6)	5	(2.9)
Right turn	4	(3.8)	1	(33.3)	239	(2.8)	4	(2.3)
Stopped in road	5	(4.8)	0	(0.0)	137	(1.6)	1	(0.6)
Starting in road	7	(6.7)	0	(0.0)	123	(1.5)	2	(1.2)
Other maneuvers	7	(6.7)	1	(33.3)	710	(8.4)	9	(5.3)
Total	105		3		8464		171	
(%)	(97.2)		(2.8)		(98.0)		(2.0)	

	Non-fatal	Fatal
χ^2 (d.f.)	182.47 (d.f. = 6) ($p < .005$)	15.05 (d.f. = 6) ($.01 < p < .025$)

Table 2.43. Maneuver of bicycle versus passenger car by injury class.

	Bicycles				Passenger Cars			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Going straight	57	(54.3)	1	(33.3)	124356	(60.8)	514	(89.4)
Changing lanes	15	(14.3)	0	(0.0)	4263	(2.1)	3	(0.5)
Left turn	10	(9.5)	0	(0.0)	23221	(11.4)	27	(4.7)
Right turn	4	(3.8)	1	(33.3)	7588	(3.7)	0	(0.0)
Stopped in road	5	(4.8)	0	(0.0)	15869	(7.8)	3	(0.5)
Starting in road	7	(6.7)	0	(0.0)	4049	(2.0)	3	(0.5)
Other maneuvers	7	(6.7)	1	(33.3)	25022	(12.2)	25	(4.3)
Total	105		3		204368		575	
(%)	(97.2)		(2.8)		(99.7)		(0.3)	

	Non-fatal	Fatal
χ^2 (d.f.)	91.21 (d.f. = 6) ($p < .005$)	198.48 (d.f. = 6) ($p < .005$)

vehicle that was either going straight or passing. Left turns and other maneuvers by motor vehicles were more involved in the non-fatal bicycle accidents.

Comparing the old and new data shows a significant difference in the non-fatals but no change in the fatals. A look at the distributions for the non-fatals shows that more passing, left turn, and other maneuvers are now being made by the motor vehicle driver than previously (Table 2.44). The recent non-fatal and fatal distributions also differed significantly, primarily due to more straight ahead and passing maneuvers by the motor vehicles. As before, practically all of the bicycle fatals involved these two motor vehicle maneuvers.

Maneuvers by the motor vehicles involved in bicycle and motorcycle accidents were significantly different for both non-fatals and fatals (Table 2.45). The trends were similar for both distributions in that the motor vehicles were much more involved in left turns than in other maneuvers. Comparing the maneuvers by motor vehicles in bicycle and passenger car accidents (Table 2.46) yielded results similar to the non-fatal motorcycle data. The fatal distributions, although significantly different, were more similar overall than the bicycle/motorcycle fatals. The passenger car fatal crashes involved fewer passing and more left-turn maneuvers than bicycle fatals did.

Point of Contact on Bicycle

Point of contact was reported in very few cases for the bicycles. In 45 percent of the non-fatal accidents, the front of the bike was struck; 26 percent were struck on the left side, 23 percent in the rear, and 6 percent on the right side (Table 2.47).

For non-fatals, motorcycle impact points were different ($p <.005$) in that more appear in the front and right side categories and fewer in the rear and left side categories. Frontal impacts predominate in motorcycle fatalities.

Table 2.44. Maneuver of the motor vehicle involved in a bicycle accident by injury class: then versus now.

	Bi NF				Bi F			
	Then		Now		Then		Now	
	N	%	N	%	N	%	N	%
Going straight	1841	(84.3)	2481	(73.9)	87	(88.8)	75	(89.3)
Passing	81	(3.7)	147	(4.4)	11	(11.2)	8	(9.5)
Left turn	124	(5.7)	300	(8.9)	0	(0.0)	0	(0.0)
Other	137	(6.3)	429	(12.8)	0	(0.0)	1	(1.2)
Total	2183		3357		98		84	
(%)	(95.7)		(97.6)		(4.3)		(2.4)	

	χ^2(d.f.)
$NF_{Then:Now}$	92.96 (d.f. = 3) ($p < .005$)
$F_{Then:Now}$	1.29 (d.f. = 3) ($.25 < p < .75$)
$NF\text{-}F_{Now}$	23.74 (d.f. = 3) ($p < .005$)

Table 2.45. Maneuver of the motor vehicle involved in a bicycle versus motorcycle accident by injury class.

	Bicycles				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Going straight	2481	(73.9)	75	(89.3)	1874	(22.1)	46	(26.9)
Passing	147	(4.4)	8	(9.5)	112	(1.3)	4	(2.3)
Left turn	300	(8.9)	0	(0.0)	1832	(21.6)	27	(15.8)
Other	429	(12.8)	1	(1.2)	4652	(54.9)	94	(55.0)
Total	3357		84		8470		171	
(%)	(97.6)		(2.4)		(98.0)		(2.0)	

	Non-fatal	Fatal
χ^2(d.f.)	3061.90 (d.f. = 3) (p <.005)	109.38 (d.f. = 3) (p <.005)

Table 2.46. Maneuver of the motor vehicle involved in a bicycle versus passenger car accident by injury class.

	Bicycles				Passenger Cars			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Going straight	2481	(73.9)	75	(89.3)	124356	(60.8)	514	(89.4)
Passing	147	(4.4)	8	(9.5)	4809	(2.4)	20	(3.5)
Left turn	300	(8.9)	0	(0.0)	23221	(11.4)	27	(4.7)
Other	429	(12.8)	1	(1.2)	52053	(25.5)	14	(2.4)
Total	3357		84		204439		575	
(%)	(97.6)		(2.4)		(99.7)		(0.3)	

	Non-fatal	Fatal
χ^2(d.f.)	376.85 (d.f. = 3) ($p < .005$)	10.75 (d.f. = 3) ($.01 < p < .025$)

Table 2.47. Point of contact on the bicycle versus motorcycle by injury class.

	Bicycles				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Frontal	35	(44.9)	2	(100.0)	4627	(60.9)	112	(71.3)
Left side	20	(25.6)	0	(0.0)	1260	(16.6)	23	(14.6)
Right side	5	(6.4)	0	(0.0)	945	(12.4)	9	(5.7)
Rear	18	(23.1)	0	(0.0)	357	(4.7)	5	(3.2)
Other	0	(0.0)	0	(0.0)	405	(5.3)	8	(5.1)
Total	78		2		7594		157	
(%)	(97.5)		(2.5)		(98.0)		(2.0)	

	Non-fatal	Fatal
χ^2(d.f.)	66.83 (d.f. = 4) ($p < .005$)	0.80 (d.f. = 4) ($.90 < p < .95$)

Bicycle and passenger car points of contact differed for the non-fatals (Table 2.48) in that there was significant variation in all impact point categories.

Point of Contact on the Motor Vehicle

The earlier study indicated that when "compared with all motor vehicle accidents, bicycle accidents are more likely to involve contact with the front and right front of the automobile." For the old and new point of contact, non-fatal and fatal distribution comparisons, all were significant (Table 2.49). For the non-fatals, the newer data showed proportionately fewer right front impacts and proportionately more side or rear impacts. For the fatals, increases were seen in the front, sides, and rear, with decreases in the right and left front. The recent fatals differed from the non-fatals in that there were substantially more frontal impacts with the motor vehicle and substantially fewer side and rear impacts. These results seem to support the fact that many bicycle accidents occur at intersections, alleys, or driveways. Two patterns identified in the earlier report are probably still prevalent: (1) the bicyclist emerges from an alley or intersection area and the motor vehicle driver is unable to avoid the cyclist, or(2) the cyclist emerges and is unable to avoid the automobile and strikes the vehicle in the side or rear.

Table 2.50 shows the motor vehicle point of contact for the motorcycle accidents. The non-fatal distributions differed significantly, the trend being fewer frontal impacts and more side and rear impacts for motorcycles. The passenger car comparisons (Table 2.51) showed significant non-fatal differences due to fewer passenger car frontal impacts and more rear impacts. For the fatal distributions, significantly fewer passenger car frontal impacts occurred, while side impacts were more frequent for passenger cars than those for bicycles.

Table 2.48. Point of contact on the bicycle versus passenger car by injury class.

	Bicycles				Passenger Cars			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Frontal	35	(44.9)	2	(100.0)	101695	(51.3)	329	(57.4)
Left side	20	(25.6)	0	(0.0)	31907	(16.1)	107	(18.7)
Right side	5	(6.4)	0	(0.0)	27112	(13.7)	78	(13.6)
Rear	18	(23.1)	0	(0.0)	33981	(17.1)	7	(1.2)
Other	0	(0.0)	0	(0.0)	3669	(1.8)	52	(9.1)
Total	78		2		198364		573	
(%)	(97.5)		(2.5)		(99.7)		(0.3)	

	Non-fatal	Fatal
χ^2(d.f.)	11.11 (d.f. = 4) ($.025 < p < .05$)	1.48 (d.f. = 4) ($.75 < p < .90$)

Table 2.49. Point of contact on the motor vehicle involved in a bicycle accident by injury class: then versus now.

	Bi NF				Bi F			
	Then		Now		Then		Now	
	N	%	N	%	N	%	N	%
Front	971	(44.5)	1386	(45.0)	56	(57.1)	54	(65.9)
Right front	472	(21.6)	335	(10.9)	27	(27.6)	10	(12.2)
Left front	253	(11.6)	246	(8.0)	12	(12.3)	6	(7.3)
Side or rear	486	(22.3)	1111	(36.1)	3	(3.1)	12	(14.6)
Total	2182		3078		98		82	
(%)	(95.7)		(97.4)		(4.3)		(2.6)	

	χ^2 (d.f.)
$NF_{\text{Then:Now}}$	194.03 (d.f. = 3) ($p < .005$)
$F_{\text{Then:Now}}$	13.94 (d.f. = 3) ($p < .005$)
$NF\text{-}F_{\text{Now}}$	18.12 (d.f. = 3) ($p < .005$)

Table 2.50. Point of contact on the motor vehicle in a bicycle versus motorcycle accident by injury class.

	Bicycles				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Front	1386	(44.3)	54	(65.1)	1004	(21.1)	44	(53.0)
Left front	246	(7.9)	6	(7.2)	355	(7.5)	5	(6.0)
Right front	335	(10.7)	10	(12.0)	296	(6.2)	5	(6.0)
Side	1025	(32.7)	11	(13.3)	2233	(46.9)	23	(27.7)
Rear	86	(2.7)	1	(1.2)	849	(17.8)	5	(6.0)
Other	53	(1.7)	1	(1.2)	26	(0.5)	1	(1.2)
Total	3131		83		4763		83	
(%)	(97.4)		(2.6)		(98.3)		(1.7)	

	Non-fatal	Fatal
χ^2(d.f.)	862.47 (d.f. = 5) ($p < .005$)	9.68 (d.f. = 5) ($.05 < p < .10$)

Table 2.51. Point of contact on the motor vehicle in a bicycle versus passenger car accident by injury class.

	Bicycles				Passenger Cars			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Front	1386	(44.3)	54	(65.1)	62220	(31.4)	246	(42.9)
Left front	246	(7.9)	6	(7.2)	22331	(11.3)	53	(9.2)
Right front	335	(10.7)	10	(12.0)	17144	(8.6)	30	(5.2)
Side	1025	(32.7)	11	(13.3)	59019	(29.8)	185	(32.3)
Rear	86	(2.7)	1	(1.2)	33981	(17.1)	7	(1.2)
Other	53	(1.7)	1	(1.2)	3669	(1.8)	52	(9.1)
Total	3131		83		198364		573	
(%)	(97.4)		(2.6)		(99.7)		(0.3)	

	Non-fatal	Fatal
χ^2(d.f.)	596.163 (d.f. = 5) ($p < .005$)	27.958 (d.f. = 5) ($p < .005$)

Approximate Speed of Bicycle

In only 94 cases were speeds reported for bicycles. Virtually all of these were for the non-fatal accidents. Obviously, bicycle speeds are much lower than those of motorcycles and passenger cars. The frequency distribution (Table 2.52) shows that 46 percent of the non-fatal accidents involved bicycles traveling 1-5 mph, 30 percent at 6-10 mph and 12 percent 11-15 mph (i.e., approximately 90 percent were at speeds less than 15 mph). The non-fatal differences shown in Tables 2.52 and 2.53 are attributable to the higher motorcycle and passenger car speeds. Because of the scarcity of the bicycle speed data, the fatal comparisons are meaningless.

The negative G-index (-1.00) reported for the fatal/non-fatal bicycle accident comparison indicates that the frequency of injury increases at lower bicycle speeds. For motorcycles and passenger cars, there is a moderate association between injury class and speed, with more than half of the fatal accidents occurring above 45 mph.

Approximate Speed of the Motor Vehicle

The approximate speeds of the motor vehicles involved in bicycle collisions are shown in Table 2.54. The old versus new distributions were similar for the fatal accidents. Significant differences for the non-fatal distributions, however, were not well-defined due to the discrepancy between the reported chi-square and rank analysis of variance test results. The chi-square test indicated no difference in the non-fatal distributions, whereas a significant difference was suggested by the Ranova-F value. Almost half of the observations in the recent non-fatal data were between 20 and 39 mph. Surprisingly, about one-fifth of the non-fatal speeds were between 40 and 59 mph.

Table 2.52. Approximate speed of the bicycle versus motorcycle by injury class.

	Bicycles				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
1-5	42	(45.7)	2	(100.0)	305	(3.8)	1	(0.6)
6-10	28	(30.4)	0	(0.0)	436	(5.5)	4	(2.5)
11-15	11	(12.0)	0	(0.0)	398	(5.0)	2	(1.3)
16-20	5	(5.4)	0	(0.0)	678	(8.5)	3	(1.9)
21-25	3	(3.3)	0	(0.0)	639	(8.1)	2	(1.3)
26-30	1	(1.1)	0	(0.0)	887	(11.2)	9	(5.7)
31-35	1	(1.1)	0	(0.0)	1241	(15.6)	12	(7.6)
36-40	1	(1.1)	0	(0.0)	857	(10.8)	14	(8.9)
41-45	0	(0.0)	0	(0.0)	893	(11.3)	21	(13.3)
46-55	0	(0.0)	0	(0.0)	1220	(15.4)	43	(27.2)
56-75	0	(0.0)	0	(0.0)	346	(4.4)	38	(24.1)
76+	0	(0.0)	0	(0.0)	35	(0.4)	9	(5.7)
Total	92		2		7935		158	
(%)	(97.9)		(2.1)		(98.0)		(2.0)	

	Non-fatal	Fatal
χ^2 (d.f.)	535.60 (d.f. = 11) ($p < .005$)	105.99 (d.f. = 11) ($p < .005$)
Ranova-F (d.f.)	201.60 (d.f. = 1, 8024) ($p < .005$)	6.23 (d.f. = 1, 157) ($.01 < p < .025$)
$G \pm s(G)$	--	--

NF:F

	Bicycles	Motorcycles
χ^2 (d.f.)	2.32 (d.f. = 7) ($.90 < p < .95$)	259.25 (d.f. = 11) ($p < .005$)
Ranova-F (d.f.)	2.00 (d.f. = 1, 91) ($.10 < p < .25$)	122.14 (d.f. = 1, 8090) ($p < .005$)
$G \pm s(G)$	-1.00 ± 0.00	0.56 ± 0.04

Table 2.53. Approximate speed of the bicycle versus passenger car by injury class.

	Bicycles				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
1-5	42	(45.7)	2	(100.0)	22960	(13.2)	11	(2.0)
6-10	28	(30.4)	0	(0.0)	19120	(11.0)	15	(2.8)
11-15	11	(12.0)	0	(0.0)	12839	(7.4)	5	(0.9)
16-20	5	(5.4)	0	(0.0)	15694	(9.0)	13	(2.4)
21-25	3	(3.3)	0	(0.0)	13282	(7.6)	6	(1.1)
26-30	1	(1.1)	0	(0.0)	16315	(9.4)	12	(2.2)
31-35	1	(1.1)	0	(0.0)	19698	(11.3)	23	(4.3)
36-40	1	(1.1)	0	(0.0)	11881	(6.8)	25	(4.6)
41-45	0	(0.0)	0	(0.0)	13398	(7.7)	48	(8.9)
46-55	0	(0.0)	0	(0.0)	20986	(12.1)	146	(27.0)
56-75	0	(0.0)	0	(0.0)	6756	(3.9)	124	(22.9)
76+	0	(0.0)	0	(0.0)	1035	(0.6)	113	(20.9)
Total	92		2		173964		541	
(%)	(97.9)		(2.1)		(99.7)		(0.3)	

	Non-fatal	Fatal
χ^2 (d.f.)	153.11 (d.f. = 11) ($p < .005$)	81.84 (d.f. = 11) ($p < .005$)
Ranova-F (d.f.)	117.86 (d.f. = 1, 4053) ($p < .005$)	6.03 (d.f. = 1, 540) ($.01 < p < .025$)
$G \pm s(G)$	--	--

NF:F

	Bicycles	Motorcycles
χ^2 (d.f.)	2.32 (d.f. = 7) ($.90 < p < .95$)	4200.22 (d.f. = 11) ($p < .005$)
Ranova-F (d.f.)	2.00 (d.f. = 1, 91) ($.10 < p < .25$)	752.48 (d.f. = 1, 4502) ($p < .005$)
$G \pm s(G)$	-1.00 ± 0.00	0.73 ± 0.02

Table 2.54. Approximate speed of the motor vehicle involved in a bicycle accident by injury class: then versus now.

	Bi NF				Bi F			
	Then		Now		Then		Now	
	N	%	N	%	N	%	N	%
0-19	589	(30.0)	1064	(33.6)	4	(4.5)	1	(1.3)
20-39	934	(47.6)	1432	(45.3)	22	(25.0)	25	(31.3)
40-59	422	(21.5)	646	(20.4)	56	(63.6)	47	(58.8)
60+	16	(0.8)	22	(0.7)	6	(6.8)	7	(8.8)
Total	1961		3164		88		80	
(%)	(95.7)		(97.5)		(4.3)		(2.5)	

	χ^2 (d.f.)	Ranova-F	G±s(G)
$NF_{Then:Now}$	7.26 (d.f. = 3) (.05 < p <.10)	5.68 (d.f. = 1, 5122) (.01 < p <.025)	--
$F_{Then:Now}$	2.48 (d.f. = 3) (.25 < p <.75)	0.001 (d.f. = 1, 165) (p > .975)	--
$NF\text{-}F_{Now}$	138.62 (d.f. = 3) (p <.005)	92.72 (d.f. = 1, 3241) (p <.005)	.079 ± 0.04

Significant differences were also shown in the recent non-fatal versus fatal comparisons ($p < .005$). Here, the motor vehicle speeds were typically higher for the fatal accidents, with almost 60 percent between 40 and 59 mph and almost 10 percent greater than 60 mph. There is a moderate association between motor vehicle speed and injury class ($G = 0.79$).

In the bicycle/motorcycle comparisons (Table 2.55), both the non-fatal and fatal distributions were significantly different (and substantiated by the Ranova-F value). In both cases, the distribution for the motor vehicles in the bicycle accidents showed higher speeds than the motor vehicles in the motorcycle accidents.

For the passenger car data (Table 2.56), both non-fatal and fatal distributions were significant, primarily due to higher speeds in the passenger car crashes. Over 80 percent of the passenger car fatals occurred at speeds greater than 40 mph.

Associations between motor vehicle speeds and injury are stronger for both bicycles and passenger cars than for motorcycles. In other words, more bicycle and passenger car accidents than motorcycle accidents are related to higher motor vehicle speeds.

Motor Vehicle Defects and Driver Violations

Motor Vehicle Defects

Of concern here is whether there was some defect in the motor vehicle involved in a collision with a bicycle that may have contributed to the crash. The earlier Waller and Reinfurt study indicated that such motor vehicles are highly unlikely to have a defect. The recent data showed no change in this result. When the motor vehicles in bicycle and motorcycle non-fatal collisions

Table 2.55. Approximate speed of the motor vehicle involved in a bicycle versus motorcycle accident by injury class.

	Bicycles				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
0-19	1064	(33.6)	1	(1.3)	3236	(63.1)	35	(41.2)
20-39	1432	(45.3)	25	(31.3)	1262	(24.6)	16	(18.8)
40-59	646	(20.4)	47	(58.8)	594	(11.6)	31	(36.5)
60+	22	(0.7)	7	(8.8)	40	(0.8)	3	(3.5)
Total	3164		80		5132		85	
(%)	(97.5)		(2.5)		(98.4)		(1.6)	

	Non-fatal	Fatal
χ^2 (d.f.)	678.06 (d.f. = 3) (p <.005)	38.85 (d.f. = 3) (p <.005)
Ranova-F (d.f.)	644.06 (d.f. = 1, 8293) (p <.005)	28.05 (d.f. = 1, 162) (p <.005)
$G \pm s(G)$	--	--

NF:F

	Bicycles	Motorcycles
χ^2 (d.f.)	138.62 (d.f. = 3) (p <.005)	58.45 (d.f. = 3) (p <.005)
Ranova-F (d.f.)	92.72 (d.f. = 1, 3241) (p <.005)	29.80 (d.f. = 1, 5214) (p <.005)
$G \pm s(G)$	0.79 ± 0.04	0.45 ± 0.08

Table 2.56. Approximate speed of the motor vehicle involved in a bicycle versus passenger car accident by injury class.

	Bicycles				Passenger Cars			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
0-19	1064	(33.6)	1	(1.3)	77329	(39.4)	37	(6.8)
20-39	1432	(45.3)	25	(31.3)	65052	(33.1)	54	(9.9)
40-59	646	(20.4)	47	(58.8)	46173	(23.5)	219	(40.0)
60+	22	(0.7)	7	(8.8)	7751	(3.9)	237	(43.3)
Total	3164		80		196305		547	
(%)	(97.5)		(2.5)		(99.7)		(0.3)	

	Non-fatal	Fatal
χ^2 (d.f.)	260.92 (d.f. = 3) (p <.005)	56.02 (d.f. = 3) (p <.005)
Ranova-F (d.f.)	0.104 (d.f. = 1, 9466) (.25 < p <.75)	32.68 (d.f. = 1, 624) (p <.005)
G$\pm$s(G)	--	--

NF:F

	Bicycles	Passenger Cars
χ^2 (d.f.)	138.62 (d.f. = 3) (p <.005)	2384.69 (d.f. = 3) (p <.005)
Ranova-F (d.f.)	92.72 (d.f. = 1, 3241) (p <.005)	807.96 (d.f. = 1, 6849) (p <.005)
G$\pm$s(G)	0.79 $\pm$ 0.04	0.80 $\pm$ 0.02

were compared (Table 2.57), statistical differences were indicated, but the overall distributions were fairly similar. Half as many motor vehicles in the bicycle crashes had defects. The same trend was evident in the passenger car comparison (Table 2.58).

Violations and Charges

Earlier data showed that motor vehicle drivers involved with bicycles in non-fatal accidents were less likely to be charged with some violation, implying that in the opinion of the investigating officer the bicyclist was more at fault. The proportion of drivers charged in non-fatal crashes is now somewhat higher than earlier data (Table 2.59), where the difference is statistically significant. The likelihood of a driver being charged was significantly higher in a fatal than a non-fatal crash for recent data. Table 2.60 shows that drivers are much more likely to be charged in motorcycle crashes. Table 2.61 provides similar information for passenger car non-fatals; however, for fatals, the driver in a bicycle crash is much more likely to be charged. Very little data are available concerning whether bicyclists are charged in these crashes.

Tables 2.62 and 2.63 provide information about the types of violations committed by drivers in accidents involving bicycles, motorcycles and passenger cars. The bicycle/motorcycle comparisons showed that significant differences in the non-fatal distributions were due to a variety of factors. Drivers in bicycle crashes tended to be involved in more speeding, improper overtaking, driving under the influence, and other improper driving. Drivers colliding with motorcycles were more involved with failure to yield, sign or signal violations, following too closely, and safe movement violations. The fatal distributions were also significantly different in the same fashion.

Passenger car driver violations (Table 2.63) in non-fatal crashes that occurred more often than driver violations in bicycle accidents included speed-

Table 2.57. Defect of the motor vehicle involved in a collision with a bicycle versus motorcycle by injury class.

	Bicycles				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Some	34	(1.2)	3	(3.9)	125	(2.8)	7	(9.6)
None	2785	(98.8)	73	(96.1)	4390	(97.2)	66	(90.4)
Total	2819		76		4515		73	
(%)	(97.4)		(2.6)		(98.4)		(2.6)	

	Non-fatal	Fatal
χ^2(d.f.)	19.25 (d.f. = 1) ($p <.005$)	1.10 (d.f. = 1) (Fisher's $p = 0.20$)

(with Yates Correction)

Table 2.58. Defect of the motor vehicle involved in a bicycle versus passenger car accident by injury class.

	Bicycles				Passenger Cars			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Some	34	(1.2)	3	(3.9)	8207	(4.6)	41	(10.3)
None	2785	(98.8)	73	(96.1)	168458	(95.4)	356	(89.7)
Total	2819		76		176665		397	
(%)	(97.4)		(2.6)		(99.8)		(0.2)	

	Non-fatal	Fatal
χ^2 (d.f.)	74.15 (d.f. = 1) (p <.005)	2.37 (d.f. = 1) (Fisher's p = 0.09)

(with Yates Correction)

Table 2.59. Driver of the motor vehicle charged with a violation in a bicycle accident by injury class: then versus now.

	Bi NF				Bi F			
	Then		Now		Then		Now	
	N	%	N	%	N	%	N	%
Driver Charged	169	(7.6)	325	(10.1)	24	(24.5)	17	(21.0)
Driver Not Charged	2048	(92.4)	2904	(89.9)	74	(75.5)	64	(79.0)
Total	2217		3229		98		81	
(%)	(95.8)		(97.6)		(4.2)		(2.4)	

χ^2(d.f.) (with Yates Correction)

$NF_{Then:Now}$ 9.21 (d.f. = 1) ($p < .005$)

$F_{Then:Now}$ 0.14 (d.f. = 1) (Fisher's $p = 0.60$)

$NF\text{-}F_{Now}$ 9.03 (d.f. = 1) ($p < .005$)

Table 2.60. Driver of the motor vehicle charged with a violation by injury class in a bicycle versus motorcycle accident.

	Bicycles				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Driver Charged	325	(10.1)	17	(21.0)	2163	(43.0)	35	(41.2)
Driver Not Charged	2904	(89.9)	64	(79.0)	2872	(57.0)	50	(58.8)
Total	3229		81		5035		85	
(%)	(97.6)		(2.4)		(98.3)		(1.7)	

	Non-fatal	Fatal
χ^2(d.f.)	1010.06 (d.f. = 1) ($p < .005$)	6.95 (d.f. = 1) ($.005 < p < .01$)

(with Yates Correction)

Table 2.61. Driver of motor vehicle charged with a violation by injury class in a bicycle versus passenger car accident.

	Bicycles				Passenger Cars			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Driver Charged	325	(10.1)	17	(21.0)	63638	(31.1)	12	(2.1)
Driver Not Charged	2904	(89.9)	64	(79.0)	140691	(68.9)	562	(97.9)
Total	3229		81		204329		574	
(%)	(97.6)		(2.4)		(99.7)		(0.3)	

	Non-fatal	Fatal
χ^2(d.f.)	661.54 (d.f. = 1) (p <.005)	55.52 (d.f. = 1) (Fisher's p = 0.00)

(with Yates Correction)

Table 2.62. Violation of driver of the motor vehicle in a collision with a bicycle versus motorcycle by injury class.

	Bicycles				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Speeding	67	(11.0)	7	(31.8)	117	(3.9)	4	(10.5)
Failed to Yield	115	(18.9)	1	(4.5)	840	(28.0)	15	(39.5)
Driving Wrong Side of Road	23	(3.8)	0	(0.0)	134	(4.5)	4	(10.5)
Improper Overtaking	40	(6.6)	2	(9.1)	62	(2.1)	1	(2.6)
Ran Stop Sign or Light	24	(3.9)	0	(0.0)	155	(5.2)	2	(5.3)
Followed Too Closely	11	(1.8)	0	(0.0)	107	(3.6)	0	(0.0)
Improper Turn	19	(3.1)	0	(0.0)	120	(4.0)	0	(0.0)
DUI	33	(5.4)	7	(31.8)	45	(1.5)	4	(10.5)
Safe Movement	178	(29.2)	0	(0.0)	1279	(42.6)	8	(21.1)
Improper Lights	2	(0.3)	1	(4.5)	4	(0.1)	0	(0.0)
Improper Brakes	2	(0.3)	0	(0.0)	7	(0.2)	0	(0.0)
Other Improper Driving	85	(14.0)	3	(13.6)	57	(1.9)	0	(0.0)
Other Violations	10	(1.6)	1	(4.5)	75	(2.5)	0	(0.0)
Total (%)	609 (96.5)		22 (3.5)		3002 (98.8)		38 (1.3)	

	Non-fatal	Fatal
χ^2(d.f.)	358.81 (d.f. = 12) ($p < .005$)	31.17 (d.f. = 9) ($p < .005$)

Table 2.63. Violation of driver of the motor vehicle in a bicycle versus passenger car accident by injury class.

	Bicycles				Passenger Cars			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Speeding	67	(11.0)	7	(31.8)	17095	(17.5)	249	(59.9)
Failed to Yield	115	(18.9)	1	(4.5)	11939	(12.2)	25	(6.0)
Driving Wrong Side of Road	23	(3.8)	0	(0.0)	7248	(7.4)	82	(19.7)
Improper Overtaking	40	(6.6)	2	(9.1)	2169	(2.2)	4	(1.0)
Ran Stop Sign or Light	24	(3.9)	0	(0.0)	7485	(7.7)	15	(3.6)
Followed Too Closely	11	(1.8)	0	(0.0)	11601	(11.9)	0	(0.0)
Improper Turn	19	(3.1)	0	(0.0)	1405	(1.4)	1	(0.2)
DUI	33	(5.4)	7	(31.8)	3745	(3.8)	4	(1.0)
Safe Movement	178	(29.2)	0	(0.0)	27792	(28.4)	20	(4.8)
Improper Lights	2	(0.3)	1	(4.5)	65	(0.1)	0	(0.0)
Improper Brakes	2	(0.3)	0	(0.0)	852	(0.9)	0	(0.0)
Other Improper Driving	85	(14.0)	3	(13.6)	3781	(3.9)	6	(1.4)
Other Violations	10	(1.6)	1	(4.5)	2558	(2.6)	10	(2.4)
Total	609		22		97735		416	
(%)	(96.5)		(3.5)		(99.6)		(0.4)	

	Non-fatal	Fatal
χ^2(d.f.)	344.22 (d.f. = 12) ($p < .005$)	132.84 (d.f. = 10) ($p < .005$)

ing, driving on the wrong side of the road, sign or signal violations, and following too closely. In fatal crashes, the most important passenger car driver violations appeared to be speeding and driving on the wrong side of the road.

Characteristics of the Motor Vehicle Driver

Sex of Driver

The previous report showed that most accidents involve males; however, a significantly greater proportion of the drivers involved in bicycle accidents were female, for both fatal ($p < .005$) and non-fatal accidents ($p < .001$). This over-representation was explained by the fact that bicycle accidents appeared to occur in the daytime in residential areas where women would be more likely driving. Comparison of the old and new non-fatals (Table 2.64) indicates that the proportion of female drivers involved in bicycle accidents is increasing ($p < .005$). For fatals, the proportion of female drivers has declined, but not significantly ($p = .09$). In recent bicycle crashes, there were proportionately more males involved in fatal accidents than in non-fatals.

No significant differences were found in the bicycle/motorcycle comparisons (Table 2.65). In the bicycle/passenger car comparisons (Table 2.66), the tendency has changed. In both the non-fatal ($p < .005$) and fatal cases ($.025 < p < .05$), female drivers are now more likely to be involved in passenger car accidents than bicycle accidents.

Age of Driver

Significant differences existed between the driver age distributions of earlier and more recent non-fatal bicycle data (Table 2.67). Larger percentages are seen in the under 16 and 16 year-old group, the 18-24 group, and the greater than 55 year-old category. There were no differences for the fatals.

Table 2.64. Sex of motor vehicle driver in a bicycle accident by injury class: then versus now.

	Bi NF				Bi F			
	Then		Now		Then		Now	
	N	%	N	%	N	%	N	%
Male	1586	(72.7)	2138	(66.2)	73	(75.3)	70	(86.4)
Female	597	(27.4)	1090	(33.8)	24	(24.7)	11	(13.6)
Total	2183		3228		97		81	
(%)	(95.7)		(97.6)		(4.3)		(2.4)	

	χ^2 (d.f.) (with Yates Correction)
$NF_{Then:Now}$	24.71 (d.f. = 1) ($p < .005$)
$F_{Then:Now}$	2.81 (d.f. = 1) (Fisher's $p = .09$)
$NF\text{-}F_{Now}$	13.61 (d.f. = 1) ($p < .005$)

Table 2.65. Sex of motor vehicle driver in a bicycle versus motorcycle accident by injury class.

	Bicycles				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Male	2138	(66.2)	70	(86.4)	3350	(65.0)	66	(77.6)
Female	1090	(33.8)	11	(13.6)	1802	(35.0)	19	(22.4)
Total	3228		81		5152		85	
(%)	(97.6)		(2.4)		(98.4)		(1.6)	

	Non-fatal	Fatal
χ^2(d.f.)	1.23 (d.f. = 1) (.25 < p < .75)	1.60 (d.f. = 1) (Fisher's p = 0.16)

(with Yates Correction)

Table 2.66. Sex of motor vehicle driver in a bicycle versus passenger car accident by injury class.

	Bicycles				Passenger Cars			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Male	2138	(66.2)	70	(86.4)	125925	(61.8)	434	(75.6)
Female	1090	(33.8)	11	(13.6)	77872	(38.2)	140	(24.4)
Total	3228		81		203797		574	
(%)	(97.6)		(2.4)		(99.7)		(0.3)	

	Non-fatal	Fatal
χ^2(d.f.)	26.41 (d.f. = 1) ($p < .005$)	4.09 (d.f. = 1) ($.025 < p < .05$)

(with Yates Correction)

Table 2.67. Age of motor vehicle driver in a bicycle accident by injury class: then versus now.

	Bi NF				Bi F			
	Then		Now		Then		Now	
	N	%	N	%	N	%	N	%
Under 16	0	(0.0)	19	(0.6)	0	(0.0)	0	(0.0)
16	47	(2.2)	117	(3.6)	4	(4.1)	1	(1.2)
17	73	(3.4)	115	(3.6)	5	(5.2)	5	(6.2)
18-19	163	(7.5)	251	(7.8)	12	(12.4)	7	(8.6)
20-24	316	(14.5)	561	(17.5)	13	(13.4)	10	(12.3)
25-34	530	(24.3)	775	(24.1)	19	(19.6)	18	(22.2)
35-44	421	(19.3)	492	(15.3)	22	(22.7)	16	(19.8)
45-54	329	(15.1)	411	(12.8)	13	(13.4)	11	(13.6)
55-64	193	(8.9)	291	(9.1)	6	(6.2)	11	(13.6)
65-74	88	(4.0)	141	(4.4)	3	(3.1)	2	(2.5)
75+	19	(0.9)	39	(1.2)	0	(0.0)	0	(0.0)
Total	2179		3212		97		81	
(%)	(95.7)		(97.5)		(4.3)		(2.5)	

	χ^2 (d.f.)
NF $_{\text{Then:Now}}$	48.88 (d.f. = 10) ($p < .005$)
F $_{\text{Then:Now}}$	4.92 (d.f. = 8) ($.75 < p < .90$)
NF-F$_{\text{Now}}$	9.06 (d.f. = 10) ($.25 < p < .75$)

Non-fatal differences were also seen in the motorcycle comparison (Table 2.68). Here, motor vehicle drivers aged 20-44 were more involved in the bicycle accidents. In the passenger car non-fatals (Table 2.69), the younger drivers (16-24 years old) were more often involved ($p < .005$). For the fatals, the driver age group from 25-64 was more often involved in the bicycle accidents ($.01 < p < .025$). One can only hypothesize that the tendency for the older drivers to be more involved in the bicycle accidents is representative of exposure differences in the driving population where bicycle accidents occur.

When recent non-fatal bicycle accidents were compared with fatals (Table 2.67), no differences in age of driver were found; that is, within each age group the proportions of fatal and non-fatal bicycle crashes were similar.

It is instructive to note that the age variable would be more meaningful if it had been controlled for driving experience so that ordering of the variable would be more accurately reflected. Driving experience would then generally increase with age. Since the relationship between age and accidents is not perfectly linear (i.e., accidents increasing or decreasing with age), it should not be considered a ranked variable in this case. The Ranova-F values, therefore, were not reported or used to interpret statistical significance.

Race of Driver

For bicycle, motorcycle and passenger car accidents, approximately three-fourths of the riders or drivers are Caucasian (Tables 2.70 and 2.71). However, for the bicycle/motorcycle non-fatals and bicycle/passenger car non-fatal and fatal comparisons, the "other" racial group drivers are significantly more involved in the bicycle accidents ($p < .005$).

Restrictions of Driver

Drivers in non-fatal bicycle accidents were more likely to have restrictions (e.g., corrective lenses, daylight driving only, 45 mph speed limit, etc.)

Table 2.68. Age of motor vehicle driver in a bicycle versus motorcycle accident by injury class.

	Bicycles				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Under 16	19	(0.6)	0	(0.0)	85	(1.7)	0	(0.0)
16	117	(3.6)	1	(1.2)	220	(4.3)	2	(2.4)
17	115	(3.6)	5	(6.2)	241	(4.7)	3	(3.5)
18-19	251	(7.8)	7	(8.6)	417	(8.1)	13	(15.3)
20-24	561	(17.5)	10	(12.3)	846	(16.5)	13	(15.3)
25-34	775	(24.1)	18	(22.2)	1132	(22.1)	24	(28.2)
35-44	492	(15.3)	16	(19.8)	685	(13.4)	7	(8.2)
45-54	411	(12.8)	11	(13.6)	652	(12.7)	10	(11.8)
55-64	291	(9.1)	11	(13.6)	487	(9.5)	5	(5.9)
65-74	141	(4.4)	2	(2.5)	256	(5.0)	6	(7.1)
75+	39	(1.2)	0	(0.0)	103	(2.0)	2	(2.4)
Total	3212		81		5124		85	
(%)	(97.5)		(2.5)		(98.4)		(1.6)	

	Non-fatal	Fatal
χ^2(d.f.)	45.44 (d.f. = 10) ($p < .005$)	13.61 (d.f. = 9) ($.10 < p < .25$)

Table 2.69. Age of motor vehicle driver in a bicycle versus passenger car accident by injury class.

	Bicycles				Passenger Cars			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Under 16	19	(0.6)	0	(0.0)	543	(0.3)	3	(0.5)
16	117	(3.6)	1	(1.2)	10363	(5.1)	26	(4.5)
17	115	(3.6)	5	(6.2)	10608	(5.2)	22	(3.8)
18-19	251	(7.8)	7	(8.6)	22201	(10.9)	65	(11.4)
20-24	561	(17.5)	10	(12.3)	41774	(20.6)	127	(22.2)
25-34	775	(24.1)	18	(22.2)	47514	(23.4)	116	(20.3)
35-44	492	(15.3)	16	(19.8)	24271	(12.0)	56	(9.8)
45-54	411	(12.8)	11	(13.6)	19662	(9.7)	59	(10.3)
55-64	291	(9.1)	11	(13.6)	14805	(7.3)	47	(8.2)
65-74	141	(4.4)	2	(2.5)	8309	(4.1)	31	(5.4)
75+	39	(1.2)	0	(0.0)	2900	(1.4)	20	(3.5)
Total	3212		81		202950		572	
(%)	(97.5)		(2.5)		(99.7)		(0.3)	

	Non-fatal	Fatal
χ^2(d.f.)	162.19 (d.f. = 10) ($p < .005$)	20.57 (d.f. = 10) ($.01 < p < .025$)

Table 2.70. Race of motor vehicle driver in a bicycle versus motorcycle accident by injury class.

	Bicycles				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Caucasian	2306	(72.2)	50	(61.7)	3995	(78.4)	62	(72.9)
Other	889	(27.8)	31	(38.3)	1103	(21.6)	23	(27.1)
Total	3195		81		5098		85	
(%)	(97.5)		(2.5)		(98.4)		(1.6)	

	Non-fatal	Fatal
χ^2(d.f.)	40.88 (d.f. = 1) ($p < .005$)	1.89 (d.f. = 1) ($.10 < p < .25$)

(with Yates Correction)

Table 2.71. Race of motor vehicle driver in a bicycle versus passenger car accident by injury class.

	Bicycles				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Caucasian	2306	(72.2)	50	(61.7)	150203	(75.0)	432	(76.3)
Other	889	(27.8)	31	(38.3)	49991	(25.0)	134	(23.7)
Total	3195		81		200194		566	
(%)	(97.5)		(2.5)		(99.7)		(0.3)	

	Non-fatal	Fatal
χ^2(d.f.)	13.50 (d.f. = 1) (p <.005)	54.94 (d.f. = 1) (p <.005)
		(with Yates Correction)

than those in motorcycle and passenger car crashes (Tables 2.72 and 2.73). The differences between bicycles and motorcycles, however, are not meaningfully significant ($.025 < p < .05$) as was the case for the fatal bicycle/passenger car distributions ($p = 0.04$).

Sobriety of Driver

Slightly more motor vehicle drivers in non-fatal bicycle accidents were reportedly "not drinking" than their counterparts in non-fatal motorcycle accidents and non-fatal passenger car accidents ($p < .005$) (Tables 2.74 and 2.75). For fatal bicycle accidents, however, there was a larger proportion of drinking drivers (16.5 percent as opposed to 13.4 percent in motorcycle accidents), but this difference was not statistically significant. A comparison of fatal bike accidents with fatal passenger car accidents showed that the passenger car drivers were three times more likely to have been drinking as reported by the investigating officer. The difference in these proportions is significant ($p < .005$).

Physical Condition of Driver

Even though the vast majority of accident-involved drivers are normal, it appears that drivers in recent non-fatal bicycle accidents were slightly more impaired than those reported in the earlier study (Table 2.76). In spite of this shift, drivers in passenger car accidents were still more impaired than those in bicycle crashes (Table 2.78). There were no differences shown in the bicycle/motorcycle comparisons (Table 2.77).

Table 2.72. Restrictions of motor vehicle driver in a bicycle versus motorcycle accident by injury class.

	Bicycles				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
None	3090	(92.0)	79	(94.0)	5013	(93.3)	77	(88.5)
Some	267	(8.0)	5	(6.0)	359	(6.7)	10	(11.5)
Total	3357		84		5372		87	
(%)	(97.6)		(2.4)		(98.4)		(1.6)	

	Non-fatal	Fatal
χ^2(d.f.)	4.82 (d.f. = 1) (.025 < p < .05)	1.02 (d.f. = 1) (Fisher's p = 0.28)

(with Yates Correction)

Table 2.73. Restrictions of motor vehicle driver in a bicycle versus passenger car accident by injury class.

	Bicycles				Passenger Cars			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
None	3090	(92.0)	79	(94.0)	203134	(99.4)	546	(98.1)
Some	267	(8.0)	5	(6.0)	1305	(0.6)	11	(1.9)
Total	3357		84		204439		575	
(%)	(97.6)		(2.4)		(99.7)		(0.3)	

	Non-fatal	Fatal
χ^2(d.f.)	344.3 (d.f. = 1) ($p < .005$)	3.49 (d.f. = 1) (Fisher's $p = 0.04$)

(with Yates Correction)

Table 2.74. Sobriety of motor vehicle driver in a bicycle versus motorcycle accident by injury class.

	Bicycles				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Not drinking	2998	(96.8)	66	(83.5)	4727	(95.4)	71	(86.6)
Drinking	99	(3.2)	13	(16.5)	228	(4.6)	11	(13.4)
Total	3097		79		4955		82	
(%)	(97.5)		(2.5)		(98.4)		(1.6)	

	Non-fatal	Fatal
χ^2(d.f.)	9.30 (d.f. = 1) (p <.005)	0.10 (d.f. = 1) (Fisher's p = 0.66)

(with Yates Correction)

Table 2.75. Sobriety of motor vehicle driver in a bicycle versus passenger car accident by injury class.

	Bicycles				Passenger Cars			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Not drinking	2998	(96.8)	66	(83.5)	177957	(91.1)	139	(57.7)
Drinking	99	(3.2)	13	(16.5)	17299	(8.9)	102	(42.3)
Total	3097		79		195256		241	
(%)	(97.5)		(2.5)		(99.9)		(0.1)	

	Non-fatal	Fatal
χ^2(d.f.)	121.48 (d.f. = 1) ($p < .005$)	16.19 (d.f. = 1) ($p < .005$)
		(with Yates Correction)

Table 2.76. Physical condition of motor vehicle driver in a bicycle accident by injury class: then versus now.

	Bi NF				Bi F			
	Then		Now		Then		Now	
	N	%	N	%	N	%	N	%
Normal	2073	(99.5)	2994	(98.7)	91	(98.9)	70	(95.9)
Impaired	11	(0.5)	40	(1.3)	1	(1.1)	3	(4.1)
Total	2084		3034		92		73	
(%)	(95.8)		(97.7)		(4.2)		(2.3)	

χ^2 (d.f.) (with Yates Correction)

$NF_{Then:Now}$ 7.05 (d.f. = 1) (.005 < p <.01)

$F_{Then:Now}$ 0.55 (d.f. = 1) (.25 < p <.75)

$NF\text{-}F_{Now}$ 2.28 (d.f. = 1) (.10 < p <.25)

Table 2.77. Physical condition of motor vehicle driver in a bicycle versus motorcycle accident by injury class.

	Bicycles				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Normal	2994	(98.7)	70	(95.9)	4756	(98.2)	77	(93.9)
Impaired	40	(1.3)	3	(4.1)	86	(1.8)	5	(6.1)
Total	3034		73		4842		82	
(%)	(97.7)		(2.3)		(98.3)		(1.7)	

	Non-fatal	Fatal
χ^2(d.f.)	2.20 (d.f. = 1) (.10 < p <.25)	0.04 (d.f. = 1) (.75 < p <.90)

(with Yates Correction)

Table 2.78. Physical condition of motor vehicle driver in a bicycle versus passenger car accident by injury class.

	Bicycles				Passenger Cars			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Normal	2994	(98.7)	70	(95.9)	182913	(96.9)	159	(88.8)
Impaired	40	(1.3)	3	(4.1)	5849	(3.1)	20	(11.2)
Total	3034		73		188762		179	
(%)	(97.7)		(2.3)		(99.9)		(0.1)	

	Non-fatal	Fatal
χ^2(d.f.)	31.20 (d.f. = 1) ($p < .005$)	2.33 (d.f. = 1) ($.10 < p < .25$)

(with Yates Correction)

Characteristics of the Bicyclist

Sex

The majority of riders involved in bicycle accidents are male, although almost twice as many females are now involved as were involved in the past in both non-fatal and fatal crashes. Only the old versus new non-fatal distributions differed significantly, however (Table 2.79).

The bicyclist/motorcyclist non-fatal and fatal distributions differed ($p <.005$) due to the overwhelming majority of motorcycle accidents that involved males (Table 2.80). For the bicycle/passenger car comparison (Table 2.81), only the non-fatals differed ($p <.005$). In this case, twice as many females were involved in the passenger car crashes.

Age

Some changes in the age distributions of the bicyclists involved in accidents were noted. In order to make an effective comparison of old and new data, all bicyclists 25 years and older were grouped. An examination of the percentage distributions comparing old data with new showed that more bicyclists were in the older age brackets (both fatal and non-fatal) than was formerly the case. The old versus new non-fatal distributions were significantly different, as well as the recent non-fatal versus fatal comparison (Table 2.82). A significantly higher proportion of fatal bicycle accidents than non-fatals involved riders in the 0 to 9 and 25 and older age groups. The 10 to 14 age group is still dominant, comprising 42.5 percent of all cyclists involved in non-fatal accidents and 33.8 percent of those in fatal accidents.

Bicyclists were significantly younger than motorcyclists (Table 2.83) when both non-fatal ($p <.005$) and fatal ($p <.005$) distributions were compared. For the bicycle non-fatal accidents, over 80 percent were less than 20 years of age, while for the fatal accidents roughly three-fourths were in this group.

Table 2.79. Sex of bicyclist by injury class: then versus now.

	Bi NF				Bi F			
	Then		Now		Then		Now	
	N	%	N	%	N	%	N	%
Male	2083	(89.2)	2614	(80.1)	96	(88.1)	68	(81.9)
Female	253	(10.8)	651	(19.9)	13	(11.9)	15	(18.1)
Total	2336		3265		109		83	
(%)	(95.5)		(97.5)		(4.5)		(2.5)	

χ^2 (with Yates Correction)

$NF_{Then:Now}$ 82.79 (d.f. = 1) (p <.005)

$F_{Then:Now}$ 0.98 (d.f. = 1) (.25 < p <.75)

$NF\text{-}F_{Now}$ 0.08 (d.f. = 1) (Fisher's p = 0.30)

Table 2.80. Sex of bicyclist versus motorcyclist by injury class.

	Bicycles				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Male	2614	(80.1)	68	(81.9)	8214	(97.3)	170	(99.4)
Female	651	(19.9)	15	(18.1)	228	(2.7)	1	(0.6)
Total	3265		83		8442		171	
(%)	(97.5)		(2.5)		(98.0)		(2.0)	

	Non-fatal	Fatal
χ^2(d.f.)	1004.94 (d.f. = 1) ($p < .005$)	26.06 (d.f. = 1) (Fisher's $p = 0.00$)

(with Yates Correction)

Table 2.81. Sex of bicyclist versus passenger car driver by injury class.

	Bicycles				Passenger Cars			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Male	2614	(80.1)	68	(81.9)	125925	(61.8)	434	(75.6)
Female	651	(19.9)	15	(18.1)	77872	(38.2)	140	(24.4)
Total	3265		83		203797		574	
(%)	(97.5)		(2.5)		(99.7)		(0.3)	

	Non-fatal	Fatal
χ^2(d.f.)	454.96 (d.f. = 1) ($p < .005$)	1.27 (d.f. = 1) ($.25 < p < .75$)

(with Yates Correction)

Table 2.82. Age of bicyclist by injury class: then versus now.

	Bi NF				Bi F			
	Then		Now		Then		Now	
	N	%	N	%	N	%	N	%
0-9	697	(29.9)	594	(19.8)	25	(23.2)	21	(26.3)
10-14	1177	(50.5)	1277	(42.5)	52	(48.2)	27	(33.8)
15-19	286	(12.3)	588	(19.6)	17	(15.7)	10	(12.5)
20-24	33	(1.4)	275	(9.2)	3	(2.8)	5	(6.3)
25+	137	(5.9)	271	(9.0)	11	(10.2)	17	(21.3)
Total	2330		3005		108		80	
(%)	(95.6)		(97.4)		(4.4)		(2.6)	

	χ^2 (d.f.)
$NF_{Then:Now}$	269.71 (d.f. = 4) ($p < .005$)
$F_{Then:Now}$	7.86 (d.f. = 4) ($.05 < p < .10$)
$NF\text{-}F_{Now}$	18.27 (d.f. = 4) ($p < .005$)

Table 2.83. Age of bicyclist versus motorcyclist by injury class.

	Bicycles				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
1-9	594	(19.8)	21	(26.3)	12	(0.1)	0	(0.0)
10-14	1277	(42.5)	27	(33.8)	155	(1.8)	8	(4.7)
15-19	588	(19.6)	10	(12.5)	2204	(26.2)	46	(27.2)
20-24	275	(9.2)	5	(6.3)	2773	(33.0)	49	(29.0)
25-34	137	(4.6)	2	(2.5)	2270	(27.0)	37	(21.9)
35-50	60	(2.0)	7	(8.8)	857	(10.2)	25	(14.8)
51+	74	(2.5)	8	(10.0)	129	(1.5)	4	(2.4)
Total	3005		80		8400		169	
(%)	(97.4)		(2.6)		(98.0)		(2.0)	

	Non-fatal	Fatal
χ^2(d.f.)	5753.92 (d.f. = 6) (p <.005)	116.21 (d.f. = 6) (p <.005)

Some 10 percent of the bicycle fatals involved riders older than 50 years of age compared to 2 percent of the motorcycle fatals.

Very similar results were obtained when the cyclist ages were compared with those of passenger car drivers (Table 2.84). A much larger proportion of those over 50 years of age are involved in passenger car accidents.

Race

Examination of the bicycle/motorcycle distributions (Table 2.85) showed significant non-fatal and fatal differences, attributable to larger proportions of non-Caucasions in the bicycle accidents. These differences are most likely due to the cost of the bicycle when compared to the motorcycle. Similar results were noted for the passenger car comparisons (Table 2.86) except fatal differences were insignificant.

Sobriety

Even though sample sizes were small, drinking on the part of the accident-involved bicyclist does not appear to be a problem. The non-fatal distributions differed in the bicycle/motorcycle comparison (Table 2.87) but due to more incidence of drinking by motorcyclists. Fatal sample sizes were so small as to preclude comparisons. Similar findings were present for the bicycle/passenger car comparisons (Table 2.88).

Table 2.84. Age of bicyclist versus passenger car driver by injury class.

	Bicycles				Passenger Cars			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
1-9	594	(19.8)	21	(26.3)	74	(0.0)	1	(0.2)
10-14	1277	(42.5)	27	(33.8)	101	(0.0)	0	(0.0)
15-19	588	(19.6)	10	(12.5)	43540	(21.5)	115	(20.1)
20-24	275	(9.2)	5	(6.3)	41774	(20.6)	127	(22.2)
25-34	137	(4.6)	2	(2.5)	47514	(23.4)	116	(20.3)
35-50	60	(2.0)	7	(8.8)	36232	(17.9)	95	(16.6)
51+	74	(2.5)	8	(10.0)	33715	(16.6)	118	(20.6)
Total	3005		80		202950		572	
(%)	(97.4)		(2.6)		(99.7)		(0.3)	

	Non-fatal	Fatal
χ^2(d.f.)	6711.75 (d.f. = 6) ($p < .005$)	364.55 (d.f. = 6) ($p < .005$)

Table 2.85. Race of bicyclist versus motorcyclist by injury class.

	Bicycles				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Caucasian	1959	(61.7)	59	(72.0)	7136	(85.2)	145	(85.3)
Other	1215	(38.3)	23	(28.0)	1241	(14.8)	25	(14.7)
Total	3174		82		8377		170	
(%)	(97.5)		(2.5)		(98.0)		(2.0)	

	Non-fatal	Fatal
χ^2(d.f.)	755.68 (d.f. = 1) ($p < .005$)	5.55 (d.f. = 1) ($.01 < p < .025$)

(with Yates Correction)

Table 2.86. Race of bicyclist versus passenger car driver by injury class.

	Bicycles				Passenger Cars			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Caucasian	1959	(61.7)	59	(72.0)	150203	(75.0)	432	(76.3)
Other	1215	(38.3)	23	(28.0)	49991	(25.0)	134	(23.7)
Total	3174		82		200194		566	
(%)	(97.5)		(2.5)		(99.7)		(0.3)	

	Non-fatal	Fatal
χ^2(d.f.)	293.04 (d.f. = 1) ($p < .005$)	0.53 (d.f. = 1) ($.25 < p < .75$)

(with Yates Correction)

Table 2.87. Sobriety of bicyclist versus motorcyclist by injury class.

	Bicycles				Motorcycles			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Not drinking	173	(97.2)	2	(66.7)	7125	(90.8)	48	(63.2)
Drinking	5	(2.8)	1	(33.3)	721	(9.2)	28	(36.8)
Total	178		3		7846		76	
(%)	(98.3)		(1.7)		(99.0)		(1.0)	

	Non-fatal	Fatal
χ^2(d.f.)	7.85 (d.f. = 1) (.005 < p <.01) (with Yates Correction)	0.015 (d.f. = 1) (Fisher's p = 1.00)

Table 2.88. Sobriety of bicyclist versus passenger car driver by injury class.

	Bicycles				Passenger Cars			
	NF		F		NF		F	
	N	%	N	%	N	%	N	%
Not drinking	173	(97.2)	2	(66.7)	177957	(91.1)	139	(57.7)
Drinking	5	(2.8)	1	(33.3)	17299	(8.9)	102	(42.3)
Total	178		3		195256		241	
(%)	(98.3)		(1.7)		(99.9)		(0.1)	

	Non-fatal	Fatal
χ^2(d.f.)	7.34 (d.f. = 1) (.005 < p <.01) (with Yates Correction)	0.098 (d.f. = 1) (Fisher's p = 1.00)

CHAPTER 3. BICYCLE NARRATIVE ANALYSIS

In an attempt to search for additional sources of existing bicycle data, an analysis was performed of the 1976 accident narratives taken from the N.C. accident report form for all reported crashes involving bicycles. The objectives of this phase of the study were to detect any accident patterns that might be useful in characterizing the bicycle data, to search for variables that might be incorporated into future supplementary bicycle accident report forms, and to evaluate the narrative as a source of unique accident information that is not found elsewhere on the standard form. As an example, the investigating officer might provide a clue in his description for determining a contributing factor as in the following: "Bicycle was being chased by a dog when he struck vehicle 1." The fact that the dog was a contributing factor in causing the accident is found only in the officer's statement.

Methodology

A computerized narrative search system developed by HSRC was used to locate over 2000 possible bicycle crash descriptions by inserting into a computer program a list of 13 bicycle-related key (search) words as shown below:

Search Word	Number of Narratives Produced
Bell	77
Bicycle	706
Bike	229
Chain	255
Cycle	73
Handle	24
Rise	18
Kick	7
Kickstand	3
Pedal	501
Reflect	84
Straddle	33
Vest	12
	2022

Initially, the narratives were scanned to determine the codability of the information and to eliminate accident cases that did not involve bicyclists. This preliminary examination revealed that 853 (43 percent) of the total number of narratives generated by the computer search were bicycle-related accidents. The accident descriptions that were eliminated included ones in which the search words (e.g., chain, pedal) referred to non-bicycle-related crashes. Shown below are the search words used in the final analysis and related percentages:

Search Word	N	Percent of Total	Percentage of Original Total Used
Bicycle	683	(80.1)	96.7
Bike	151	(17.7)	65.9
Cycle	10	(1.2)	13.7
Handle	4	(0.5)	16.7
Kick or kickstand	5	(0.6)	50.0
Total	853	(100.0)	

The word "bicycle" was by far the most productive, yielding 80 percent of the usable narratives. As reflected by the last column, this word was also the most efficient, with some 97 percent (683/706) of the narratives referring to an accident-involved bicycle.

Previous bicycle studies have reported that bicyclist violation and maneuver variables are often not indicated on the report form, so that pre-crash factors cannot be well determined. For this reason we attempted to include such variables in the narrative analysis. Frequency distributions for the most important variables (maneuver, violation, contributing factor and accident type) are presented in the results section.

Incorporating variables from the N.C. accident report form and other HSRC supplementary bicycle accident report forms, a format was developed so that after each narrative was read, it could be coded for further analysis.

The variables and coding scheme that were used are presented in the appendix. Since only the narrative section of each accident report was available for study, there were problems with interpretation of some variables. For example, determining who was at fault in coding "bicyclist violation" was often difficult due to the brevity of the description. Consider the following:

> "Vehicle 1 was traveling west on RP 1166, struck bicycle and rider traveling in the same direction. Vehicle 1 left scene."

Similarly, the typically short narrative precluded coding of variables such as "bicyclist wearing protective clothing," "lights in use," "riding experience," and "bicycle type." Consequently, there are many "unknowns" in the resulting frequency tables.

In addition, it was difficult to distinguish between bicycles (pedalcycles), motorized bicycles and motor scooters when the search word was simply "bike." In such cases, "bicycle" was assumed. Some of the coded narratives, therefore, may include some non-bicycles.

After an examination of the frequency distributions of the variables, it was decided to combine certain categories, since some were quite small and could logically be grouped together. For example, the variable "bicycle maneuver" includes four "entering roadway" categories that were collapsed since they all describe a similar event, that is, entering traffic from the side of the road (from a driveway, sidewalk, from between parked vehicles, or "all other" cases except at an intersection). After the grouping procedure, crosstabulations were developed and the unknowns eliminated from most variables so that the resulting percentage distributions would be meaningful.

Results

From the reading of the crash descriptions, it was generally found that the typical bicyclist was entering the roadway from the side; and while crossing the street, he failed to yield to oncoming traffic. The angle collision that resulted most often involved a bicycle and a motor vehicle. When contributing factors could be determined, there seemed to be problems with detecting the other vehicle. In other words, both the motor vehicle driver and the bicyclist had difficulty in seeing each other or in interpreting the other's maneuver. Visual obstructions or problems due to parked vehicles, trees and bushes, and sun or glare were also noted. There were also a large number of accidents resulting from a "phantom bicycle," in which a motor vehicle avoided a collision with a bicycle (which subsequently left the scene) and then collided with another motor vehicle or ran off the road.

Bicycle Maneuver

Bicycle maneuver (Table 3.1) could not be determined in a fourth of the accident narratives. When this variable was determined, the bicycles were usually either entering the roadway from the side (driveway, sidewalk, or between parked vehicles) or going straight ahead. Crossing at an intersection and turning into the path of another motor vehicle occurred in about 1 out of 5 accidents.

Bicyclist Violation

As mentioned earlier, determining the violation of the bicyclist from the narrative itself was often difficult. In fact, violation was unknown in 35 percent of all accidents (Table 3.2). When the unknowns were excluded from

Table 3.1. Bicycle maneuver.

	N	%
Going straight	157	24.5
Changing lanes or passing	22	3.4
Making turn	32	5.0
Entering road (from driveway, sidewalk, between parked vehicles, other)	161	25.2
Crossing at intersection	134	20.9
Turned into path of a motor vehicle, same roadway	113	17.7
All others	21	3.3
Total, excluding "unknowns"	640	100.0
Unknown	213	25.0
Total, including "unknowns"	853	

Table 3.2. Bicyclist violation.

	N	%
None	98	17.8
Failed to yield, unsafe crossing	251	45.5
Left of center, improper passing & lane	14	2.5
Passed stop sign, ran traffic light	52	9.4
Improper turn	11	2.0
Riding on wrong side of road (against traffic)	40	7.2
Riding with no headlights	11	2.0
Improper brakes	22	4.0
Other improper equipment	8	1.4
Failed to keep to right side of road	27	4.9
All other violations	18	3.3
Total, excluding "unknowns"	552	100.0
Unknowns	301	35.3
Total, including "unknowns"	853	

the frequency distribution, failure to yield to oncoming traffic accounted for almost half (46 percent) of all accidents. This category also includes "unsafe crossing," which is essentially a "yield" violation. Sign and signal violations were identified in about 10 percent of the cases, and riding facing traffic in about 7 percent of the cases. Table 3.3 presents a crosstabulation of bicyclist maneuver by violation. Most of the bicyclists who failed to yield to traffic were entering the road from the side. Approximately half of the intersection crossing problems involved sign or signal violations. The bicyclist had no violations in only 17 percent of the cases, indicating that he may be a prime contributor to these bicycle/motor vehicle accidents.

Table 3.4 gives some added information concerned with whether there were multiple bicycles present in the accident, and shows that the majority of the bicyclists in a group failed to yield to oncoming traffic. In this situation, there was a "follow-the-leader" effect when one bicyclist generally followed another and, ignoring traffic, turned into the path of an oncoming vehicle. This tendency has been seen in other studies.

Another crosstabulation (not shown) of bicycle crossing traffic by bicycle violation revealed that failing to yield while crossing traffic occurred in a third of all accidents. Although the violation "improper brakes" accounted for only three percent of all bicycle-related accidents, it seemed to occur more often when a bicyclist was crossing in front of or merging with traffic. Half of the riders whose bicycles had brake defects were crossing at an intersection, and over a third of the riders were entering traffic from the side of the road or driveway.

Contributing Factor

The causal elements of any accident are often complex and frequently determined only by an in-depth investigation. The officer's crash description

Table 3.3. Bicycle maneuver by bicyclist violation.
(Row percentages in parentheses)

Bicycle Maneuver	Bicyclist Violation: None	Failed to yield	Left of center, improper passing, improper lane	Ran stop sign, traffic light	Improper turn	Riding wrong side of road	No headlights	Improper brakes	Other improper equipment	Failed to keep to right side of road	All other violations	Row Total
Going straight	68 (61.3)	1 (0.9)	1 (0.9)	2 (1.8)	0 (0.0)	20 (18.0)	6 (5.4)	1 (0.9)	3 (2.7)	2 (1.8)	7 (6.3)	111 (22.6)
Changing lanes, passing	0 (0.0)	7 (43.8)	7 (43.8)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (6.3)	1 (6.3)	0 (0.0)	16 (3.3)
Making turn	0 (0.0)	12 (46.2)	0 (0.0)	1 (3.8)	10 (38.5)	1 (3.8)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (7.7)	26 (5.3)
Entering road	3 (2.1)	130 (89.7)	0 (0.0)	0 (0.0)	0 (0.0)	2 (1.4)	0 (0.0)	6 (4.1)	2 (1.4)	0 (0.0)	2 (1.4)	145 (29.5)
Crossing at intersection	4 (3.8)	41 (39.0)	1 (1.0)	49 (46.7)	0 (0.0)	2 (1.9)	0 (0.0)	8 (7.6)	0 (0.0)	0 (0.0)	0 (0.0)	105 (21.4)
Turned into path of m.v., same road	0 (0.0)	35 (46.7)	3 (4.0)	0 (0.0)	0 (0.0)	9 (12.0)	2 (2.7)	1 (1.3)	1 (1.3)	24 (32.0)	0 (0.0)	75 (15.3)
All other maneuvers	7 (53.8)	3 (23.1)	0 (0.0)	0 (0.0)	0 (0.0)	1 (7.7)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (15.4)	13 (2.6)
Column Total (%)	82 (16.7)	229 (46.6)	12 (2.4)	52 (10.6)	10 (2.0)	35 (7.1)	8 (1.6)	16 (3.3)	7 (1.4)	27 (5.5)	13 (2.6)	491 (100.0)

Table 3.4. Group of bicycles by bicyclist violation. (Row percentages in parentheses)

Group of Bicycles	None	Failed to yield	Left of center, improper passing, improper lane	Ran stop sign, traffic light	Improper turn	Riding wrong side of road	No headlights	Improper brakes	Other improper equipment	Failed to keep to right side of road	All other violations	Row Total
Unknown	96 (18.7)	228 (44.4)	11 (2.1)	51 (9.9)	11 (2.1)	38 (7.4)	11 (2.1)	21 (4.1)	8 (1.6)	21 (4.1)	17 (3.3)	513 (92.9)
Yes	2 (5.1)	23 (59.0)	3 (7.7)	1 (2.6)	0 (0.0)	2 (5.1)	0 (0.0)	1 (2.6)	0 (0.0)	6 (15.4)	1 (2.6)	39 (7.1)
Column Total %	98 (17.8)	251 (45.5)	14 (2.5)	52 (9.4)	11 (2.0)	40 (7.2)	11 (2.0)	22 (4.0)	8 (1.4)	27 (4.9)	18 (3.3)	552 (100.0)

is intuitively a good source to identify contributing factors associated with accidents. Unfortunately, only a third of the narratives for the 1976 bicycle-related crashes included any sort of statement pertaining to these factors.

For analysis purposes, the original 25 categories for this variable were collapsed to 9 by grouping, for example, environmental factors pertaining to detection difficulty (trees, bushes, hill, curve, sun and glare). When the unknowns (64 percent of the total) and the "all other" category were ignored, the factor that was cited most often was "phantom bicycle" (Table 3.5). In this situation, the bicycle was the possible cause of the accident but was not involved in the crash and then left the scene. The phantom bicycle was usually alone, going straight and caused a motor vehicle either to run off the road or to stop suddenly, often resulting in a rear-end collision with another vehicle.

The next highest category, "all others," includes such factors as bicyclist chased by dog, bicyclist lost control of bicycle, or object or debris in road and kickstand fell and struck pavement. Most of these factors are single-bicycle accidents (not involving a motor vehicle) in which the bicycle was simply going straight ahead.

The driver of the motor vehicle did not see the bicycle in 17 percent of the bicycle crashes. When this was a factor, the bicyclist was probably alone and not at fault (no violation), and the accident was usually an angle collision. Whether there was some visibility problem (i.e., bicycle not equipped with reflectors) could not be determined. Visibility problems either due to obstructions or glare accounted for almost a fifth of the contributing factors.

Table 3.5. Contributing factor.

	N	%
None	3	1.0
Vehicle traffic (parked vehicle; traffic; headlights too bright; bus, truck or van)	29	9.8
Environmental factors (trees, bushes, hill, curve, sun, glare)	28	9.4
Bicyclist inexperienced with bike or route or distracted	7	2.4
Mechanical defect	31	10.4
Driver of motor vehicle didn't see bicycle	49	16.5
Bicyclist didn't see motor vehicle	28	9.4
Phantom bicycle	61	20.5
All others	61	20.5
Total, excluding "unknowns"	297	99.9
Unknowns	556	65.2
Total, including "unknowns"	853	

Mechanical defect of the bicycle, including improper brakes, loose chain, no headlights, etc., was a factor in 10 percent of the accidents. The majority of the defects were brake-related (61 percent). These accidents usually occurred while a bicyclist was crossing at an intersection and resulted in angle collisions.

Accident Type

Identifying the type of accident involvement (i.e., rear-end, sideswipe, angle) was not quite as difficult a determination as dealing with some of the other variables, and an accident type was determined in three-fourths of the narratives. The majority (52 percent) of the bicycle accidents resulted in angle collisions, while nearly a fourth were sideswipe crashes (Table 3.6).

When an angle accident occurred, the bicycle was entering the road from the side 43 percent of the time or crossing at an intersection in 40 percent of the crashes. Crosstabulations of accident type by bicyclist violation and accident type by contributing factor are presented in Tables 3.7 and 3.8, respectively. Table 3.7 indicates that almost two-thirds of the angle collisions resulted when the bicyclist failed to yield the right of way. This same type of occurrence also accounted for over one-third (167/458) of all the classifiable events in this table. Along with the failure to yield problem, a fair number of sideswipe accidents occurred when the bicyclist failed to keep to the right side of the road, as would certainly be expected. The detection problem is again apparent in Table 3.8 for the angle, sideswipe, and left turn accidents.

Other Variables

Vehicle involvement - Nearly all of the accidents were collisions between a bicycle and a motor vehicle (86 percent). Four percent involved only

Table 3.6. Accident type.

	N	%
Rear end	32	5.1
Left turn	35	5.6
Right turn	10	1.6
Head-on	5	0.8
Sideswipe	145	23.3
Angle	321	51.5
Single-bicycle	30	4.8
Other	45	7.2
Total, excluding "unknowns"	623	99.9
Unknowns	230	27.0
Total, including "unknowns"	853	

Table 3.7. Accident type by bicyclist violation.
(Row percentages in parentheses)

Accident Type	None	Failed to yield	Left of center, improper passing, improper lane	Ran stop sign, traffic light	Improper turn	Riding wrong side of road	No headlights	Improper brakes	Other improper equipment	Failed to keep to right side of road	All other violations	Row Total
	Bicyclist Violation											
Rear end	10 (55.6)	1 (5.6)	0 (0.0)	0 (0.0)	0 (0.0)	1 (5.6)	0 (0.0)	0 (0.0)	1 (5.6)	1 (5.6)	4 (22.2)	18 (3.9)
Left turn	13 (50.0)	6 (23.1)	0 (0.0)	0 (0.0)	0 (0.0)	1 (3.8)	5 (19.2)	1 (3.8)	0 (0.0)	0 (0.0)	0 (0.0)	26 (5.7)
Right turn	1 (33.3)	0 (0.0)	1 (33.3)	0 (0.0)	0 (0.0)	1 (33.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	3 (0.7)
Head-on	1 (33.3)	0 (0.0)	0 (0.0)	1 (33.3)	0 (0.0)	1 (33.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	3 (0.7)
Sideswipe	20 (19.4)	33 (32.0)	6 (5.8)	0 (0.0)	3 (2.9)	7 (6.8)	3 (2.9)	1 (1.0)	2 (1.9)	23 (22.3)	5 (4.9)	103 (22.5)
Angle	25 (9.1)	167 (60.7)	1 (0.4)	50 (18.2)	2 (0.7)	15 (5.5)	1 (0.4)	12 (4.4)	1 (0.4)	0 (0.0)	1 (0.4)	275 (60.0)
Single-bicycle	3 (37.5)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (12.5)	0 (0.0)	4 (50.0)	8 (1.7)
Other accident types	11 (50.0)	9 (40.9)	0 (0.0)	0 (0.0)	2 (9.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	22 (4.8)
Column Total (%)	84 (18.3)	216 (47.2)	8 (1.7)	51 (11.1)	7 (1.5)	26 (5.7)	9 (2.0)	14 (3.1)	5 (1.1)	24 (5.2)	14 (3.1)	458 (100.0)

Table 3.8. Accident type by contributing factor.
(Row percentages in parentheses)

	Contributing Factor									
Accident Type	None	Vehicle factor	Environmental factor	Bicyclist inexperience, distraction	Mechanical defect	Driver of motor vehicle didn't see bicycle	Bicyclist didn't see motor vehicle	Phantom bicycle	All others	Row Total
Rear end	1 (4.3)	3 (13.0)	2 (8.7)	0 (0.0)	1 (4.3)	0 (0.0)	0 (0.0)	15 (65.2)	1 (4.3)	23 (10.3)
Left turn	0 (0.0)	0 (0.0)	2 (12.5)	1 (6.3)	2 (12.5)	7 (43.8)	1 (6.3)	0 (0.0)	3 (18.8)	16 (7.2)
Right turn	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (50.0)	2 (50.0)	0 (0.0)	0 (0.0)	4 (1.8)
Head-on	0 (0.0)	0 (0.0)	1 (33.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (33.3)	1 (33.3)	3 (1.3)
Sideswipe	0 (0.0)	6 (15.0)	5 (12.5)	1 (2.5)	2 (5.0)	4 (10.0)	5 (12.5)	4 (10.0)	13 (32.5)	40 (17.9)
Angle	2 (2.5)	13 (16.0)	9 (11.1)	3 (3.7)	15 (18.5)	17 (21.0)	10 (12.3)	2 (2.5)	10 (12.3)	81 (36.3)
Single-bicycle	0 (0.0)	0 (0.0)	4 (16.7)	0 (0.0)	1 (4.2)	0 (0.0)	0 (0.0)	0 (0.0)	19 (79.2)	24 (10.8)
Other accident types	0 (0.0)	2 (6.3)	0 (0.0)	0 (0.0)	0 (0.0)	4 (12.5)	1 (3.1)	24 (75.0)	1 (3.1)	32 (14.3)
Column Total (%)	3 (1.3)	24 (10.8)	23 (10.3)	5 (2.2)	21 (9.4)	34 (15.2)	19 (8.5)	46 (20.6)	48 (21.5)	223 (100.0)

bicycles, and seven percent involved only motor vehicles. Vehicle involvement was unknown two percent of the time.

Lights in use - The narrative is a poor source for determining if the bicycle is using its lights. Rarely are there clues in the crash description to distinguish between day and night accidents.

Other bicycle variables that were seldom identified from the narrative include the following with their corresponding percentages of unknowns:

Variable	% Unknown
Group of Bicycles	94
More than 1 Rider	89
Cyclist or Passenger Fell Off	86
Cyclist Wearing Protective Clothing	99
Riding Experience	99
Physiological Problem of Cyclist	99
Relative Size of Bicycle	100
Bicycle Type	99
Purpose of Bicycle Trip	99

Injury - Bicyclist injury is seldom mentioned, only five percent of the time. Degree of injury (laceration, sprain, etc.) is identified in only two percent of the narratives. In most cases when an injury to a bicyclist occurs, however, it is probably indicated in the basic injury section of the standard accident report. Of the 42 accident narratives that mentioned a bicyclist injury, half were probably "B" injuries (minor cuts, bruises, sprains), less than 10 percent were "A," and only 1 fatality was mentioned. About 40 percent of the narratives that mentioned injury were not detailed enough to determine severity. Information pertaining to such variables is important to the understanding of bicycle accidents. However, such information is basically unavailable on the standard N.C. accident report form, whether from the regularly-coded portion or the narrative. Supplemental reporting would be necessary to gain such data.

Summary

In summary, even though the accident narrative is ostensibly a source for identifying unique bicycle data not reported elsewhere on the accident form, the narratives are typically so brief that not a great deal of information is available. Variables such as bicycle maneuver, violation, accident type, experience of the bicyclist, trip purpose, etc. are not covered by the basic report form and are typically not mentioned in the narrative. Thus, reconstruction of the accident based on the description cannot be done with much detail.

On the positive side, the information from the narrative that can be analyzed tends to agree with findings from previous bicycle studies. Since bicycle accidents occur relatively infrequently when compared to motor vehicle crashes, the standard accident report form is not keyed to pick up variables that can be important in bicycle crashes. Thus, investigating officers should be encouraged to be more thorough in their written description of these events.

The current exercise shows that by utilizing the narrative search system, the basic narrative can be analyzed in a fashion that is not so cumbersome as to make the process prohibitive. The limiting factor is primarily the quality of the description.

CHAPTER 4. MERGED SYSTEM ANALYSIS

In 1976, HSRC was contracted by the N.C. Board of Transportation to design an information system which would merge North Carolina accident and roadway characteristics data in a useful fashion. This project, entitled, "Highway Safety Improvements through Utilization of Merged Accident and Roadway Data" (Merged System) was performed through funding provided by the N.C. Governor's Highway Safety Program.

As described in the Merged System project report, data elements from the following sources were selected for initial inclusion:

1. Mileposted accident tape - a tape containing mileposted accident information on all accidents which occur on the N.C. rural primary system (or on a secondary road within 500 feet of its intersection with a primary road).

2. Mileage inventory tape - a tape containing mileposted roadway characteristics data (e.g., ADT, median width, shoulder design, etc.) for the rural primary system.

3. Location inventory tape - a tape containing a mileposted listing of all major roadway junctions and other reference points (e.g., urban boundaries, county lines).

4. Structures inventory file - a file of information on all state-maintained bridges and many other structures such as overhead signs and tunnels.

5. Federal railroad crossing inventory file - a tape with information about railroad crossings (e.g., signalization, number of tracks, and crossing number).

Utilizing these major sources as initial elements, the Merged System was developed and implemented as a direct access disk system and loaded into the N.C. Department of Transportation computer system. The following text describes some analyses of bicycle accidents contained in the system. Because of small yearly sample sizes, all bicycle accidents from 1971 through mid-1976 were aggregated and appropriate tabulations and crosstabulations developed. Variables containing useful information will be discussed. One important caveat should be noted. The tables presented here contain only accident-related information. As such, some factors relating to accidents may be identified, but the all-important exposure data were not available for comparison.

Road Type

Table 4.1 shows the distribution of bicycle accidents on the rural primary system by road type and accident severity. The vast majority of all fatal and non-fatal injuries occurred on U.S. and N.C. routes. Using the same statistics presented in Chapter 2, significant differences were noted between the fatal and non-fatal distributions ($.025 < p < .05$). Proportionately more of the fatals occurred on U.S. routes while proportionately more of the non-fatals occurred on the other routes (Interstate, N.C., secondary roads).

Table 4.2 presents the crosstabulation of the road type with the functional classification of the route. The N.C. route rural major collectors and U.S. route rural principal arterials accounted for the largest frequencies. Examining the row percentage values in these cells versus those in the total row indicated that there were more observed accidents than expected.

Road type and speed limit interactions are examined in Table 4.3. The data indicate that a large number of bicycle accidents occurred on U.S. and N.C. routes with speed limits of 55 or 60 miles per hour. This is not surprising, given that the data source is the rural primary system.

Some interesting pavement condition results are shown in Table 4.4 (although differences were non-signficant), in that bicycle accidents occurred on routes with fair or poor pavement conditions about one-third of the time. One can only speculate as to whether the pavement conditions contributed to the accidents. The results may simply be indicative of exposure differences, whereby a bicyclist might choose a route with marginal pavement conditions and a concomitant lesser amount of vehicular traffic.

Table 4.1 Road type by accident severity.

Road Type	Accident Severity: Fatal N (%)	Accident Severity: Non-Fatal N (%)
Interstate	0 (0.0)[1]	3 (100.0)
U.S.	45 (10.9)	369 (89.1)
N.C.	33 (7.2)	423 (92.8)
Secondary Road	0 (0.0)	47 (100.0)
Total	78 (8.5)	842 (91.5)

$\chi^2 = 8.59$ (d.f. = 3) $(.025 < p < .05)$

[1]Row percentage

Table 4.2. Road type by functional classification.

Road Type	Interstate	Rural Principal Arterial (or urban link of same)	Rural Minor Arterial (or urban link of same)	Other Urban Principal Arterial	Rural Major Collector or Urban Minor Arterial	Traveled Ways	Total
	Functional Classification						
Interstate	2 (66.7)[1]	0 (0.0)	0 (0.0)	0 (0.0)	1 (33.3)	0 (0.0)	3 (0.3)[2]
U.S.	0 (0.0)	145 (36.3)	98 (24.5)	45 (11.3)	98 (24.5)	14 (3.5)	400 (43.0)
N.C.	3 (0.6)	26 (5.5)	25 (5.3)	33 (6.9)	388 (81.5)	1 (0.2)	476 (51.2)
Secondary Road	4 (7.8)	10 (19.6)	6 (11.8)	10 (19.6)	19 (37.3)	2 (3.9)	51 (5.5)
Total	9 (1.0)	181 (19.5)	129 (13.9)	88 (9.5)	506 (54.4)	17 (1.8)	930 (100.0)

$\chi^2 = 485.9$ (d.f. = 15) ($p < .005$)

[1]Row percentage

[2]Column percentage

Table 4.3. Road type by speed limit.

Road Type	Speed Limit (mph) 20	35	45	50	55	60	>60	Total
Interstate	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (33.3)	0 (0.0)	2 (66.7)	3 (0.3)
U.S.	5 (1.3)	38 (9.5)	56 (14.0)	3 (0.8)	121 (30.3)	174 (43.5)	3 (0.8)	400 (43.0)
N.C.	4 (0.8)	29 (6.1)	45 (9.5)	1 (0.2)	275 (57.8)	119 (25.0)	3 (0.6)	476 (51.2)
Secondary Road	0 (0.0)	9 (17.6)	5 (9.8)	1 (2.0)	21 (41.2)	11 (21.6)	4 (7.8)	51 (5.5)
Total	9 (1.0)	76 (8.2)	106 (11.4)	5 (0.5)	418 (44.9)	304 (32.7)	12 (1.3)	930 (100.0)

$\chi^2 = 199.4$ (d.f. = 18) ($p < .005$)

Table 4.4. Road type by pavement condition.

Road Type	Pavement Condition Excellent	Good	Fair	Poor	Total
Interstate	0 (0.0)	0 (0.0)	1 (100.0)	0 (0.0)	1 (0.3)
U.S.	15 (13.2)	59 (51.8)	39 (34.2)	1 (0.9)	114 (34.3)
N.C.	33 (16.3)	94 (46.5)	60 (29.7)	15 (7.4)	202 (60.8)
Secondary Road	1 (6.7)	9 (60.0)	5 (33.3)	0 (0.0)	15 (4.5)
Total	49 (14.8)	162 (48.8)	105 (31.6)	16 (4.8)	332 (100.0)

$\chi^2 = 11.9$ (d.f. = 9) ($.10 < p < .25$)

Access control and development factors as a function of road type are shown in Table 4.5 and again reflect the characteristics of the data source (i.e., accidents on the rural primary system). Although roughly one-half of the accidents occurred in rural areas with some roadside development, another one-fifth occurred in rural areas with no development. Some injury differences were seen in the development variable and will be discussed later in this chapter.

Traffic mix (as related to truck percentage) was investigated in Table 4.6, and there were significant differences. For these accident involvements, bicyclists were traveling on routes with relatively high percentages of truck traffic. Truck percentage versus injury severity will be discussed later in the text.

The final comparison with road type in this section concerned average daily traffic (no table presented). Significant differences were shown, and the accidents were widely distributed, although the majority occurred on routes with less than 4000 vehicles per day.

Functional Classification

The majority of the bicycle accidents occurred on rural major collectors or urban minor arterials (Table 4.7). However, there were no significant differences in the fatal non-fatal distributions. Rural principal and minor arterials also accounted for a good portion of the non-fatals, although the row percentages for these cells were about what was expected, based on the marginals.

Table 4.8 is the crosstabulation of the functional classification with pavement condition. Accidents involving fair or poor pavement tended to occur on either rural major collectors/urban minor arterials or the traveled ways of various routes. The differences were very close to being significant ($p = .055$).

Table 4.5. Road type by access control and development factors.

Road Type	Access Control and Development Factors						
	No Control	Moderate Commercial Development	Heavy Residential	Rural With Some Roadside Development	Rural With No Development	Other	Total
Interstate	0 (0.0)	0 (0.0)	1 (33.3)	0 (0.0)	0 (0.0)	2 (66.7)	3 (0.3)
U.S.	33 (8.3)	38 (9.5)	81 (20.3)	157 (39.3)	66 (16.5)	25 (6.3)	400 (43.0)
N.C.	20 (4.2)	23 (4.8)	70 (14.7)	238 (50.0)	114 (23.9)	11 (2.3)	476 (51.2)
Secondary Road	3 (5.9)	6 (11.8)	12 (23.5)	18 (35.3)	4 (7.8)	8 (15.7)	51 (5.5)
Total	56 (6.0)	67 (7.2)	164 (17.6)	413 (44.4)	184 (19.8)	46 (4.9)	930 (100.0)

$\chi^2 = 81.4$ (d.f. = 15) ($p < .005$)

Table 4.6. Road type by percent trucks.

Road Type	Percent Trucks 0-4.99%	5-9.99%	>10%	Total
Interstate	0 (0.0)	0 (0.0)	1 (100.0)	1 (0.1)
U.S.	13 (3.7)	104 (29.2)	239 (67.1)	356 (41.7)
N.C.	116 (25.4)	257 (56.2)	84 (18.4)	457 (53.5)
Secondary Road	5 (12.5)	18 (45.0)	17 (42.5)	40 (4.7)
Total	134 (15.7)	379 (44.4)	341 (39.9)	854 (100.0)

$\chi^2 = 214.1$ (d.f. = 6) ($p < .005$)

Table 4.7. Functional classification by accident severity.

Functional Classification	Accident Severity: Fatal	Accident Severity: Non-fatal
Interstate	0 (0.0)	9 (100.0)
Rural Principal Arterial (or urban link of same)	12 (7.1)	157 (92.9)
Rural Minor Arterial (or urban link of same)	13 (11.1)	104 (88.9)
Other Urban Principal Arterial	6 (7.3)	76 (92.7)
Rural Major Collector or Urban Minor Arterial	41 (8.7)	432 (91.3)
Traveled Ways	2 (11.8)	15 (88.2)
Total	74 (8.5)	793 (91.5)

$\chi^2 = 2.67$ (d.f. = 5) ($.75 < p < .90$)

Table 4.8. Functional classification by pavement condition.

Functional Classification	Pavement Condition Excellent	Good	Fair	Poor	Total
Rural Minor Arterial (or urban link of same)	9 (20.0)	26 (57.8)	9 (20.0)	1 (2.2)	45 (13.6)
Other Urban Principal Arterial	8 (17.8)	29 (64.4)	8 (17.8)	0 (0.0)	45 (13.6)
Rural Major Collector or Urban Minor Arterial	3 (9.1)	17 (51.5)	11 (33.3)	2 (6.1)	33 (9.9)
Traveled Ways	29 (13.9)	90 (43.1)	77 (36.8)	13 (6.2)	209 (63.0)
Total	49 (14.8)	162 (48.8)	105 (31.6)	16 (4.8)	332 (100.0)

$\chi^2 = 16.64$ (d.f. = 9) ($.05 < p < .10$)

A few other comments can be made concerning functional classification and its interaction with other variables. As noted in Tables 4.7 and 4.8, the accident frequency was largest on rural major collectors or urban minor arterials, and this trend carried through for other variables. For example, about one-half of the accidents occurred on these facilities with speed limits of 55 and 60 miles per hour. Similarly, accidents in rural areas with some roadside development and with no development were frequent. These rural areas accounted for three-fourths of all bicycle accidents occurring on these types of roads. The accidents with high percentages of truck traffic were likewise on these routes.

Speed Limit

As one might suspect, when examining bicycle accidents occurring on the rural primary system, the large majority (about 75 percent) occurred on routes with speed limits of 55 and 60 miles per hour. This can be seen in Table 4.9, which examines the accident severity by speed limit. Differences in the fatal and non-fatal distributions were not significant, although the RANOVA-F approaches significance.[1] The fatal accidents were associated with routes having higher speed limits. Proportionately more non-fatals occurred on routes with speed limits of 35 mph, 45 mph, and greater than 60 mph.

Table 4.10 is the speed limit by percent of trucks crosstabulation, and again, the 55 and 60 mile per hour speed limits predominated. It is interesting to note that many bicycle accidents occurred on these same high-speed routes

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[1]The table is presented in this fashion to show the more complete distribution of speed limits. For purposes of computing the statistics, the table could be collapsed by grouping certain values. This, in fact, was done for this table, but the resulting statistics and p-values were very close in magnitude to those for Table 4.9.

Table 4.9. Speed limit by accident severity.

Speed limit (mph)	Accident Severity: Fatal	Non-fatal
20	1 (11.1)	8 (88.9)
35	2 (2.9)	68 (97.1)
45	4 (4.1)	94 (95.9)
50	0 (0.0)	3 (100.0)
55	38 (9.7)	352 (90.3)
60	29 (10.2)	256 (89.8)
>60	0 (0.0)	12 (100.0)
Total	74 (8.5)	793 (91.5)

χ^2 = 8.57 (d.f. = 6) (.10 < p <.25)

Ranova-F = 3.20 (d.f. = 1,864) (.05 < p <.10)

$G \pm s(G) = -0.18 \pm 0.09$

Table 4.10. Speed limit by percent of trucks.

Speed limit (mph)	Percent of Trucks 0-4.99%	5-9.99%	>10%	Total
35	6 (18.8)	19 (39.6)	20 (41.7)	48 (5.6)
45	7 (8.0)	36 (40.9)	45 (51.1)	88 (10.3)
50	0 (0.0)	1 (33.3)	2 (66.7)	3 (0.4)
55	106 (25.8)	194 (47.2)	111 (27.0)	411 (48.1)
60	12 (4.0)	128 (42.5)	161 (53.5)	301 (35.2)
>60	0 (0.0)	1 (33.3)	2 (66.7)	3 (0.4)
Total	134 (15.7)	379 (44.4)	341 (39.9)	854 (100.0)

χ^2 =94.13 (d.f. = 10) ($p < .005$)

Ranova-F = 14.06 (d.f. = 2,850) ($p < .005$)

$G \pm s(G) = 0.24 \pm 0.05$

where the percentage of trucks exceeded 5 percent (almost 70 percent of all crashes). One would expect such routes to be unappealing to bicyclists.

The trend of higher frequencies of accidents on the 55 and 60 miles per hour routes was prevalent throughout. Pavement condition was excellent or good for the majority of the accidents on the 60 mph routes but fair or poor for about half the accidents on the 55 mph routes. In terms of access control and development factors, the rural with some roadside development and rural with no development groups predominated for these speed limits. Where ADP was concerned, most accidents on these higher speed routes occurred where there were less than 5000 vehicles per day.

Access Control and Development Factors

The access control and development factors variable has, for bicycle accidents, only a small amount of data concerned with access control and most of the data concerned with the development factors. Distributing this variable by injury (Table 4.11) showed only marginally significant differences ($.05 < p < .10$). Again, the fatal accidents tended to occur most often in the rural areas with no development.

Access control and development factors were crosstabulated with percent of trucks in Table 4.12. The accidents were again concentrated in the rural areas. Based on the cell calculations, there were more accidents than expected in the rural areas with some or no development and 5-10 percent trucks.

Percentage of Trucks

Accident severity by percentage of truck traffic on rural primary roads is presented in Table 4.13. The differences were not significant, although

Table 4.11. Access control and development factors by accident severity.

Access Control and Development Factors	Accident Severity Fatal	Non-fatal
No Access Control	2 (3.7)	52 (96.3)
Moderate Commercial	3 (7.1)	56 (92.9)
Heavy Residential	16 (10.1)	142 (89.9)
Rural with Some Roadside Development	26 (6.8)	354 (93.2)
Rural with No Roadside Development	24 (13.8)	150 (86.2)
Other	3 (7.1)	39 (92.9)
Total	74 (8.5)	793 (91.5)

$\chi^2 = 10.69$ (d.f. = 5) ($.05 < p < .10$)

Table 4.12. Access control and development factors by percentage of trucks.

Access Control and Development Factors	Percent Trucks 0-4.99%	5-9.99%	>10%	Total
No Access Control	5 (11.6)	13 (30.2)	25 (58.1)	43 (5.0)
Moderate Commercial	0 (0.0)	22 (40.0)	33 (60.0)	55 (6.4)
Heavy Residential	24 (15.4)	67 (42.9)	65 (41.7)	156 (18.3)
Rural with Some Roadside Development	73 (18.1)	182 (45.0)	149 (36.9)	404 (47.3)
Rural with No Roadside Development	30 (17.8)	87 (51.5)	52 (30.8)	169 (19.8)
Other	2 (7.4)	8 (29.6)	17 (63.0)	27 (3.2)
Total	134 (15.7)	379 (44.4)	341 (39.9)	854 (100.0)

$\chi^2 = 35.03$ (d.f. = 10) ($p < .005$)

Table 4.13. Percentage of trucks by accident severity.

Percent Trucks	Accident Severity	
	Fatal	Non-fatal
0-4.99%	14 (10.9)	114 (89.1)
5-9.99%	27 (7.7)	325 (92.3)
>10%	30 (9.5)	286 (90.5)
Total	71 (8.9)	725 (91.1)

$\chi^2 = 1.45$ (d.f. = 2) ($.25 < p < .75$)

Ranova-F = 0.00 (d.f. = 1,793) ($p = 1.0$)

$G \pm s$ (G) = 0.0009 ± 0.1097

there were slightly more fatal bicycle accidents than expected when the truck percentage exceeded 10 percent. However, this was also true for truck percentages less than 5 percent, making interpretation difficult.

Average Daily Traffic

Accident severity by average daily traffic is examined in Table 4.14, and based on the RANOVA-F, there were significant differences. There was a slight tendency for more fatal accidents than expected at low traffic volumes (up to 5,000 vehicles per day). The opposite was true for the non-fatals.

On examining the ADT by percentage of trucks crosstabulation (Table 4.15), the lower volumes were again important in the sense that more bicycle accidents than expected occurred for volumes less than 6,000 vehicles per day with 5-10 percent trucks. The opposite effect occurred for those accidents where truck percentage exceeded 10 percent.

Summary

Utilizing the Merged System to analyze bicycle accidents occurring on the North Carolina rural primary system proved to be an interesting exercise. However, while some insights can be gained from examining this data source, the merged system is not a strong data base to use when concerned with bicycle accidents. Overall, the number of accidents per year on the system is small, especially the fatal accidents.

The data do reflect the characteristics of the rural primary system, in that accident frequencies are higher in the rural areas on routes with 55 or 60 miles per hour speed limits. Interestingly, where data were available, about one-third of the accidents occurred on routes with either fair or poor pavement conditions. Many accidents also occurred on routes with fairly high percentages

Table 4.14. Average daily traffic by accident severity.

Average Daily Traffic (vehicles per day)	Accident Severity	
	Fatal	Non-fatal
< 1000	9 (14.3)	54 (85.7)
1000-1999	18 (11.1)	144 (88.9)
2000-2999	8 (6.1)	124 (93.9)
3000-3999	12 (10.7)	100 (89.3)
4000-4999	8 (9.3)	78 (90.7)
5000-5999	3 (5.2)	55 (94.8)
6000-6999	3 (7.7)	36 (92.3)
7000-7999	1 (2.8)	35 (97.2)
> 8000	12 (6.7)	167 (93.3)
Total	74 (8.5)	793 (91.5)

$\chi^2 = 9.00$ (d.f. = 8) ($.25 < p < .75$)

Ranova-F = 4.22 (d.f. = 1,864) ($.025 < p < .05$)

$G \pm s$ (G) = 0.17 ± 0.08

Table 4.15. Average daily traffic by percentage of trucks.

Average Daily Traffic (vehicles per day)	Percentage of Trucks 0-4.99%	5-9.99%	>10%	Total
< 1000	25 (39.1)	33 (51.6)	6 (9.4)	64 (7.5)
1000-1999	45 (26.3)	94 (55.0)	32 (18.7)	171 (20.0)
2000-2999	26 (19.0)	64 (46.7)	47 (34.3)	137 (16.0)
3000-3999	16 (13.7)	55 (47.0)	46 (39.3)	117 (13.7)
4000-4999	4 (4.4)	41 (45.6)	45 (50.0)	90 (10.5)
5000-5999	2 (3.8)	26 (50.0)	24 (46.2)	52 (6.1)
6000-6999	2 (4.8)	13 (31.0)	27 (64.3)	42 (4.9)
7000-7999	2 (5.6)	12 (33.3)	22 (61.1)	36 (4.2)
> 8000	12 (8.3)	41 (28.3)	92 (63.4)	145 (17.0)
Total	134 (15.7)	379 (44.4)	341 (39.9)	854 (100.0)

χ^2 =143.85 (d.f. = 16) (p <.005)

Ranova-F = 74.49 (d.f. = 2,850) (p <.005)

G$\pm$s (G) = 0.44 $\pm$ 0.03

of trucks. In terms of comparing the fatal and non-fatal distributions, there were significant differences for the variables of road type and average daily traffic. For road type, proportionately more of the fatals occurred on the U.S. routes, while proportionately more of the non-fatals occurred on other than U.S. routes. For ADT, there was a tendency for more fatals than expected up to 5,000 vehicles per day, while the opposite was true for the non-fatals.

In summary, the vast majority of bicycle accidents occur in urban areas, which limits the utility of the Merged System. The Merged System does allow examination of variables like average daily traffic, functional highway classification, percentage of trucks, etc., which are not contained on the standard accident report forms. Overall, however, the results of this analysis do not differ substantially from the ones in Chapter 2 (using standard accident form data) that pertain to rural highway accidents.

CHAPTER 5. DISCUSSION AND RECOMMENDATIONS

This project involved analysis of recent (primarily 1974-1976) North Carolina bicycle accident data. Several different data sources were utilized, including: (1) the data from the standard accident report form, which was used to update a 1969 bicycle study by HSRC, (2) the narrative descriptions of investigating officers for 1976 N.C. bicycle accidents, and (3) the Merged System developed for the N.C. Board of Transportation by HSRC, which combined accident and roadway characteristics data from 1971 through mid-1976. Even though the results from all data sources were in basic agreement, a brief discussion of the results from each would be pertinent.

Basic Accident Report Form Data

A large part of the effort in this contract was concerned with updating a 1969 HSRC study performed by Waller and Reinfurt. A variety of variables, distributed by injury severity (fatal or non-fatal), were examined. The recent bicycle data (1974-1976) were compared with: (1) the older bicycle data (1965-1968), (2) recent motorcycle data (1974-1976), and (3) recent passenger car data (1976 only). Concerning all these data comparisons, the following comments apply:

Features of the Accident Situation

1. The recent data show more weekday bicycle accidents than in the past. Proportionately more motorcycle and passenger car accidents occur on weekends.
2. Slightly more non-fatal bicycle accidents now occur at night.
3. More bicycle non-fatals now occur in business areas and fewer in residential areas. Bicycle fatals now occur more often in residential localities and less often in open country. More motorcycle and passenger car accidents occur in open country.

4. The recent bicycle data show twice as many fatals on city streets and proportionately fewer on rural roads. More bicycle accidents occur on city streets than either motorcycle or passenger car accidents.

5. About 60 percent of the bicycle non-fatals still occur at intersections (including driveways and alleys). Over 40 percent of the current fatalities occur at these same locations.

6. Slightly more bicycle accidents now occur in unfavorable weather.

7. About one-fifth of the fatals occur in darkness with no street lights.

8. Bicycle accidents are associated, in general, with lower speed limits than either motorcycle or passenger car accidents. Fatal bicycle accidents are associated with higher speed limits than non-fatals.

9. Most of the non-fatal and fatal bicycle accidents occur in cities with populations in excess of 25,000. Fatal motorcycle and passenger car accidents are more associated with rural areas.

Characteristics of the Accident

1. There is much missing data concerning the maneuvers of accident-involved bicyclists and the resulting points of contact. From the sparse amount of point of contact information that exists, bicycles tend to be struck on the front, left side and rear. These points correspond with the intersection and alley crashes that typically occur.

2. Similarly, there is little data concerned with the speed of the bicycle involved in an accident. Data that exists suggest that over 90 percent of all accident-involved bicycles are traveling less than 15 miles per hour. Motorcycle and passenger car accidents tend to be associated with a much wider range of speeds.

3. Fatal bicycle accidents are clearly associated with higher motor vehicle speeds.

Vehicle Defects and Driver Violations

1. Motor vehicles involved in a bicycle collision are highly unlikely to have a defect.

2. In non-fatal bicycle accidents, the motor vehicle driver is more likely to be charged with a violation than in the past. Nonetheless, drivers are now charged in such accidents only 10 percent of the time. Drivers are much more likely to be charged in motorcycle accidents.

3. Typical violations of drivers of motor vehicles in non-fatal bicycle accidents are speeding, failure to yield and safe movement violations. Little data exist for fatal accidents. Practically no data exist concerning bicycle violations.

Characteristics of the Driver

1. More female motor vehicle drivers are now involved in bicycle non-fatal collisions. Substantially fewer female drivers are involved in fatal bicycle collisions.

2. More drivers aged 55 or greater are now involved in both non-fatal and fatal crashes. Such differences are likely related to exposure.

3. Non-Caucasian drivers are more involved in bicycle accidents than in either motorcycle or passenger car accidents.

4. Drivers in bicycle non-fatals are more likely to have restrictions than those in motorcycle or passenger car crashes.

5. Very few drivers in bicycle non-fatal accidents have been drinking. The proportion is five times greater in bicycle fatals.

Characteristics of the Bicyclist

1. Most accident-involved bicyclists are male (about 80 percent). However, almost twice as many females are now involved in both non-fatal and fatal accidents. Almost all accident-involved motorcyclists are male.

2. Bicyclists in non-fatal collisions are older than in the past, but over 90 percent are less than age 25. The 10-14 age group still dominates. The same trend is true for fatal bicycle collisions. About 20 percent of the bicyclists in fatal collisions are greater than age 25. Accident-involved motorcyclists are older than bicyclists.

Narrative Description Analysis

The HSRC Narrative Search System was used to extract narratives written by investigating officers concerning bicycle accidents from 1976 data. Search words were used to extract the descriptions, and from a preliminary total of over 2,000 narratives, 853 were found to be related to bicycle accidents. These narratives were then read, coded, and keypunched and stored for analysis.

For the analysis, variables were created for items not routinely found on the standard accident form, such as type of bicycle, riding experience, use of special clothing and equipment, etc. However, the narratives were typically so brief that many variable items could not be coded at all. Some of the more useful findings are as follows:

1. Crossing at intersections and entering from driveways, alleys, etc. were found to be frequent bicyclist maneuvers.
2. Frequent bicyclist "violations" included failure to yield, traffic sign and signal neglect, and riding against traffic.
3. In terms of contributing factors, there were many instances of "phantom bicycle" involvement (i.e., the bicycle was the possible cause of the accident but was not directly involved and left the scene). Also important was the inability of the motorist to see the bicyclist. Mechanical bicycle defects and visibility obstructions were noted to a lesser extent.
4. Angle collisions accounted for about one-half of the accident types and sideswipes another one-fourth.

Merged System Analysis

The final data source analyzed was the Merged System, a system created by HSRC for the N.C. Board of Transportation which combines accident and roadway characteristics data. The file contains accidents from 1971 through mid-1976 occurring on the N.C. rural primary system. It was hoped that this file might yield results about geometric variables not contained on the basic accident form.

Results from this analysis basically reflect the characteristics of the rural primary system. In other words, many bicycle accidents were found to occur in rural areas with partial or no development and on routes with 55 mile per hour speed limits. Given that accidents occur in such locations, some other interesting findings emerged:

1. The majority of the accidents occurred on rural major collectors or urban minor arterials.

2. Bicycle accidents occurred on routes with fair or poor pavement about one-third of the time.

3. Percentages of truck traffic exceeded five percent in over three-fourths of the cases and exceeded 10 percent in over one-third of the cases.

4. More fatal accidents than expected occurred at traffic volumes of less than 5000 vehicles per day while the opposite trend was true for non-fatals.

Summary of Data Analyses

The findings from these data analyses are not new or startling. The patterns that are identified in the North Carolina data are similar to those in other studies. In general, many bicycle accidents occur because of the difficulty in seeing the bicyclist. Intersections, driveways, and alleys are prominent locations. Bicycle speeds are typically less than 15 miles per hour and frequent bicycle contact points are the front and left sides of the bike. Motor vehicle speed is definitely an important factor and is directly proportional to the injury severity outcome. Bicyclists aged 10-14 constitute the group with the highest accident frequency, but there are more riders greater than age 25 now than in the past. More females are now involved in bicycle accidents (twice as many as in 1965-1968), but males constitute about 80 percent of the group.

These comments about the accident factors, especially the old versus new differences, easily fit the hypothesis of a higher proportion of young and middle-aged bicyclists using the vehicle as a means of commuting to work or other types of trips. Exposure data would be needed to test the hypothesis, but such a pattern tends to fit the accident data.

On the whole, bicycle accidents are not very severe. For the three years of data examined here, over 97 percent of the accidents were non-fatal. There are also fewer "A" injuries than indicated in the older data, along with a higher proportion of "C" injuries and PDO's. Part of the injury distribution shift is due to a change in the definitions of the classes of injuries. Nevertheless, minor injury is the rule in most bicycle accidents.

The analysis of these data files indicates another problem that has been mentioned many times in the past. Police data leaves something to be desired when one is attempting to determine the causes of bicycle accidents and develop suitable countermeasures. In the first place, the standard accident report form is designed to collect information about crashes between motor vehicles. As such, the information items are not as well-suited to bicycle accidents. Thus, bicycle accident reports are typically not as thorough as those for motor vehicles, and a fair amount of missing information exists. Even though these crashes are rather low probability events, the investigating officer should report the information as completely as possible.

The narrative description could also be vastly improved for these crashes. At present, such narratives are very brief. This is a section where the unique features of accidents can be mentioned. Since the accident form is not as well-suited to the bicycle accidents, a host of candidate items could be entered in the narrative, such as bicycle pre-crash maneuvers, bicycle type, bicycle special equipment, etc. The HSRC Narrative Search system enables one to now analyze such narrative information in a suitable fashion.

Countermeasures and Recommendations

In looking for solutions, one path is toward the behavioral errors of the bicyclists and motorists involved, and another is toward equipment and environmental considerations. Some of the countermeasures or recommendations may not affect a large portion of the population, nor may they be suitable for societal change. Such is not infrequent in the highway safety field.

Bicycle Equipment

From an examination of these accident data, two bicycle equipment areas (or items) appear to be problematical. In the first place, it is often the case that the bicyclist is difficult to see, which undoubtedly results from many reasons, such as size of bicycle, riding location (sidewalks, facing traffic, etc.), and others. Thus, a device that could be attached to the bicycle to make the vehicle more conspicuous would be desirable. One alternative would be the use of the high-rise pennant or safety flag. This could be quite helpful during the daylight hours, but at night, such a device with some sort of strobe light would possibly be needed. Use of a strobe during the day, also, might not be unrealistic, in that many accidents result simply from the difficulty involved in searching for and detecting the bicycle. In the same context, it seems logical to recommend the wearing of light-colored clothes by the bicyclist, if such apparel can help to increase conspicuity.

In regard to the nighttime riding, it would seem that not only better conspicuity is needed but also better recognizability. Of major importance is that the bicycle have lights or reflectors that can simply be seen. Secondarily, it is important that others recognize the specific vehicle that is seen as a bicycle, for this conveys much more information to the motorist. Thus, reflectors on tire rims or pedals, or lights attached to the arm or leg may serve to more readily enable a motorist to identify a bicycle.

Besides the difficulty of the motorist seeing the bicycle, the bicyclist seems to have trouble in seeing and detecting overtaking vehicles. As such, the use of rear-view bicycle mirrors or other rear-vision devices offers a possible solution to this problem. It is recognized that there are problems to be solved in developing a suitable rear-vision device, such as the difficulty in focusing due to road vibration and the small motor vehicle image, but these devices are relatively inexpensive. Some consideration should be given to making mirrors a standard bicycle equipment item.

Educational Programs - Bicyclists

In addition to the conspicuity and vision problems, bicyclists seem to commit certain behavioral-type errors when riding. As has been noted in other studies, cyclists have difficulty perceiving and assessing risk. In these accident data, there are many instances of improper entering, wrong-way riding, and other types of violations. Bicyclists also often misevaluate the intent of the motorist in feeling that they have been seen and will be granted the right of way. Finally, many problems occur at intersections, in that cyclists make strange turning and crossing movements. At times, they behave more like pedestrians than pedalcyclists (perhaps out of necessity).

It would appear that educational programs for young bicyclists would be beneficial. These programs should concentrate on the behavioral error typically made in accident situations. Cyclists must be made aware of the hazard associated with entering roadways improperly, riding facing traffic, and swerving to the left in front of following vehicles. They must be taught that they are hard to see and must be selective about where to ride. They must learn how to search both front and rear, and how to deal with distractions. Finally, they need information about certain problem situations, such as watching for opening doors from parked cars and the overtaking of motor vehicles from the right rear. Parents should receive the same type of information so that they might positively reinforce proper riding technique.

Educational Programs - Motorists

Similar to the above, motorists need information about the magnitude of the bicycle accident problem and the behavioral errors that bicyclists typically make. The driver license examination is one place that motorists might be reached, either with pamphlets or test questions dealing with bicycle/motor vehicle accidents. Some candidate information items include the following:

1. Searching and scanning techniques.
2. The hazards associated with driveways, alleys, and other places cyclists may enter the roadway.
3. The movements cyclists may make at intersections or in other traffic situations.

Enforcement Efforts

A two-phased effort is needed here. First, municipalities should be encouraged to pass ordinances dealing with certain hazardous bicycle riding techniques, such as riding facing traffic, entering the roadway without slowing or stopping, turning without signalling, and violations at intersections. Secondly, police should actively cite bicyclists who fail to obey these ordinances. It is rare when cyclists are penalized for improper riding.

Environmental Considerations

The most effective environmental recommendation would be to separate bicyclists from motor vehicles by use of specially-constructed bike paths. However, such facilities entail large expenses, and other studies indicate that problems still occur when bike paths cross or intersect with other roadway facilities. Special bike lanes can help to some extent.

Visual obstructions, such as vegetation and parked vehicles, are a problem in many bicycle/motor vehicle accidents. Consideration should be given to removing unnecessary foliage and signs near intersections and entrances to roadways. Parking should also be restricted in these areas. Finally, the use of special bicycle crossing signals could aid in negotiating wide intersections.

In summary, there are some realistic steps that can be taken to help solve some of these types of problems. However, care should be taken to ensure that the bicycle is not overregulated or overburdened with requirements fostered by those who see the bicycle as some sort of menace. For the bicycle is certainly not a menace, but rather a viable and relatively safe mode of transportation, and this is how it should remain.

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APPENDIX

Variable Format for the Analysis
of the 1976 Narratives of
Bicycle Accidents in North Carolina

1976 N.C. BIKE NARRATIVES - FORMAT

Variable	Column	Description
00	1	Search Word 1 BICY 2 BIKE 3 CYCL 4 HANDLE 5 KICKSTAND
	2-7	Case Number
01	8-9	Bicycle Maneuver 01 Going straight ahead 02 Changing lanes, passing 03 Making turn (left, right, U) 04 Entering road from driveway, sidewalk, between parked vehicles, other 05 Crossing traffic at intersection 06 Turned into path of a motor vehicle, same roadway 07 Other: backing, slowing or stopping in travel lane, stopped in travel lane, parking and/or dismounting from bicycle, pushing bicycle, right turn on red, riding or standing on sidewalk, other maneuver
02	10	Bicycle Crossing Traffic 1 Not crossing traffic 2 Crossing (at crosswalk or intersection, not at crosswalk or intersection, unknown) 3 Unknown
03	11-12	Bicyclist Violation 01 None 02 Failure to yield, unsafe crossing 03 Riding left of center, passing violation, improper lane 04 Stop sign, traffic signal violation 05 Improper turn 06 Riding on wrong side of road (against traffic) 07 Riding with no headlights or defective headlights 08 Improper brakes 09 Other improper equipment 10 Failed to keep to right side of road 11 Other: excess speed, following too closely, improper or no signal, improper parking location, other violation

Variable	Column	Description
04	13	Vehicle Involvement at Crash 1 Bicycle(s) only 2 Bicycle(s) and 1 motor vehicle 3 Bicycle(s) and 2 or more motor vehicles 4 Motor vehicle(s) only 5 Bicycle(s) and other vehicle 0 Unknown
05	14	Group of Bicycles (2 or more) 1 Yes 0 Unknown
06	15	More Than One Rider on a Bicycle 1 Yes 0 Unknown
07	16	Bicyclist and/or Passenger Fell Off Bicycle 1 Yes 2 No 0 Unknown
08	17	Bicyclist Wearing Protective Clothing (i.e., light-colored clothing suitable for night riding; protective vest; helmet; etc.) 1 Yes 0 Unknown
09	18	Lights in Use (front or rear) 1 Neither headlight nor tail light present 2 Not in use during daylight 3 Not in use during non-daylight 4 Headlight in use 5 Tail light in use 6 Both headlight and tail light in use 0 Unknown
10	19	Riding Experience 1 Learner 2 Less than 6 months 3 6-12 months 4 Over 1 year 5 Other 0 Unknown
11	20	Physiological Problem of Bicyclist 1 None 2 Had been drinking 3 Drunk 4 Drug impairment 5 Sick 6 Fatigue 7 Other 0 Unknown

Variable	Column	Description
12	21	Relative Size of Bicycle 1 Too large for rider 2 Too small for rider 3 No disaccommodation 0 Unknown
13	22-23	Possible Contributing Factor 01 None 02 Vehicle factor (parked or parking vehicle, vehicle traffic, headlights too bright or dim, bus, truck or van) 03 Environmental factor (post or sign, building, trees or bushes, hill or curve, sun, glare, street lights too bright or too dim) 04 Bicyclist inexperienced with bicycle or route, bicyclist distracted 05 Mechanical defect of bicycle (e.g., brakes, light, chain) 06 Driver of motor vehicle did not see bicycle 07 Bicyclist did not see motor vehicle 08 "Phantom" bicycle (bicycle possible cause of accident, but not involved in crash) 09 Other: bicyclist chased by dog, bicyclist lost control of bike, object or debris in road, kickstand fell and struck pavement, other factor 00 Unknown
14	24	Other Possible Search Words 1 None 2 Dart
15	25	Accident Type 1 Rear end 2 Left turn 3 Right turn 4 Head-on 5 Sideswipe 6 Angle 7 Single-bicycle accident 8 Other 0 Unknown
16	26	Bicycle Type 1 3, 5 or 10 speed 2 Conventional 3 Highrise 4 Junior 5 Other 0 Unknown

Variable	Column	Description
17	27	Purpose of Bicycle Trip 1 Recreation 2 Commuting 3 Errand 4 Other 0 Unknown