THE UNIVERSITY OF NORTH CAROLINA HIGHWAY SAFETY RESEARCH CENTER
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BICYCLES: An Analysis of Accidents in North Carolina

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A B S T R A C T

Bicycle accidents for the three-year period covering July, 1965, through June, 1968, were analyzed according to a number of variables. In addition to comparing fatal and non-fatal bicycle accidents with each other, further comparisons were made with sample data for 1966 motor vehicle accidents in North Carolina.

The variables investigated covered five major categories. The first category involves features of the situation in which the accident occurred, such as the time of day, the weather conditions, and the road conditions. The second category concerns characteristics of the accident itself, namely the vehicle maneuver involved, the approximate speed of the motor vehicle, and the point of contact with the motor vehicle. The third category concerns the presence of defects in the motor vehicle and whether the motor vehicle driver was charged with a traffic violation. Certain characteristics of the driver are reported in the fourth category, namely sex, age, and physical condition. The fifth category concerns the bicyclist and includes information concerning sex and age.

Probably most of the differences found between bicycle accidents and all motor vehicle accidents can be attributed to differences in exposure. For example, the finding that in bicycle accidents there is a greater probability that the motor vehicle driver will be female is presumably related to the fact that bicycle accidents tend to occur more frequently in the daytime and in residential areas. It is likely that there is a greater proportion of female drivers in these particular circumstances than in general.

The major differences between fatal and non-fatal bicycle accidents appear to involve the location of the accident, age of the bicyclist, and approximate speed of the motor vehicle. Fatal accidents are more likely to involve the older bicyclist and to occur in open country at higher motor vehicle speeds, while non-fatal accidents are concentrated in residential areas with the younger bicyclist being involved. Also, accidents occurring at night on unlighted roads have a higher probability of resulting in a fatality than do accidents occurring under other light conditions.

ACKNOWLEDGEMENTS

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BICYCLES: An Analysis of
Accidents in North Carolina

INTRODUCTION

In the three-year period from July, 1965, through June of 1968, 2,453 bicycle accidents were reported to the Department of Motor Vehicles in North Carolina, each accident involving at least one motor vehicle. Of these 109 (4%) involved fatalities, 2,054 (84%) involved Class A or B injuries*, 282 (11.5%) involved Class C injuries, and 8 (less than 0.33%) involved property damage only. The low incidence of bicycle accidents involving property damage only is due to the fact that, if the accident was sufficiently minor that the bicyclist was not injured, it probably did not involve $100 worth of damage and hence was not reported.

The following analyses break the data into two major categories, namely, fatal accidents and non-fatal accidents. The latter category includes the property damage accidents, but these comprise so small a portion that they do not appreciably affect any of the findings.

These fatal and non-fatal bicycle accidents are further compared with a sample of fatal and injury-producing <u>motor vehicle</u> accidents in the state of North Carolina for the year 1966. In order to make some judgment as to the appropriateness of comparing the three years of bicycle accidents with

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* "C" - No visible injury but complaint of pain or momentary unconsciousness.
"B" - Visible injury such as bruises, abrasions, swelling, limping, etc.
"A" - Visible injury such as bleeding wound, distorted member, or had to be carried from the scene.

the sample of motor vehicle accidents from 1966, the three-year bicycle data were compared with the sample of bicycle accidents for the year 1966 alone. Distributions for the variables under consideration were essentially the same for the two groups. Although it does not necessarily follow that distributions for all motor vehicle accidents would be the same for 1966 alone compared with the three-year period, nevertheless it was felt that the similarity in distributions for bicycle accidents provided some justification for using the 1966 data for all motor vehicle accidents as a basis for comparison with the bicycle accidents for all three years. It might be noted that our bicycle sample includes all bicycle accidents, while our motor vehicle sample excludes those accidents involving property damage only. Because, as noted above, there were very few bicycle accidents involving property damage only, there are no comparisons made on this basis.

The variables examined are divided into five major categories. The first category is concerned with the features of the situation in which the accident occurred. This category includes information on when and where the accident occurred and what factors obtained at that time, e.g., weather conditions, light conditions, and roadway characteristics.

The second major category of variables includes characteristics of the accident itself, namely the vehicle maneuver, the approximate speed of the motor vehicle involved, and the point of contact.

The third major category provides information on whether the motor vehicle was found to be defective in any way and whether the driver of the motor vehicle was charged with a traffic violation.

Information concerning the driver of the motor vehicle is contained in the fourth major category. Variables in this category include the sex, age, and physical condition of the driver.

It should be noted that in bicycle accidents the driver of the motor vehicle is always listed as Driver 1 on the North Carolina accident report form. When comparisons are made between bicycle accidents and all motor vehicle accidents, the driver of the automobile in the bicycle accident is compared with the first driver listed in the motor vehicle accident, again Driver 1. This choice of Driver 1 for comparison purposes was arbitrary. However, when more than one driver is involved in an accident, there is apparently no systematic method for determining which driver is listed first on the North Carolina accident report form. Consequently, there is no reason to suspect that our data are affected appreciably by our choice of the first driver listed in motor vehicle accidents.

The fifth category concerns the bicyclist and provides information concerning sex and age.

Concerning comparisons made between bicycle accidents and all motor vehicle accidents, it should be emphasized that throughout the analyses there has been no way to control for the exposure variable. It is likely that at least some of the differences that are reported could be accounted for by differences in exposure if the relevant information were available.

Several statistical tests were used in the analyses comparing fatal and non-fatal bicycle accidents and comparing bicycle accidents with all motor vehicle accidents. In each comparison a Chi square (X^2) test of independence was run to determine the presence or absence of any overall differences. In those comparisons in which there was some logical ordering of the variable under consideration, e.g., age of bicyclist, the Rank Analysis of Variance (RANOVA) was run (see Quade, 1968).[1] When both

[1]Quade, D. A Computer Program for the Analysis of Two-Way Contingency Tables. Institute of Statistics, University of North Carolina, Mimeo Series No. 567, February, 1968.

dimensions under consideration could be ordered, e.g., approximate speed versus injury or fatality for the bicyclists, the Goodman-Kruskal rank correlation coefficient (G) was computed along with its standard error (Quade, 1968). This index G indicates not only the strength of the association between the two variables but also the direction of the association. In the case of the age of driver variable, a special Chi square test was used, as explained later.

I. Features of the Accident Situation

Month of Year

The frequency of bicycle accidents, both fatal and non-fatal, increases during the summer months (see Figure 1)*. This increase is undoubtedly related to an increase in exposure during the warmer weather and the school holiday.

When bicycle accidents are compared with all motor vehicle accidents, the summer (i.e., May-September) increase for fatal bicycle accidents is not significant, ($.05 < p < .10$), but for non-fatal accidents the differences between bicycles and all motor vehicles is highly significant ($p < .001$); i.e., there are proportionately more non-fatal bicycle accidents in the summer months than corresponding motor vehicle accidents during this period. This latter difference lends support to the hypothesis that bicycle exposure shows greater seasonal variation than is true for motor vehicles in general.

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* The corresponding frequencies and percentages for each figure in the text are given in the like-numbered tables in Appendix A.

Day of Week

There is a marked variation in bicycle accidents as a function of the day of the week on which they occur (see Figure 2). Saturday contributes the greatest proportion of accidents, both fatal and non-fatal.

When bicycles are compared with all motor vehicles, the differences are not significant for fatal accidents. However, for non-fatal accidents there are highly significant differences, with the weekends contributing proportionately more for the bicycle accidents ($p < .001$).

When fatal bicycle accidents are compared with non-fatal bicycle accidents, there are no significant differences associated with the day of the week on which they occur.

Locality

The location of bicycle accidents differs from the location of all motor vehicle accidents (see Figure 3). There are proportionately more bicycle fatalities in the open country than for motor vehicles ($.025 < p < .05$), although the majority of fatalities in both cases occur in the open country where, of course, the vehicle speeds are greater than in residential areas. With regard to non-fatal accidents, bicycles differ from motor vehicles ($p < .001$) in that the vast majority of non-fatal bicycle accidents occur in residential areas (where undoubtedly the exposure is greater) while the majority of non-fatal motor vehicle accidents appear to occur in the open country.

When fatal and non-fatal bicycle accidents are compared on the basis of location, a highly significant difference is found ($p < .001$). Non-fatal accidents are more likely to occur in residential areas, while fatal accidents are most likely to occur in the open country. It is of interest that very

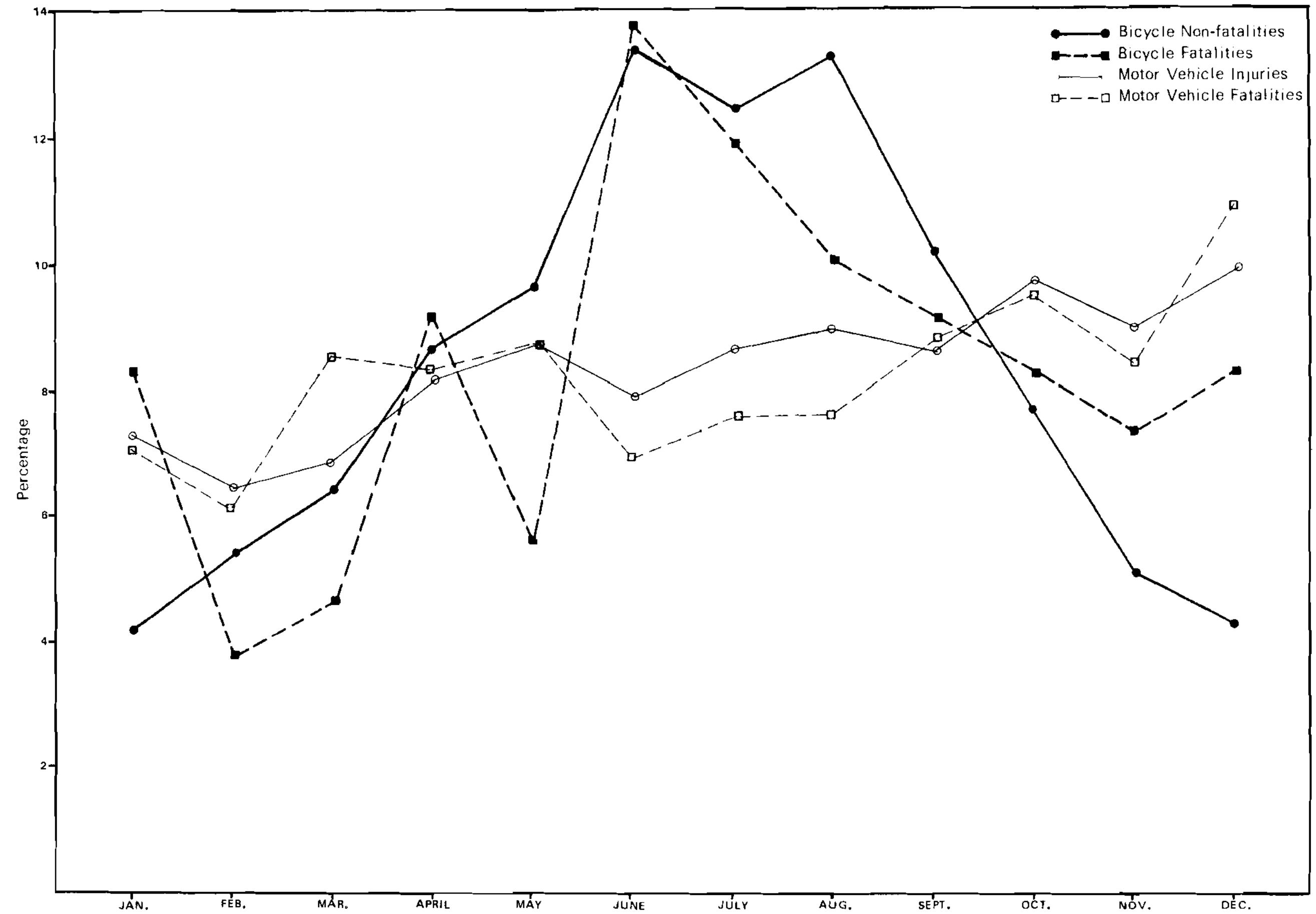

FIGURE 1. MONTH OF YEAR

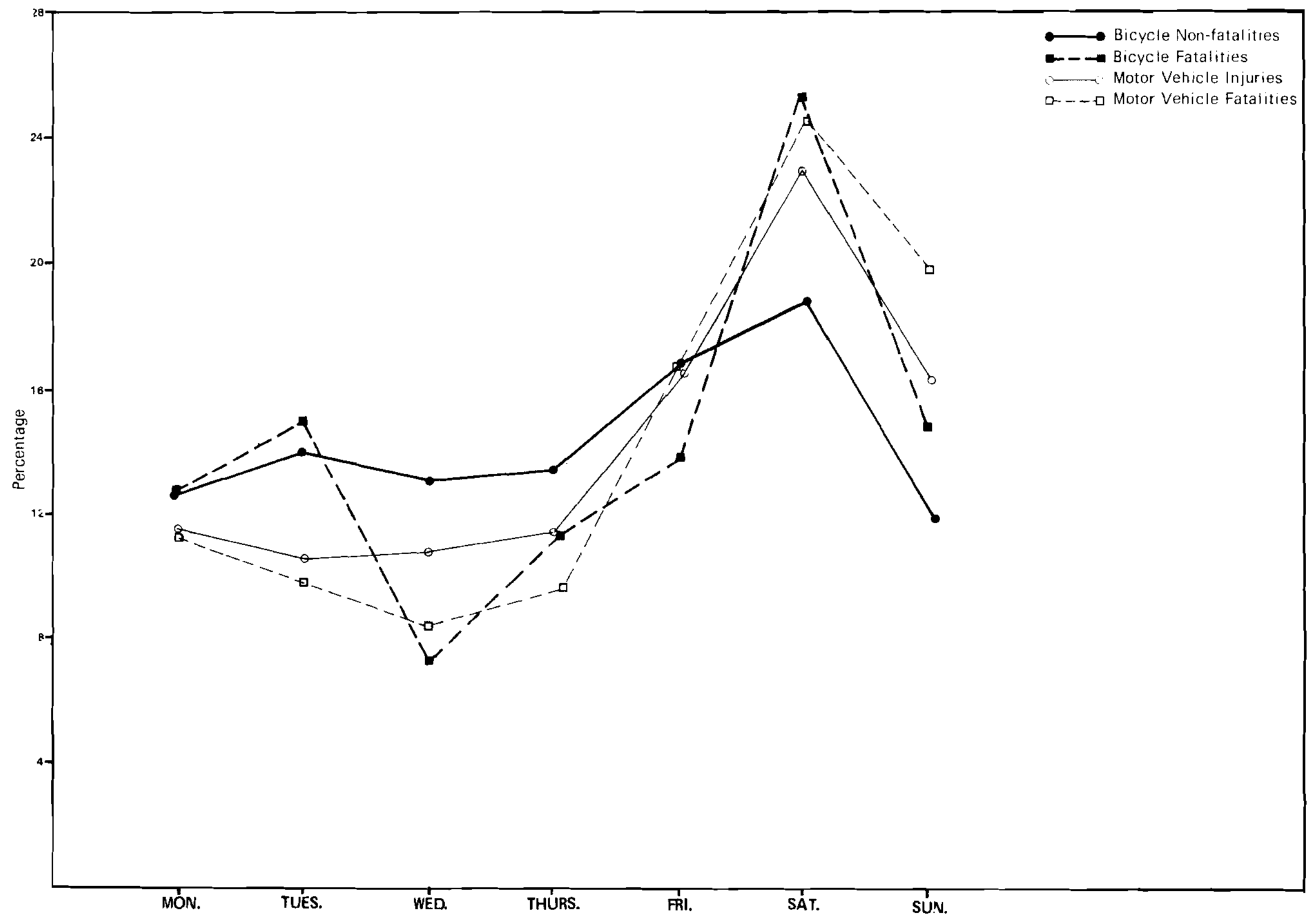

FIGURE 2. DAY OF THE WEEK

few reported bicycle accidents occurred in a school or playground area (no fatalities and less than 1.5 percent of the non-fatal bicycle accidents). It may be assumed that exposure around such areas is high, but it may also be that drivers are on the alert in these localities.

Highway Class

When bicycle accidents are compared with all motor vehicle accidents, there are marked differences associated with highway class (see Figure 4). For fatal accidents it can be seen that bicycle accidents are more likely to occur on rural roads, while all motor vehicle accidents show a larger proportion occurring on major roads (state and federal) and interstate highways ($p < .001$). Interestingly, when non-fatal accidents are analyzed, differences between bicycles and all motor vehicle accidents still exist ($p < .001$), but the pattern is different. Non-fatal bicycle accidents occur overwhelmingly on city streets. The rural road pattern observed in fatal bicycle accidents does not hold true for the non-fatal ones.

When fatal and non-fatal bicycle accidents are compared with each other, there are marked differences associated with highway class ($p < .001$). This finding is further substantiated by a highly significant RANOVA F. The index G (.668) further shows that while the non-fatals occur predominantly on city streets, the fatals occur more on major and minor roads (federal and state road systems plus rural roads). Such a finding is undoubtedly related at least in part to the differing speed limits on the various kinds of highways. City streets customarily have a speed limit no higher than 35 mph, while the rural paved roads, the federal, and the state highways may carry a speed limit of 55 mph or higher. Thus once a collision occurs, it is more likely to result in a fatality at the higher speed levels, i.e., outside the city.

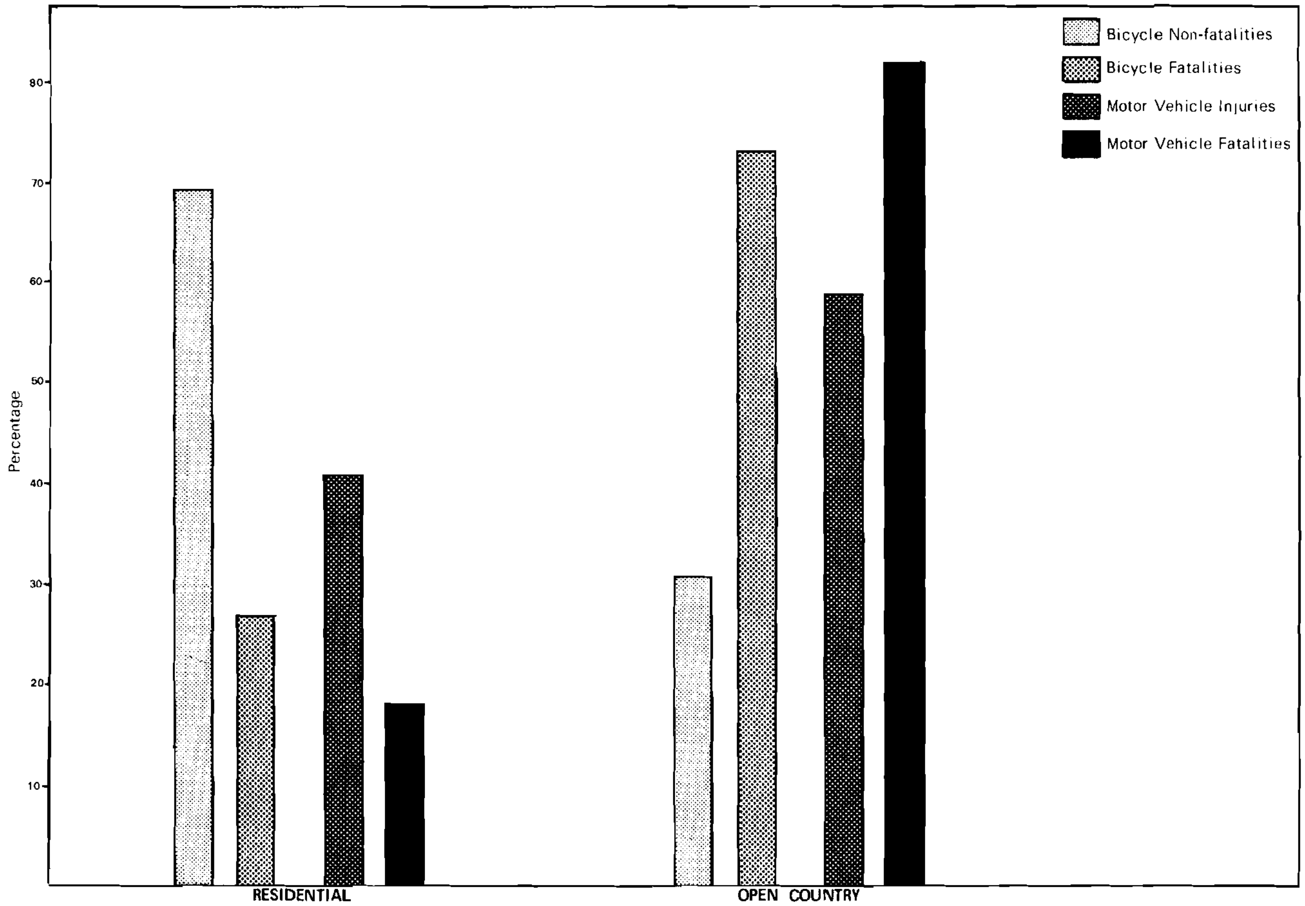

FIGURE 3, LOCALITY

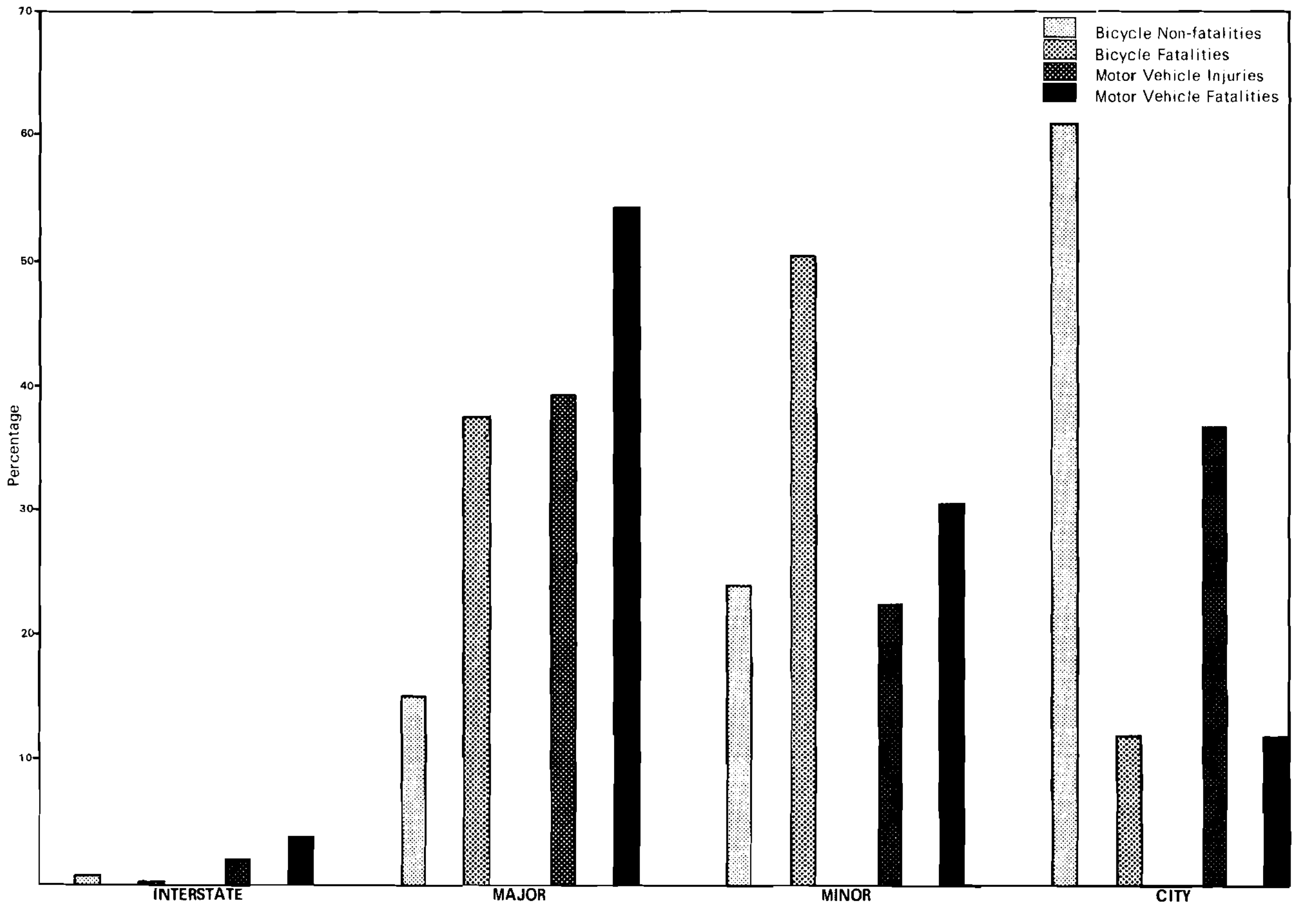

FIGURE 4, HIGHWAY CLASS

Road Construction

Although both motor vehicle and bicycle accidents are most likely to occur on a smooth asphalt road*, nevertheless there are some significant differences between bicycle accidents and all motor vehicle accidents in regard to road surface (see Figure 5). Compared with bicycle accidents all motor vehicle accidents are more likely to occur on a concrete road. This finding holds true for fatal accidents ($p = .02$) and non-fatal accidents ($p < .001$). Since concrete construction is more likely to occur on major roadways where bikes are sometimes forbidden (as on interstate highways), these differences are undoubtedly reflecting differences in exposure.

Roadway Features

Compared with all fatal motor vehicle accidents, fatal bicycle accidents show a larger proportion occurring where there is some kind of intersection (an alley, two roadways crossing, or a driveway). This difference is highly significant ($p < .001$). This same difference is even more striking for non-fatal accidents; i.e., compared with all non-fatal motor vehicle accidents, non-fatal bicycle accidents are much more likely to occur at some kind of intersection (see Figure 6).

When fatal and non-fatal bicycle accidents are compared, it is found that the majority (63%) of non-fatalities occur at intersections, while fatals are more likely to occur where there is no particular roadway feature ($p < .001$).

Road Character

The greatest portion of all accidents occurs on straight level roads. However, this characteristic is more dramatic for bicycle accidents than for

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* Asphalt surfaces were dichotomized as being either "rough" or "smooth."

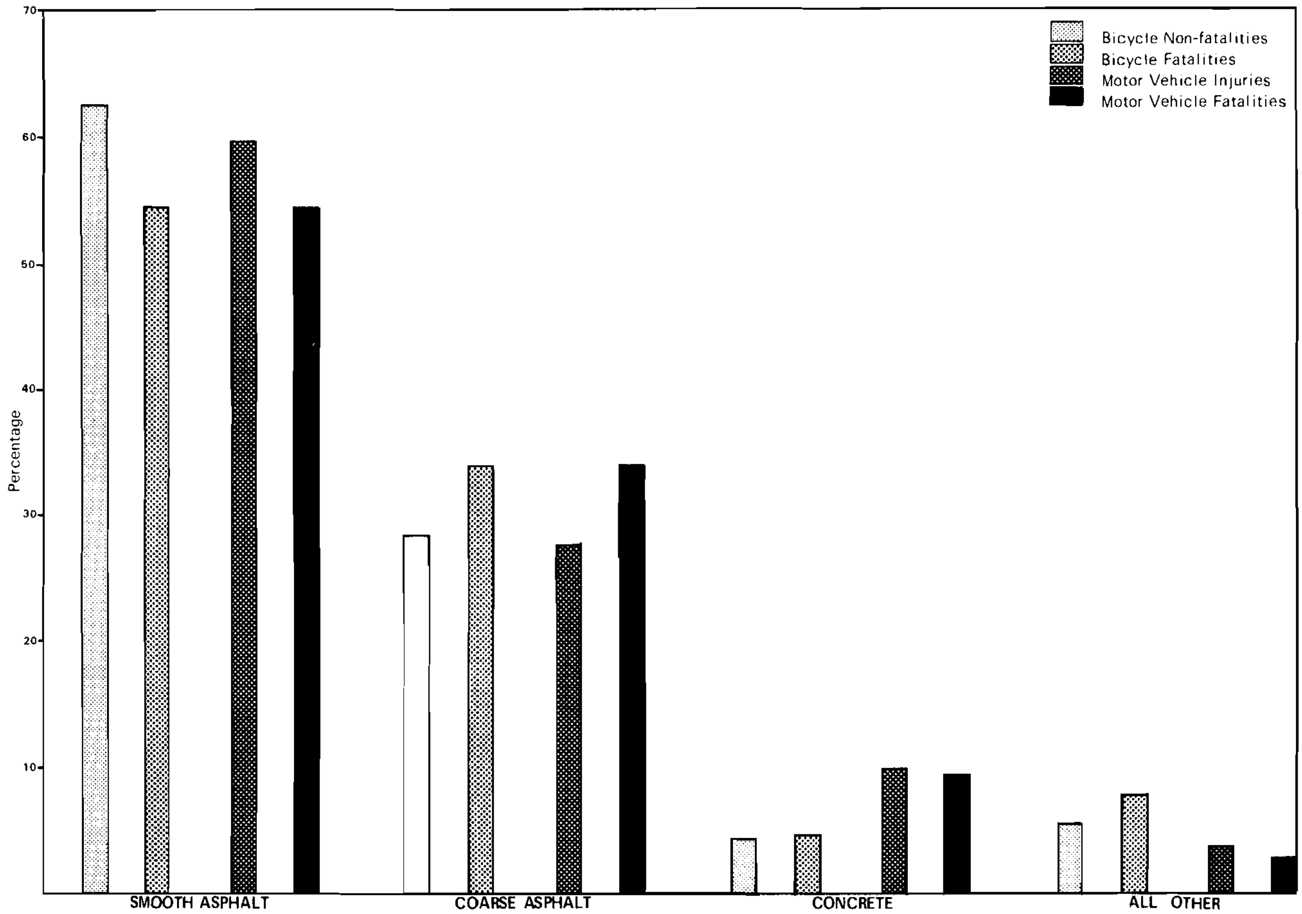

FIGURE 5, ROAD CONSTRUCTION

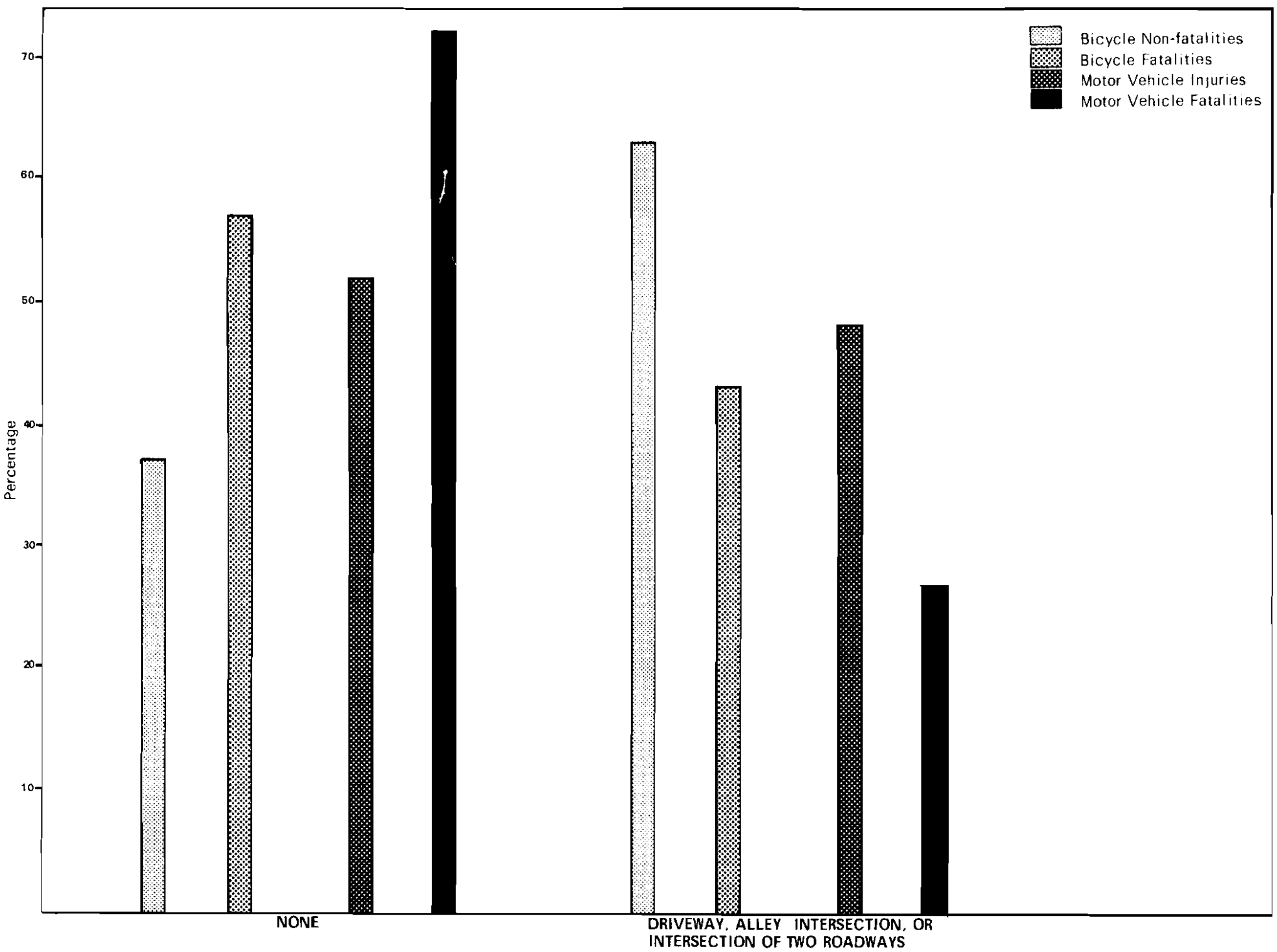

FIGURE 6, ROADWAY FEATURE

all motor vehicle accidents (see Figure 7). Conversely, there are proportionately fewer bicycle accidents of both types on roads that are not straight. The differences are significant for both fatal accidents ($p < .005$) and for non-fatal accidents ($p < .001$). Of course, these results do not mean that straight level roads are more dangerous than other kinds of roads. Rather it is probable that exposure factors differ according to the type of road, and the greatest portion of all driving probably occurs on straight level roads.

Road Conditions

Dry roads are involved in the vast majority of all accidents (see Figure 8). However, when bicycle accidents are compared with all motor vehicle accidents, there is a highly significant difference in road conditions for both fatal accidents ($p < .005$) and non-fatal accidents ($p < .001$). In both kinds of accidents, the bicycles are more likely to be associated with dry roads. Since bicycles tend to be used primarily in good weather, it follows that there would be few accidents occurring on streets that are wet, muddy, snowy, or icy.

Road Defects

As can be seen in Figure 9, most accidents occur on roads with no defects noted. Because the proportion of "No Defects" was virtually identical for all groups concerned, no statistical analyses were run.

Weather Conditions

From Figure 10 it can be seen that the majority of all accidents occur in clear weather. However, bicycle accidents differ from all motor vehicle accidents in that a greater proportion of bicycle accidents occur in clear weather. This finding holds true for both fatal ($p < .001$) and non-fatal accidents

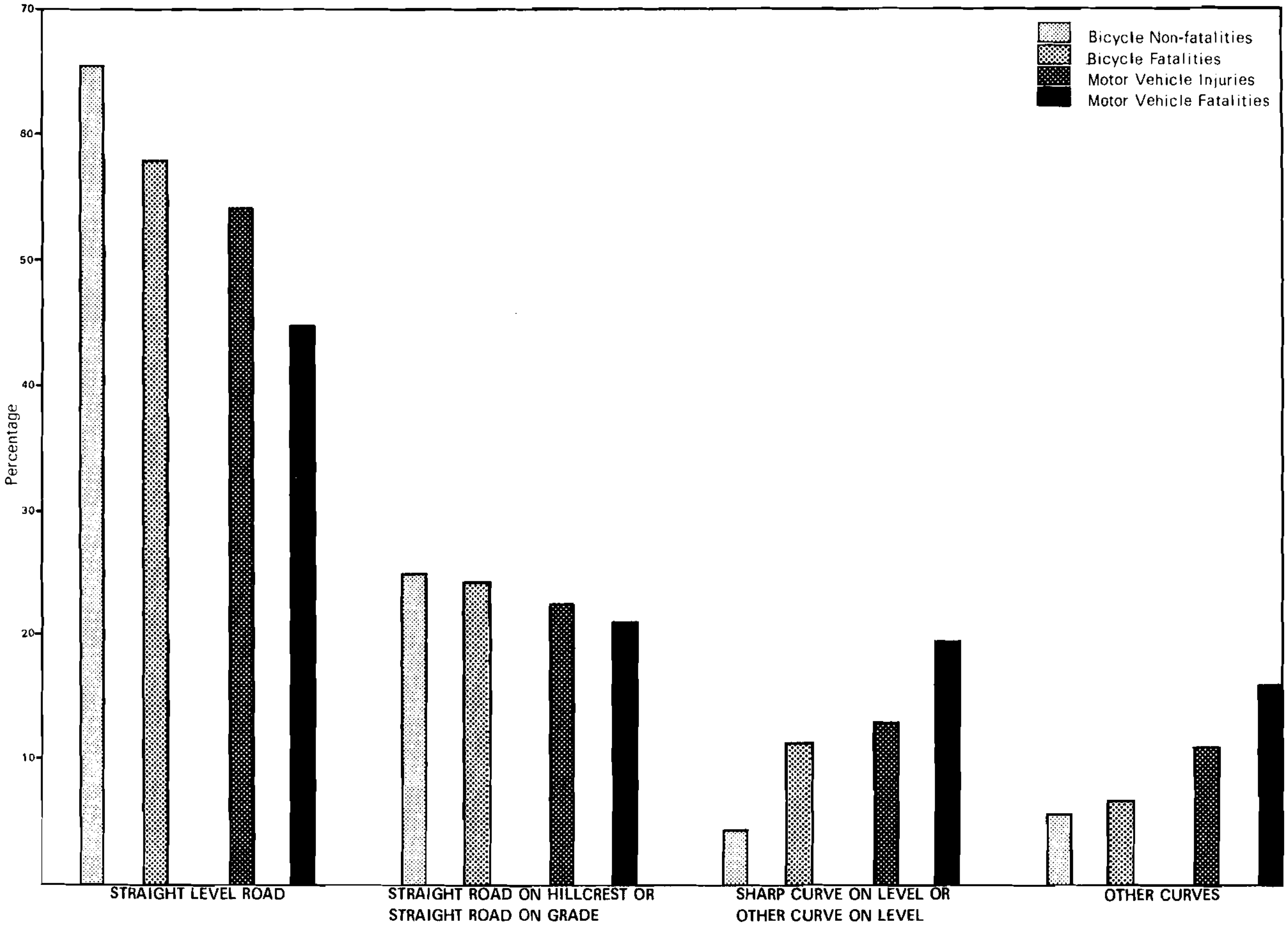

FIGURE 7. ROAD CHARACTER

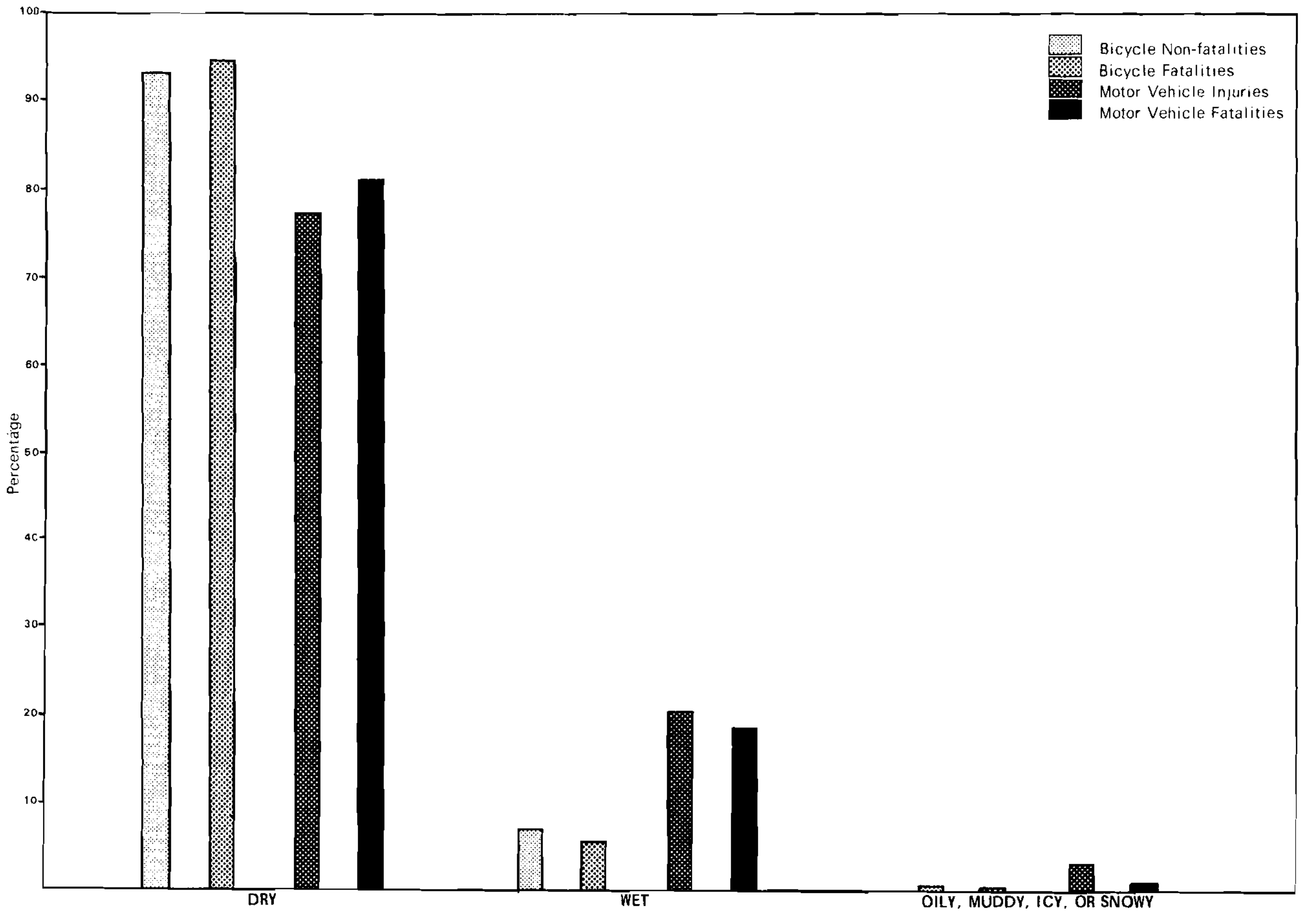

FIGURE 8. ROAD CONDITIONS

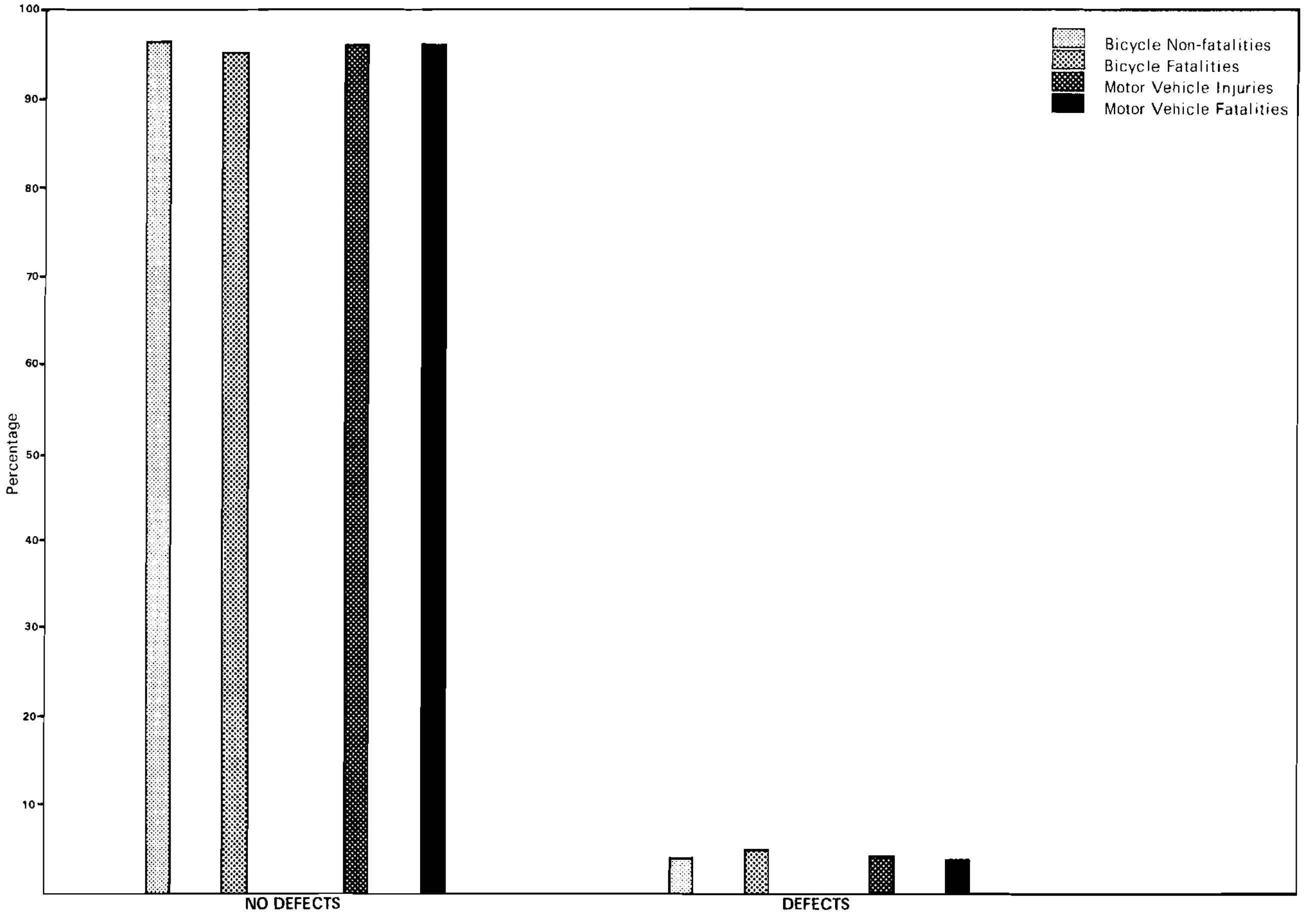

FIGURE 9. ROAD DEFECTS

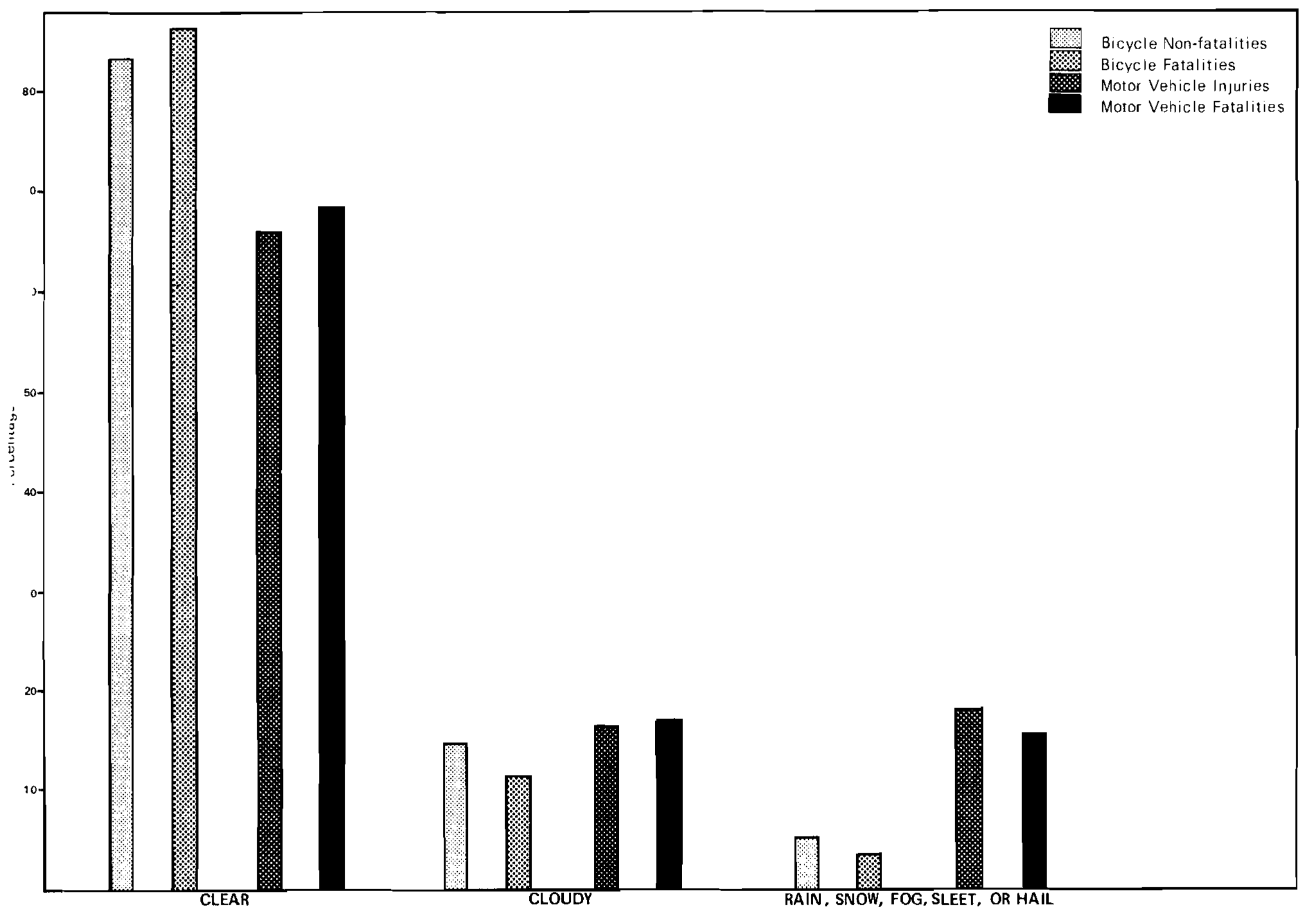

FIGURE 10. WEATHER CONDITIONS

($p < .001$). A highly significant RANOVA statistic in both instances further substantiates that bicycle and all motor vehicle accident distributions differ over the range of weather conditions for both fatal and non-fatal accidents. Of course, relatively few bicycle accidents would be expected to occur in rain or snow, since the bicycle is not likely to be used under such conditions. Consequently, once again the exposure variable is undoubtedly accounting for significant findings.

There were no significant differences found between fatal and non-fatal bicycle accidents that were associated with weather conditions.

Light Conditions

While the largest portion of all accidents occur during daylight hours, it can be seen from Figure 11 that the percentage of bicycle accidents which occur in daylight is significantly higher than the daylight percentage for all motor vehicle accidents. This finding holds for fatal accidents ($p < .001$) and non-fatal accidents ($p < .001$).

When bicycle accidents are compared by fatal and non-fatal, again a highly significant difference is found ($p < .001$). If a bicycle accident occurs in darkness on an unlighted road, it has a much higher probability of being fatal than if it occurs either in daylight or in darkness on a lighted road. While many factors undoubtedly contribute to this finding, such evidence emphasizes the importance of both bicyclist and bicycle being made as visible as possible at night.

II. Characteristics of the Accident

Vehicle Maneuver

The great majority of all highway accidents involve a vehicle that is going straight ahead (see Figure 12). While the differences between bicycle and all motor vehicle accidents do not appear to be great, they are statistically significant. All bicycle fatalities occurred with the motor vehicle going straight ahead or passing. This was in contrast to fatal accidents for all motor vehicles, some of which involved making a left turn or some other maneuver ($p < .005$). The differences for non-fatal accidents were even more significant ($p < .001$). Compared with non-fatal bicycle accidents, non-fatal motor vehicle accidents appear less likely to involve going straight ahead and more likely to involve making a left turn or some other maneuver.

Approximate Speed

Figure 13 depicts the approximate speed of the motor vehicles involved in bicycle accidents and in all motor vehicle accidents. This speed is an estimate recorded by the investigating officer after the accident has occurred and cannot be assumed to be a highly accurate figure. Nevertheless, the same problems in estimation presumably would hold true for all accidents.

When bicycle accidents are compared with all motor vehicle accidents with respect to the approximate speed of the motor vehicles involved, the driver involved in a bicycle accident is more likely to be driving at lower and intermediate speeds than his counterpart in a motor vehicle accident in both fatal and non-fatal accidents ($p < .001$ in both cases). This is further substantiated by the RANOVA F which takes advantage of the natural ordering provided by the speed groups ($p < .001$).

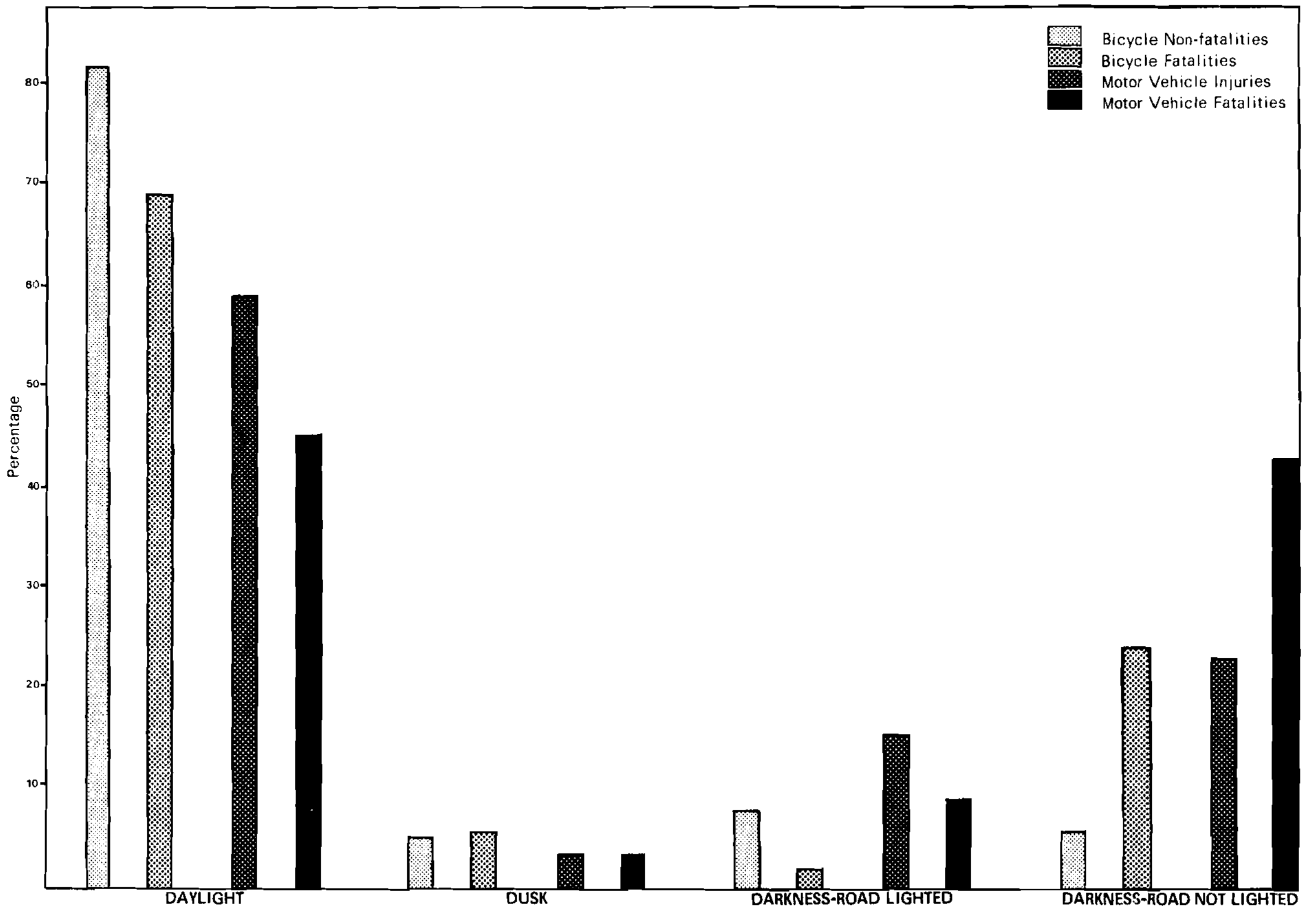

FIGURE 11. LIGHT CONDITION

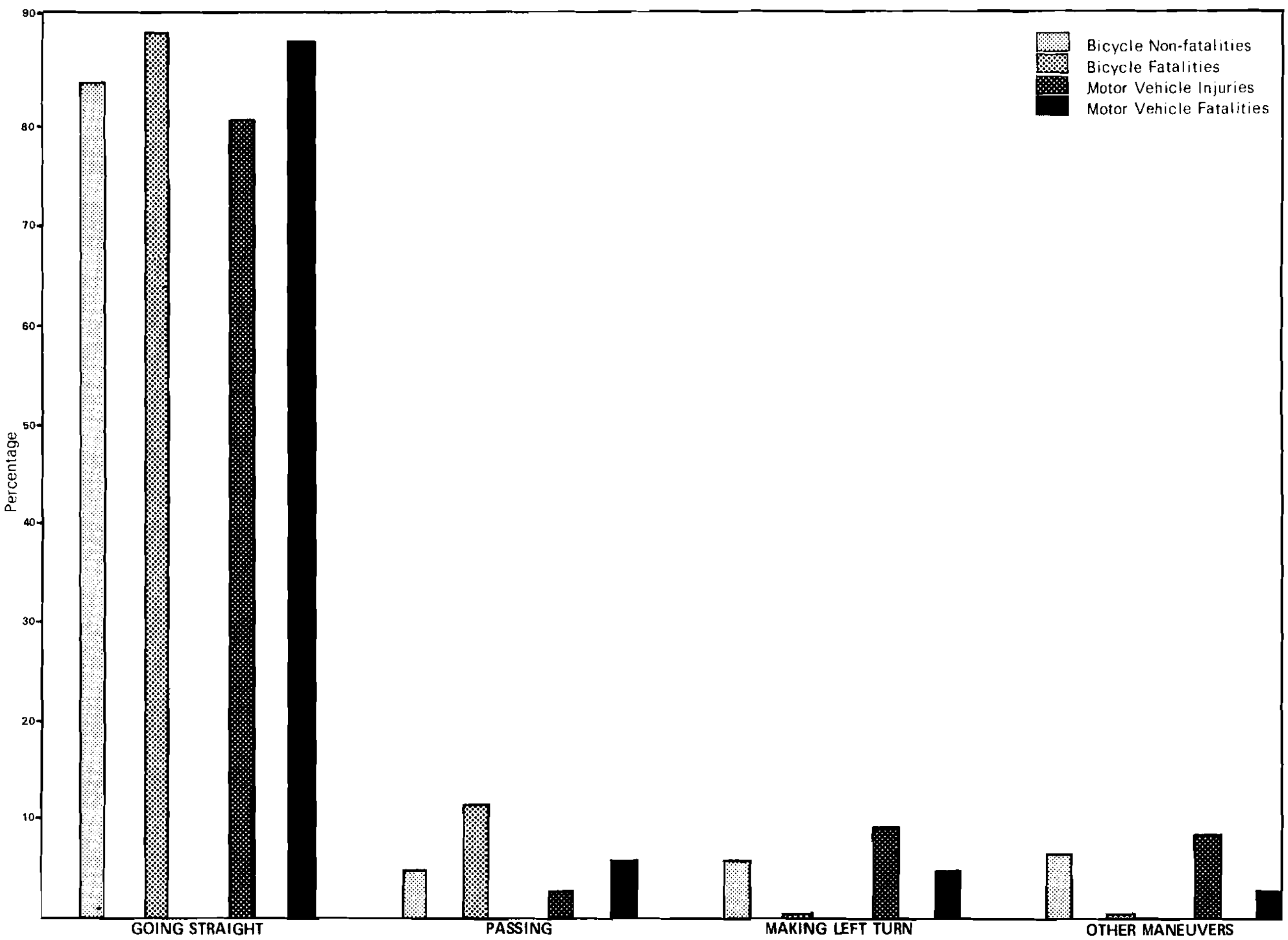

FIGURE 12. VEHICLE MANEUVER

When fatal and non-fatal bicycle accidents are compared with each other, again there are highly significant differences ($p < .001$ for both the Chi square and RANOVA tests). The index G (-.746) indicates most clearly that fatal bicycle accidents are more likely to occur at the higher speeds, while non-fatal bicycle accidents are more likely to occur at lower speeds, particularly between 20 and 39 miles per hour. Of course, speed is related to the locality in which the accident occurs; that is, lower speeds are associated with residential districts, while higher speeds are more likely to occur in open country (see Figure 3).

Point of Contact

Compared with all motor vehicle accidents, bicycle accidents are more likely to involve contact with the front and right front of the automobile (see Figure 14). This finding holds true for both fatal ($p < .001$) and non-fatal ($p < .001$) accidents. When bicycle accidents alone are examined, an interesting finding emerges. Fatal accidents are more likely to involve the front or right front of the vehicle, while non-fatal accidents show a higher proportion of cases involving the other parts of the vehicle, i.e., the sides or rear ($p < .001$).

Data discussed earlier (see Figure 6) indicate that non-fatal bicycle accidents are most likely to occur at intersections. The differences noted in point of contact between fatal and non-fatal accidents seem to suggest that two kinds of events are involved in these bicycle accidents: (a) the driver is unable to see the bicyclist until he emerges from the driveway, alley, or intersection, at which point it is too late for the driver to avoid a collision, and he hits the bicyclist or, (b) the bicyclist emerges after the automobile has started into the intersection and collides with the side

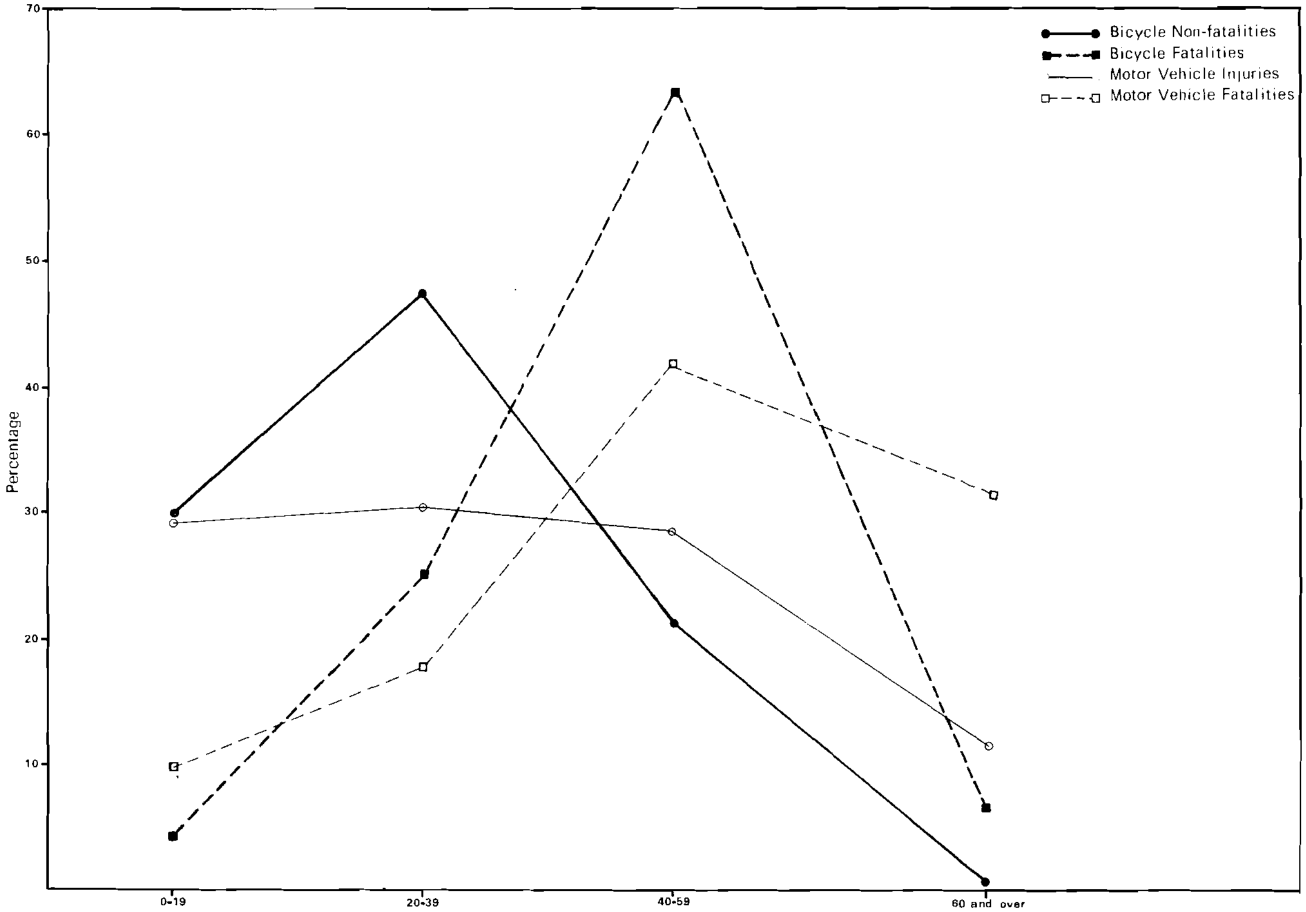

FIGURE 13. APPROXIMATE SPEED IN MILES PER HOUR

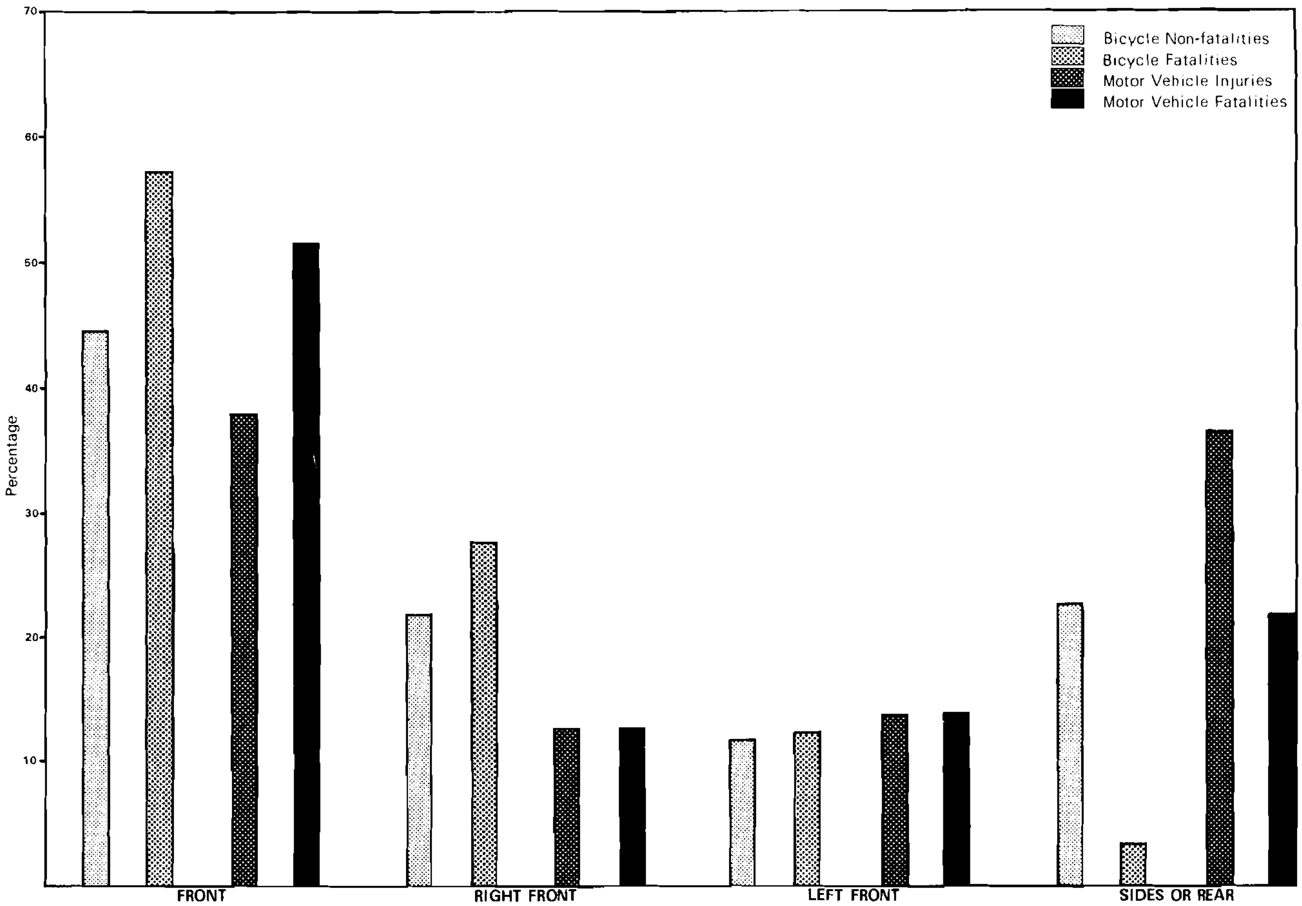

FIGURE 14. POINT OF CONTACT

or rear of the automobile. In the latter instance the impact may not be as great as in the former, and thus the likelihood of a fatality is reduced.

III. Vehicle Defects and Driver Violations

Vehicle Defect

As can be seen in Figure 15, in the vast majority of all accidents there is no defect reported for the motor vehicles involved. This finding is more marked for accidents involving bicycles than it is for all motor vehicle accidents. The differences between all motor vehicles and bicycles are significant for both fatal accidents ($p < .05$) and non-fatal accidents ($p < .001$). Thus, motor vehicles involved in collisions with bicycles are especially unlikely to have any known defect.

Violation-Driver Charged

In most accidents it is likely that the driver will not be charged with a violation. When bicycle accidents are compared with all motor vehicle accidents, there are no significant differences found for fatals. However, for non-fatal accidents, there is a highly significant difference ($p < .001$, see Figure 16). Drivers involved in non-fatal bicycle accidents are <u>less</u> likely to be charged with a violation than drivers involved in non-fatal motor vehicle accidents in general, suggesting that the officer may consider the bicyclist to be at fault in most non-fatal bicycle accidents.

It should be noted that, in motor vehicle accidents, Driver 1 is charged in a higher proportion of accidents than is Driver 2. This may be due largely to the fact that in single vehicle accidents there is no Driver 2. However, in bicycle accidents, if either party is charged it is virtually always the

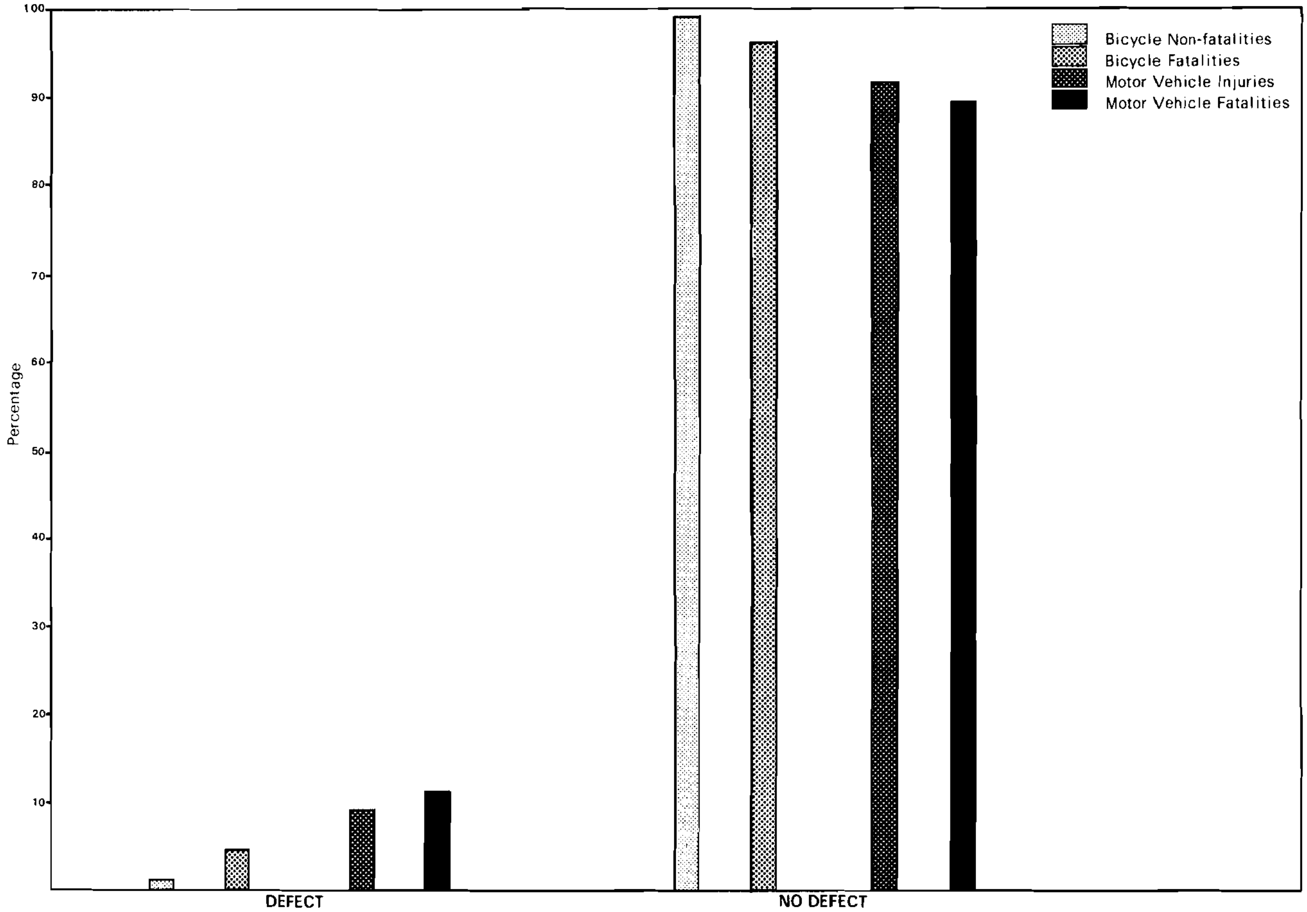

FIGURE 15. VEHICLE DEFECT

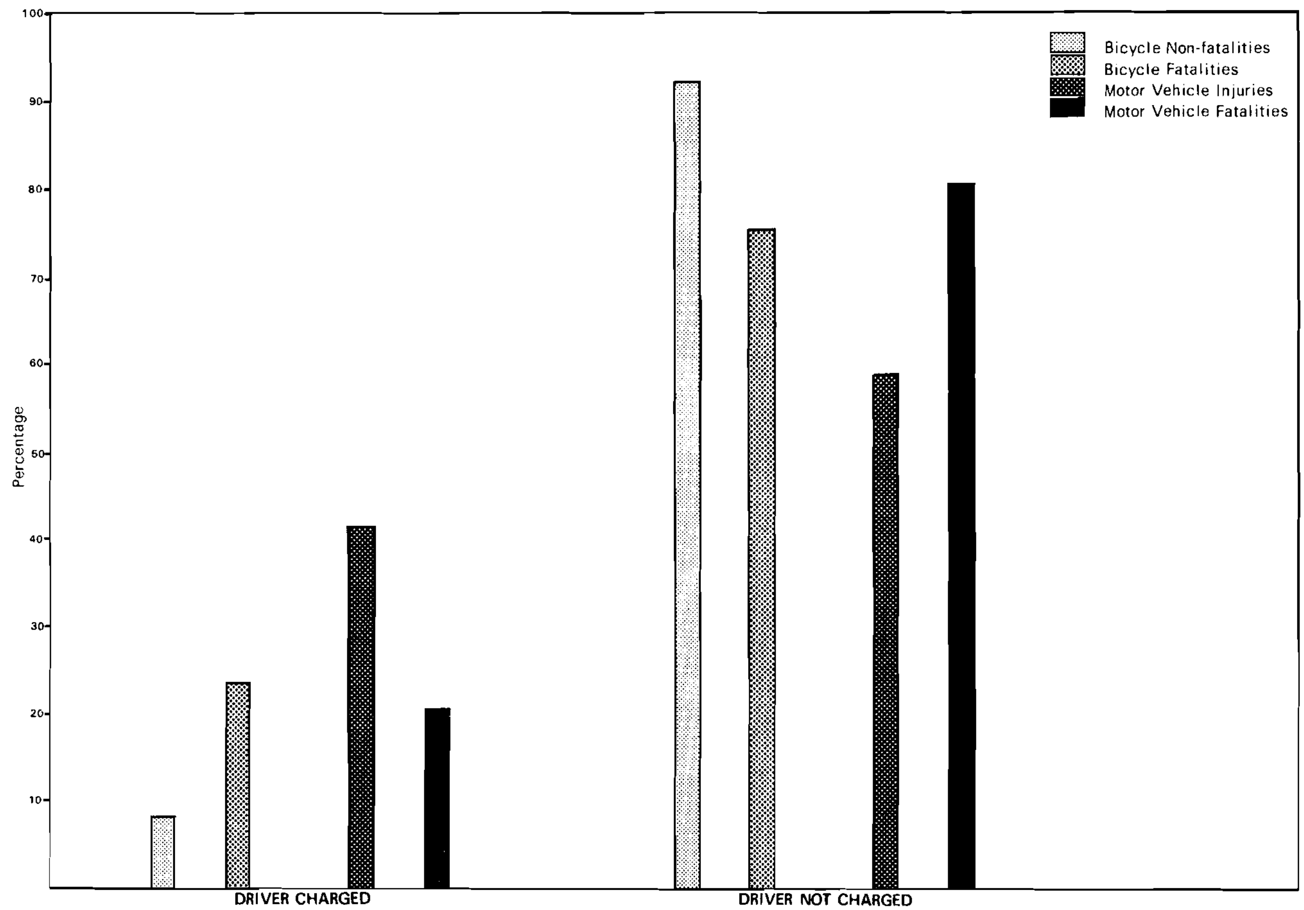

FIGURE 16. VIOLATION–DRIVER CHARGED

driver of the motor vehicle, i.e., Driver 1. Since in the motor vehicle accidents there are many instances involving more than one motor vehicle driver and thus greater opportunity for Driver 2 to be charged, the findings with respect to this variable are, if anything, on the conservative side.

IV. Characteristics of the Driver

Sex of Driver

While most motor vehicle drivers involved in accidents are males (see Figure 17), a greater proportion of drivers involved in bicycle accidents are female than is true for all motor vehicle accidents (for fatal accidents, $p < .005$; for non-fatal accidents, $p < .001$). Since other evidence indicates that bicycle accidents are likely to occur in the daytime in residential areas, it makes sense that women drivers would be somewhat overrepresented compared to all drivers involved in motor vehicle accidents.

Age of Driver

When the age of the motor vehicle driver is considered (see Figure 18), it is found that there is no difference between fatal bicycle accidents and all fatal motor vehicle accidents ($p > .5$); i.e., the age distributions are approximately the same for motor vehicle drivers involved in fatal bicycle accidents and for those involved in all fatal motor vehicle accidents. However, for non-fatal accidents there is a striking difference ($p < .001$) in that drivers involved in non-fatal bicycle accidents tend to be somewhat older than drivers involved in all non-fatal motor vehicle accidents. Such an age difference may reflect a difference in the driving populations that are exposed at the particular times and places where bicycle accidents tend to occur. A special Chi square test with 1 d.f. aimed specifically at the alternative of a difference

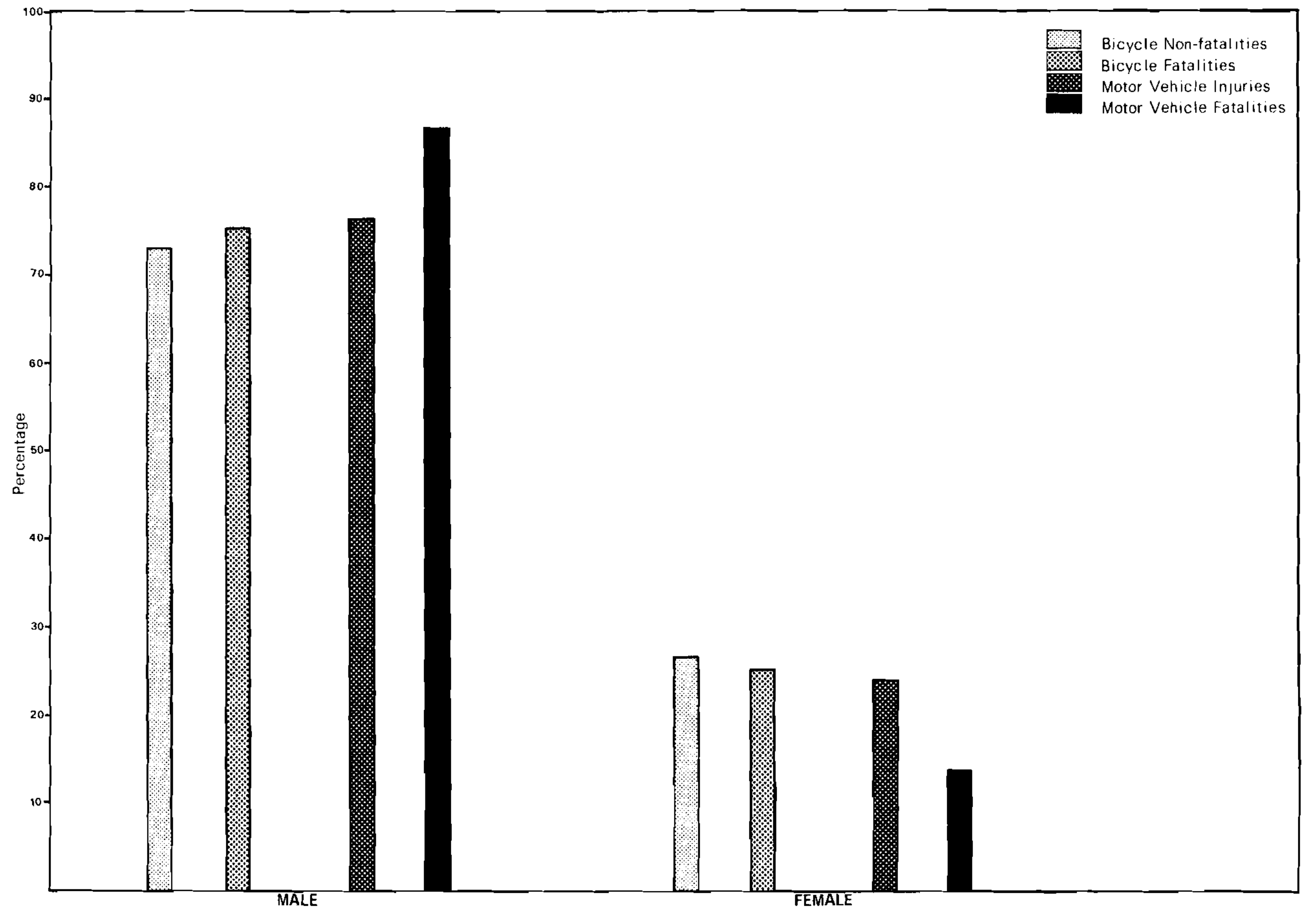

FIGURE 17. SEX OF DRIVER

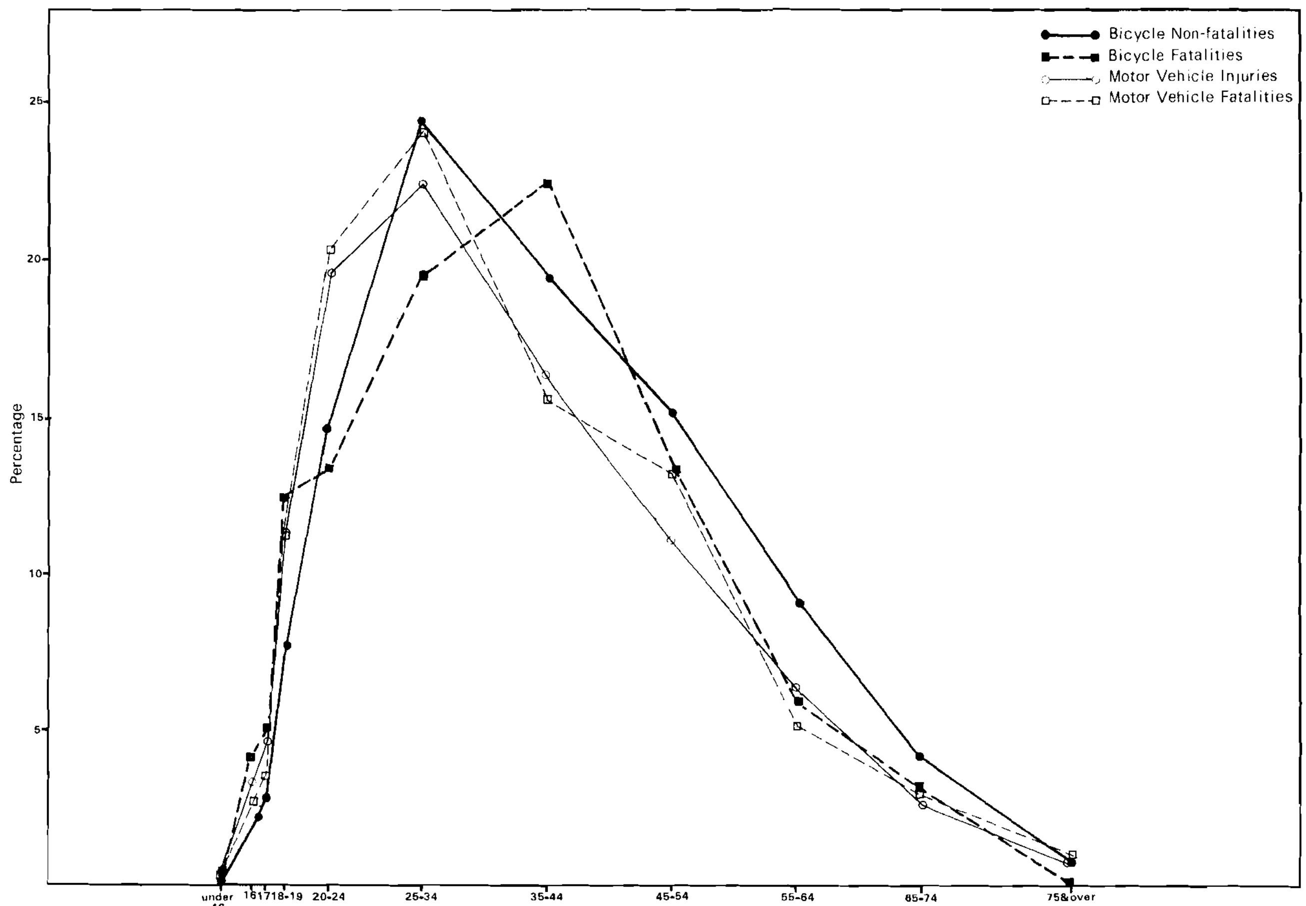

FIGURE 18. AGE OF DRIVER

in the mean ages of the motor vehicle drivers involved further substantiates these observations and suggests an overall average of approximately 37 years of age for the motor vehicle driver involved in a non-fatal bicycle accident and 33 years of age for the motor vehicle driver represented in non-fatal motor vehicle accidents. When fatal and non-fatal bicycle accidents are compared with each other, there are no significant differences found in the age of the motor vehicle drivers involved ($.05 < p < .10$).

Physical Condition of the Driver of the Motor Vehicle

Our comparisons on this variable excluded those cases where no judgment was made regarding the physical condition of the driver. Hence we are comparing only those instances in which the driver was definitely judged to be in normal condition or judged to be in some way not normal, e.g., ill, fatigued, or asleep (see Figure 19). In almost all accidents the physical condition of the driver of the motor vehicle is judged to be normal. When fatal accidents are examined, there are no significant differences between bicycle and all motor vehicle accidents ($p < .1$). However, for non-fatal accidents, compared with drivers of all motor vehicles, an even greater proportion of drivers involved in bicycle accidents is adjudged to be in normal physical condition ($p < .001$).

V. Characteristics of the Bicyclist

Sex of Bicyclist

The greatest proportion of both fatal and non-fatal bicycle accidents involved male riders. As can be seen in Figure 20, close to 90% of all bicyclists involved in accidents are males. There are no differences in

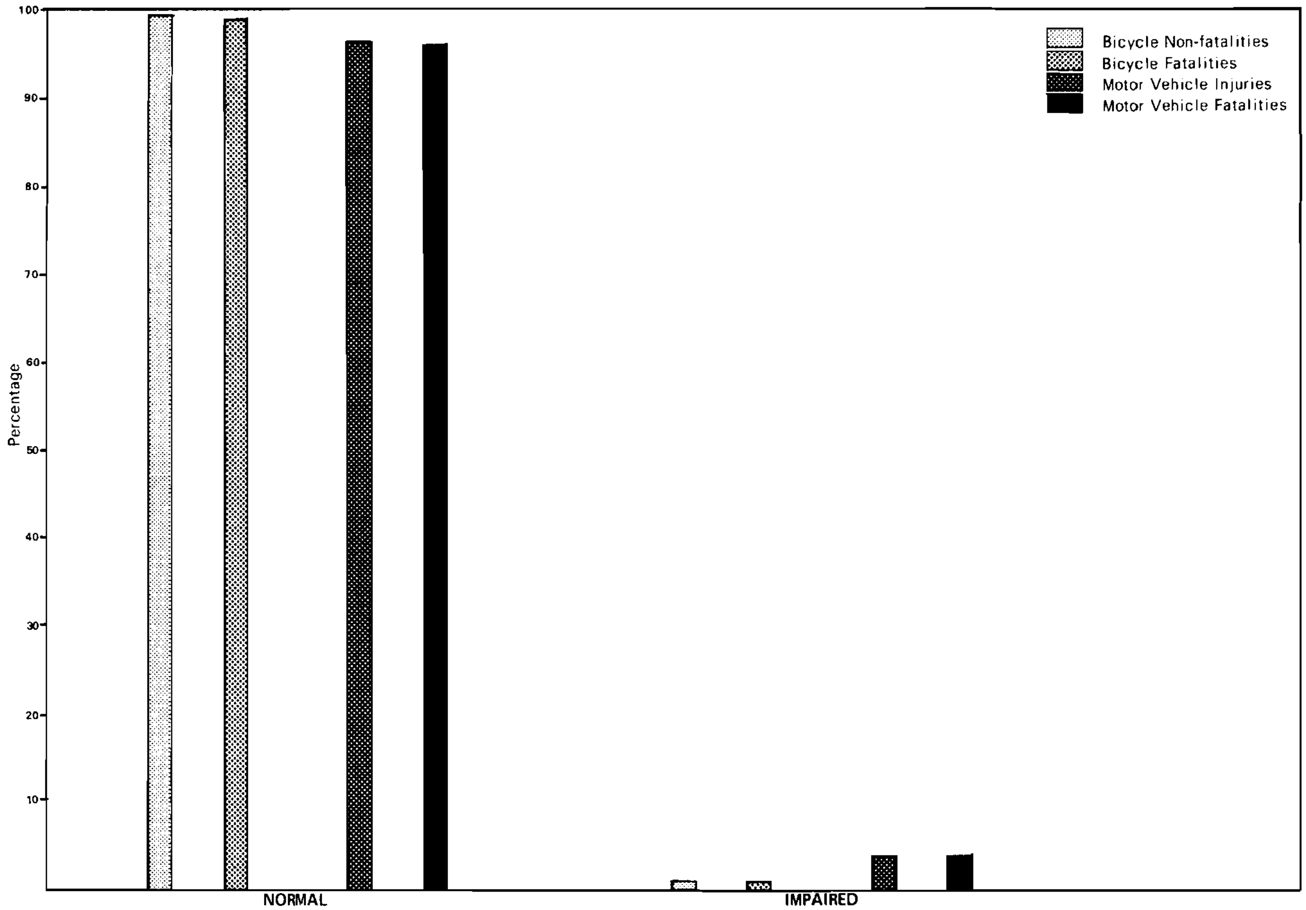

FIGURE 19. PHYSICAL CONDITION OF DRIVER

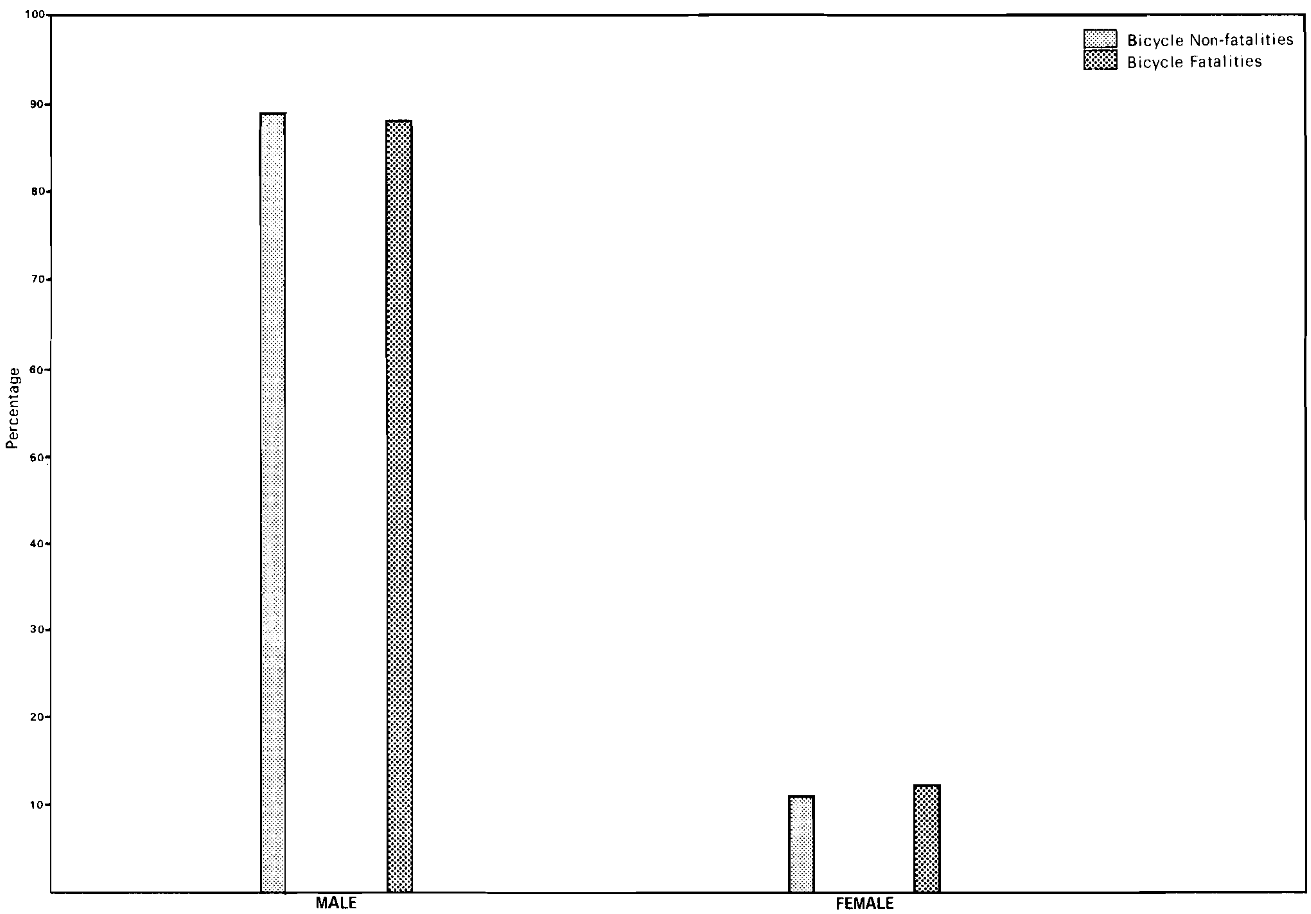

FIGURE 20. SEX OF BICYCLIST

this regard when fatal and non-fatal bicycle accidents are compared ($p > .5$). Since we have no data on exposure by sex of bicyclist, it is not possible to determine whether males are overrepresented in the accident population. However, it is highly probable that most bicycle riding is done by male riders.

Age of Bicyclist

Approximately half of all bicycle accidents, both fatal and non-fatal, involve bicyclists in the age range from 10 to 14 years (see Figure 21). The next greatest proportion is in the age range from 5 to 9 years, with the third greatest portion age 15 through 19 years. These figures undoubtedly reflect to a large extent exposure factors. However, a number of adults are involved in bicycle accidents, and here it is more difficult to estimate exposure. For example, the two fatal accidents involving riders age 75 or over may well be an overrepresentation of this age group were exposure figures available.

When fatal and non-fatal bicycle accidents are compared with respect to the age of the bicyclist, the Chi square test fails to detect a significant difference ($.05 < p < .1$). However, the RANOVA F test, taking into account the fact that the age groupings are ordered, does indicate significant differences ($p < .025$). The index G (-.185) suggests that non-fatal accidents are more likely to involve the younger bicyclist. Younger riders probably stay closer to home (residential areas) where it has been previously noted that non-fatal bicycle accidents are more likely to occur. This finding is also consistent with the fact that daytime bicycle accidents are less likely to result in fatalities; i.e., younger riders would be unlikely to be out at night.

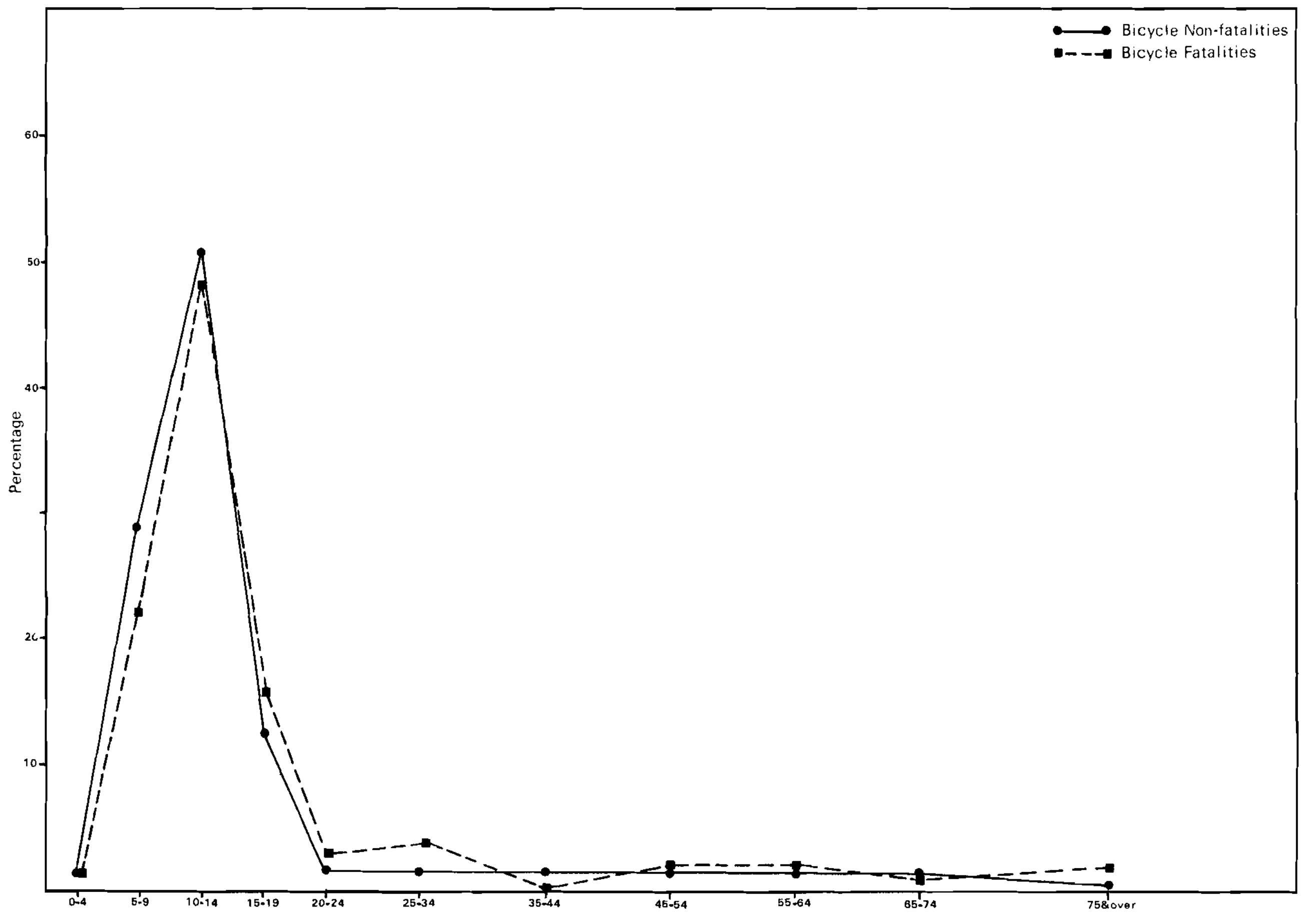

FIGURE 21. AGE OF BICYCLIST

SUMMARY

Bicycle accidents in North Carolina were found to vary according to a number of factors. First of all, the month of the year and the day of the week were associated with variations in number of bicycle accidents. Summer months and Saturdays contribute proportionately greater frequencies of bicycle accidents. Furthermore, compared with all motor vehicle accidents, bicycle accidents are more likely to occur in residential areas on city streets. However, compared with non-fatal bicycle accidents, fatal bicycle accidents are more likely to occur in open country on non-city streets.

Like most accidents, bicycle accidents are most likely to occur on straight level roads which are dry and have no reported defects. Furthermore they usually occur in clear weather during daylight hours. However, if a bicycle accident occurs at night on an unlighted road, it has a higher probability of being fatal than is true for daylight accidents.

Perhaps one of the most important differences between bicycle accidents and all motor vehicle accidents is that bicycle accidents are much more likely to occur where there is some kind of intersection, such as an alley, a driveway, or two roads crossing.

When bicycle accidents are compared with all motor vehicle accidents, it is found that bicycle accidents are more likely to involve a motor vehicle that is going straight ahead and at a lower speed. However, fatal bicycle accidents involve higher speeds than non-fatal ones.

When compared with all motor vehicle accidents, bicycle accidents are even less likely to involve a motor vehicle with a reported defect. Furthermore, the driver involved in a bicycle accident is less likely to be charged with a violation than drivers involved in all motor vehicle accidents.

While most drivers involved in accidents are males, in bicycle accidents there is a greater proportion of female drivers, probably reflecting the time and place of bicycle accidents, i.e., daytime in a residential area. Also, the driver in a non-fatal bicycle accident tends to be somewhat older than drivers involved in non-fatal motor vehicle accidents in general. The vast majority of drivers involved in bicycle accidents are adjudged to be in normal physical condition.

Who are the riders of the bicycles involved in accidents? The great majority are young males ranging from age 5 through 19, with the greatest proportion between 10 and 14 years of age. Since we do not have information concerning exposure, it is impossible to say whether the accident proportions for age and sex roughly approximate the exposure, or whether male riders are indeed overrepresented (they constitute almost 90% of both fatal and non-fatal accidents).

It appears that the typical bicycle accident occurs in clear dry weather during daylight hours and involves a male automobile driver between the ages of 24 and 45. The cyclist is usually a young male between 10 and 14 years of age who apparently emerges unexpectedly from a driveway, alley, or intersection of some sort. Fatal bicycle accidents appear to be associated with the older bicycle rider, possibly reflecting the tendency of the younger rider to remain closer to home (in a residential area) where accidents are less likely to result in fatalities. In most cases there is no defect found in the motor vehicle, the driver is in normal physical condition, and there are no violations reported.

Because of the particular characteristics of these accidents, it is not easy to make recommendations that clearly would lead to a reduction in their frequency. However, it was found that bicycle accidents occurring at night on unlighted roads have a higher tendency to be fatal. Therefore, efforts to promote the use of more highly visible wearing apparel and more highly visible bicycles would possibly lead to a reduction in the high nighttime fatality rate for bicyclists.

APPENDIX A

Frequency and Percentage Distributions of Bicycle and Motor Vehicle Accidents in North Carolina

Frequencies (percentages) within accident types for each of the variables discussed in the text are presented in the following tables. Since "not stated" and "blank" entries were omitted in the analyses, they are likewise omitted in these tables, accounting for the variations in the marginal totals.

The following notation is used:

Accident types:

Bi F = bicycle fatality

Bi N-F = bicycle non-fatality

MV F = motor vehicle fatality

MV N-F = motor vehicle injury

Test statistics:

$\chi^2_{Bi}(\ )$ = calculated Chi square statistic with ( ) d.f. for Bi F vs. Bi N-F comparisons

$F_{Bi}(\ ,\ )$ = RANOVA F statistic with (,) d.f. for testing homogeneity of the Bi F and Bi N-F distributions over the variable under consideration

G_{Bi} = Goodman - Kruskal index of association of Bi F and Bi N-F with the variable under consideration

$s(G_{Bi})$ = standard error of G_{Bi}

Similar notation is used for the Bi F vs. MV F comparisons and the Bi N-F vs. MV N-F comparisons.

It should be noted that, since the non-fatal accidents far outnumber the fatal accidents, differences between bicycle and motor vehicle accidents are much more likely to be detected in the former case than in the latter.

Table A-1. Month of Year

Month	Bi N-F No.	Bi N-F (%)	Bi F No.	Bi F (%)	MV N-F No.	MV N-F (%)	MV F No.	MV F (%)
January	97	(4.17)	9	(8.26)	2482	(7.31)	109	(7.09)
February	123	(5.29)	4	(3.67)	2181	(6.44)	94	(6.11)
March	148	(6.36)	5	(4.59)	2351	(6.94)	131	(8.52)
April	200	(8.60)	10	(9.17)	2764	(8.16)	128	(8.32)
May	221	(9.50)	6	(5.50)	2947	(8.70)	131	(8.52)
June	312	(13.41)	15	(13.76)	2665	(7.86)	106	(6.89)
July	288	(12.38)	13	(11.93)	2916	(8.61)	147	(9.56)
August	307	(13.20)	11	(10.09)	3008	(8.88)	117	(7.61)
September	237	(10.19)	10	(9.17)	2912	(8.59)	134	(8.71)
October	178	(7.65)	9	(8.26)	3278	(9.67)	145	(9.42)
November	117	(5.03)	8	(7.34)	3043	(8.98)	129	(8.39)
December	98	(4.22)	9	(8.26)	3340	(9.86)	167	(10.86)
TOTAL	2326	(100.00)	109	(100.00)	33887	(100.00)	1538	(100.00)

χ^2_F (1) = 3.52 (.05 < p < .10)

χ^2_{N-F} (1) = 227.90 (p < .001)

Table A-2. Day of Week

Day	Bi N-F No.	Bi N-F (%)	Bi F No.	Bi F (%)	MV N-F No.	MV N-F (%)	MV F No.	MV F (%)
Monday	301	(12.84)	14	(12.84)	3885	(11.45)	173	(11.25)
Tuesday	325	(13.87)	16	(14.68)	3568	(10.53)	149	(9.69)
Wednesday	304	(12.97)	8	(7.34)	3632	(10.72)	131	(8.52)
Thursday	314	(13.40)	12	(11.01)	3836	(11.32)	148	(9.62)
Friday	386	(16.46)	15	(13.76)	5613	(16.56)	258	(16.78)
Saturday	435	(18.56)	28	(25.69)	7824	(23.09)	374	(24.32)
Sunday	279	(11.90)	16	(14.68)	5534	(16.33)	305	(19.82)
TOTAL	2344	(100.00)	109	(100.00)	33892	(100.00)	1538	(100.00)

χ^2_F (6) = 5.15 (p > .50)

χ^2_{N-F} (6) = 91.34 (p < .001)

χ^2_{Bi} (6) = 7.03 (p > .25)

Table A-3. Locality

Locality	Bi N-F No.	Bi N-F (%)	Bi F No.	Bi F (%)	MV N-F No.	MV N-F (%)	MV F No.	MV F (%)
Residential	1367	(69.29)	28	(26.92)	10937	(40.85)	259	(18.21)
Open country	606	(30.71)	76	(73.08)	15836	(59.15)	1163	(81.79)
SUBTOTAL	1973	(100.00)	104	(100.00)	26773	(100.00)	1422	(100.00)
Business or playground	371		5		7119		116	
TOTAL	2344		109		33892		1538	

$\chi^2_F\ (1) = 4.81 \quad (.025 < p < .05)$

$\chi^2_{N-F}\ (1) = 606.86 \quad (p < .001)$

$\chi^2_{Bi}\ (1) = 80.40 \quad (p < .001)$

Table A-4. Highway Class

Highway Class	Bi N-F No.	Bi N-F (%)	Bi F No.	Bi F (%)	MV N-F No.	MV N-F (%)	MV F No.	MV F (%)
Interstate	5	(0.21)	0	(0.00)	618	(1.83)	55	(3.58)
Major	353	(15.06)	41	(37.61)	13267	(39.14)	833	(54.16)
Minor	558	(23.81)	55	(50.46)	7633	(22.52)	471	(30.62)
City	1428	(60.92)	13	(11.93)	12374	(36.51)	179	(11.64)
TOTAL	2344	(100.00)	109	(100.00)	33892	(100.00)	1538	(100.00)

$\chi^2_F\ (3) = 21.70 \quad (p < .001)$

$\chi^2_{N-F}\ (3) = 716.02 \quad (p < .001)$

$\chi^2_{Bi}\ (3) = 105.39 \quad (p < .001)$

$F_{Bi}\ (1,2450) = 105.40 \quad (p < .001)$

$G_{Bi} = 0.668, \quad s(G_{Bi}) = 0.039$

Table A-5. Road Construction

Road Construction	Bi N-F No.	Bi N-F (%)	Bi F No.	Bi F (%)	MV N-F No.	MV N-F (%)	MV F No.	MV F (%)
Smooth asphalt	1464	(62.46)	59	(54.13)	20089	(59.67)	829	(54.22)
Coarse asphalt	662	(28.24)	37	(33.94)	9293	(27.61)	517	(33.81)
Concrete	95	(4.05)	5	(4.59)	3176	(9.43)	142	(9.29)
All other	123	(5.25)	8	(7.34)	1109	(3.29)	41	(2.68)
TOTAL	2344	(100.00)	109	(100.00)	33667	(100.00)	1529	(100.00)

χ^2_F (3) = 9.89 (p = .02)

χ^2_{N-F} (3) = 97.48 (p < .001)

Table A-6. Roadway Feature

Roadway Feature	Bi N-F No.	Bi N-F (%)	Bi F No.	Bi F (%)	MV N-F No.	MV N-F (%)	MV F No.	MV F (%)
No special feature	857	(37.07)	62	(56.88)	16920	(51.68)	1065	(72.95)
Driveway, alley intersection, or intersection of two roadways	1455	(62.93)	47	(43.12)	15819	(48.32)	395	(27.05)
TOTAL	2312	(100.00)	109	(100.00)	32739	(100.00)	1460	(100.00)

χ^2_F (1) = 12.94 (p < .001)

χ^2_{N-F} (1) = 184.52 (p < .001)

χ^2_{Bi} (1) = 17.35 (p < .001)

Table A-7. Road Character

Road Character	Bi N-F No.	Bi N-F (%)	Bi F No.	Bi F (%)	MV N-F No.	MV N-F (%)	MV F No.	MV F (%)
Straight level road	1520	(65.83)	63	(58.33)	18220	(54.14)	680	(44.41)
Straight road on hillcrest or straight road on grade	572	(24.77)	26	(24.07)	7545	(22.42)	319	(20.84)
Sharp curve on level or other curve on level	96	(4.16)	12	(11.11)	4269	(12.69)	292	(19.07)
Other curves	121	(5.24)	7	(6.48)	3619	(10.75)	240	(15.68)
TOTAL	2309	(100.00)	108	(99.99)	33653	(100.00)	1531	(100.00)

$\chi^2_F\ (3) = 13.92 \quad (p < .005)$ $\qquad$ $\chi^2_{N-F}\ (3) = 251.70 \quad (p < .001)$

Table A-8. Road Conditions

Road Conditions	Bi N-F No.	Bi N-F (%)	Bi F No.	Bi F (%)	MV N-F No.	MV N-F (%)	MV F No.	MV F (%)
Dry	2152	(93.08)	102	(94.44)	25914	(76.95)	1238	(80.76)
Wet	154	(6.66)	6	(5.56)	6834	(20.29)	279	(18.20)
Oily, muddy, icy, or snowy	6	(0.26)	0	(0.00)	930	(2.76)	16	(1.04)
TOTAL	2312	(100.00)	108	(100.00)	33678	(100.00)	1533	(100.00)

$\chi^2_F\ (2) = 12.73 \quad (p < .005)$ $\qquad$ $\chi^2_{N-F}\ (2) = 331.32 \quad (p < .001)$

Table A-9. Road Defects

Road Defects	Bi N-F No.	Bi N-F (%)	Bi F No.	Bi F (%)	MV N-F No.	MV N-F (%)	MV F No.	MV F (%)
No defects	2208	(96.29)	103	(95.37)	32180	(95.91)	1468	(96.07)
Defects	85	(3.71)	5	(4.63)	1372	(4.09)	60	(3.93)
TOTAL	2293	(100.00)	108	(100.00)	33552	(100.00)	1528	(100.00)

Table A-10. Weather Conditions

Weather Conditions	Bi N-F No.	Bi N-F (%)	Bi F No.	Bi F (%)	MV N-F No.	MV N-F (%)	MV F No.	MV F (%)
Clear	1911	(82.19)	93	(86.11)	22294	(66.07)	1044	(68.24)
Cloudy	325	(13.98)	12	(11.11)	5563	(16.49)	253	(16.54)
Rain, snow, fog, sleet, or hail	89	(3.83)	3	(2.78)	5884	(17.44)	233	(15.22)
TOTAL	2325	(100.00)	108	(100.00)	33741	(100.00)	1530	(100.00)

χ^2_F (2) = 17.33 $(p < .001)$

χ^2_{N-F} (2) = 335.91 $(p < .001)$

F_F (1,1635) = 16.94 $(p < .001)$

F_{N-F} (1,36063) = 307.00 $(p < .001)$

χ^2_{Bi} (2) = 1.11 $(p > .50)$

Table A-11. Light Conditions

Light Conditions	Bi N-F No.	(%)	Bi F No.	(%)	MV N-F No.	(%)	MV F No.	(%)
Daylight	1911	(81.70)	75	(68.81)	19643	(58.55)	684	(45.00)
Dusk	116	(4.96)	6	(5.50)	1023	(3.05)	51	(3.36)
Darkness -- road lighted	180	(7.70)	2	(1.83)	5168	(15.40)	133	(8.75)
Darkness -- road not lighted	132	(5.64)	26	(23.85)	7716	(23.00)	652	(42.89)
TOTAL	2339	(100.00)	109	(99.99)	33550	(100.00)	1520	(100.00)

χ^2_F (3) = 28.44 $(p < .001)$

χ^2_{N-F} (3) = 608.67 $(p < .001)$

χ^2_{Bi} (3) = 60.52 $(p < .001)$

Table A-12. Vehicle Maneuver

Vehicle Maneuver	Bi N-F No.	(%)	Bi F No.	(%)	MV N-F No.	(%)	MV F No.	(%)
Going straight	1841	(84.33)	87	(88.78)	24660	(80.67)	1310	(88.99)
Passing	81	(3.71)	11	(11.22)	833	(2.73)	68	(4.62)
Making left turn	124	(5.68)	0	(0.00)	2646	(8.66)	56	(3.81)
Other maneuver	137	(6.28)	0	(0.00)	2429	(7.94)	38	(2.58)
TOTAL	2183	(100.00)	98	(100.00)	30568	(100.00)	1472	(100.00)

χ^2_F (3) = 14.23 $(p < .005)$

χ^2_{N-F} (3) = 39.05 $(p < .001)$

Table A-13. Approximate Speed

Approximate Speed	Bi N-F No.	Bi N-F (%)	Bi F No.	Bi F (%)	MV N-F No.	MV N-F (%)	MV F No.	MV F (%)
0-19	589	(30.03)	4	(4.54)	9077	(29.66)	135	(9.92)
20-39	934	(47.63)	22	(25.00)	9342	(30.51)	241	(17.71)
40-59	422	(21.52)	56	(63.64)	8748	(28.57)	561	(41.22)
60 and over	16	(0.82)	6	(6.82)	3448	(11.26)	424	(31.15)
TOTAL	1961	(100.00)	88	(100.00)	30615	(100.00)	1361	(100.00)

χ^2_F (3) = 31.16 $(p < .001)$

χ^2_{N-F} (3) = 392.94 $(p < .001)$

F_F (1,1446) = 8.34 $(p < .001)$

F_{N-F} (1,32573) = 131.15 $(p < .001)$

χ^2_{Bi} (3) = 120.45 $(p < .001)$

F_{Bi} (1,2046) = 90.58 $(p < .001)$

$G_{Bi} = -0.746$, $s(G_{Bi}) = 0.051$

Table A-14. Point of Contact

Point of Contact	Bi N-F No.	Bi N-F (%)	Bi F No.	Bi F (%)	MV N-F No.	MV N-F (%)	MV F No.	MV F (%)
Front	971	(44.50)	56	(57.14)	8434	(37.52)	497	(51.61)
Right front	472	(21.63)	27	(27.55)	2809	(12.50)	123	(12.77)
Left front	253	(11.59)	12	(12.25)	3079	(13.70)	133	(13.81)
Sides or rear	486	(22.28)	3	(3.06)	8153	(36.28)	210	(21.81)
TOTAL	2182	(100.00)	98	(100.00)	22475	(100.00)	963	(100.00)

χ^2_F (3) = 29.99 $(p < .001)$

χ^2_{N-F} (3) = 267.87 $(p < .001)$

χ^2_{Bi} (3) = 21.00 $(p < .001)$

Table A-15. Vehicle Defect

Vehicle Defect	Bi N-F No.	Bi N-F (%)	Bi F No.	Bi F (%)	MV N-F No.	MV N-F (%)	MV F No.	MV F (%)
Defect	18	(0.93)	4	(4.30)	2227	(8.71)	108	(10.99)
No defect	1923	(99.07)	89	(95.70)	23349	(91.29)	875	(89.01)
TOTAL	1941	(100.00)	93	(100.00)	25576	(100.00)	983	(100.00)

χ^2_F (1) = 4.07 ($p < .05$) χ^2_{N-F} (1) = 145.74 ($p < .001$)

Table A-16. Violation - Driver Charged

Violation-Driver Charged	Bi N-F No.	Bi N-F (%)	Bi F No.	Bi F (%)	MV N-F No.	MV N-F (%)	MV F No.	MV F (%)
Driver charged	169	(7.62)	24	(24.49)	13689	(41.27)	303	(20.19)
Driver not charged	2048	(92.38)	74	(75.51)	19478	(58.73)	1198	(79.81)
TOTAL	2217	(100.00)	98	(100.00)	33167	(100.00)	1501	(100.00)

χ^2_F (1) = 1.05 ($p > .25$) χ^2_{N-F}(1) = 987.61 ($p < .001$)

Table A-17. Sex of Driver

Sex of Driver	Bi N-F No.	Bi N-F (%)	Bi F No.	Bi F (%)	MV N-F No.	MV N-F (%)	MV F No.	MV F (%)
Male	1586	(72.65)	73	(75.26)	25143	(76.34)	1280	(86.60)
Female	597	(27.35)	24	(24.74)	7794	(23.66)	198	(13.40)
TOTAL	2183	(100.00)	97	(100.00)	32937	(100.00)	1478	(100.00)

χ^2_F (1) = 9.68 ($p < .005$) χ^2_{N-F} (1) = 15.28 ($p < .001$)

Table A-18. Age of Driver

Age of Driver	Bi N-F No.	Bi N-F (%)	Bi F No.	Bi F (%)	MV N-F No.	MV N-F (%)	MV F No.	MV F (%)
Under 16	0	(0.00)	0	(0.00)	75	(0.23)	4	(0.27)
16	47	(2.16)	4	(4.12)	1267	(3.85)	45	(3.05)
17	73	(3.35)	5	(5.15)	1547	(4.71)	56	(3.80)
18-19	163	(7.48)	12	(12.37)	3795	(11.54)	159	(10.79)
20-24	316	(14.50)	13	(13.40)	6422	(19.54)	298	(20.24)
25-34	530	(24.32)	19	(19.59)	7402	(22.52)	356	(24.17)
35-44	421	(19.32)	22	(22.68)	5403	(16.44)	228	(15.48)
45-54	329	(15.10)	13	(13.40)	3709	(11.28)	192	(13.03)
55-64	193	(8.86)	6	(6.18)	2120	(6.44)	76	(5.16)
65-74	88	(4.04)	3	(3.09)	920	(2.80)	42	(2.85)
75 and over	19	(0.87)	0	(0.00)	213	(0.65)	17	(1.15)
TOTAL	2179	(100.00)	97	(99.98)	32873	(100.00)	1473	(99.99)

χ^2_F (10) = 8.50 $(p > .50)$

χ^2_{N-F} (10) = 155.10 $(p < .001)$

χ^2_{Bi} (10) = 8.84 $(p > .50)$

χ'^2_F (1) = 0.17 $(p > .50)$

χ'^2_{N-F} (1) = 118.35 $(p < .001)$

χ'^2_{Bi} (1) = 3.05 $(.05 < p < .10)$

Table A-19. Physical Condition of Driver

Physical Condition of Driver	Bi N-F No.	Bi N-F (%)	Bi F No.	Bi F (%)	MV N-F No.	MV N-F (%)	MV F No.	MV F (%)
Normal	2073	(99.47)	91	(98.91)	28862	(96.05)	965	(96.12)
Impaired	11	(0.53)	1	(1.09)	1188	(3.95)	39	(3.88)
TOTAL	2084	(100.00)	92	(100.00)	30050	(100.00)	1004	(100.00)

χ^2_F (1) = 1.88 $(p > .10)$

χ^2_{N-F} (1) = 63.67 $(p < .001)$

APPENDIX B

Distribution of North Carolina Bicycle Accidents in Time According to Longitude

The National Highway Safety Bureau raised the question of how the time of local sunset might affect the occurrence of bicycle accidents, that is, how longitude within a time zone might be associated with variations in the time distribution of bicycle accidents. To investigate this question, we divided the state of North Carolina into thirds according to longitude. The counties in the eastern third were then compared with the counties in the western third of the state. If a county fell partly in and partly out of the dividing line, we included it only if half or more of it was located within the third in question. This method resulted in 35 counties in the eastern third of the state and 22 in the western third. Table B1 lists the counties in the eastern and western groups.

Because of the differing numbers of counties, as well as other differences in population, comparisons were based on percentages within the regions rather than on absolute frequencies. Figures B1 through B9 show the percentages of accidents occurring throughout the 24 hours. Because of the low frequencies for fatal bicycle accidents, especially in the western counties (see Table B2), statistical tests were run only for the non-fatal accidents. As would be surmised from inspection of the graphs, there were no significant differences found between the time distributions for bicycle accidents occurring in the east and for those occurring in the west.

It should be pointed out that North Carolina is perhaps not an ideal state in which to test a hypothesis concerning the effects of longitude.

Table A-20. Sex of Bicyclist

Sex of Bicyclist	Bi N-F No.	Bi N-F (%)	Bi F No.	Bi F (%)
Male	2083	(89.17)	96	(88.07)
Female	253	(10.83)	13	(11.93)
TOTAL	2336	(100.00)	109	(100.00)

χ^2_{Bi} (1) = 0.129 ($p > .50$)

Table A-21. Age of Bicyclist

Age of Bicyclist	Bi N-F No.	Bi N-F (%)	Bi F No.	Bi F (%)
0- 9	697	(29.91)	25	(23.15)
10-14	1177	(50.52)	52	(48.15)
15-19	286	(12.27)	17	(15.73)
20-24	33	(1.42)	3	(2.78)
25 and over	137	(5.88)	11	(10.19)
TOTAL	2330	(100.00)	108	(100.00)

χ^2_{Bi} (4) = 7.16 ($.05 < p < .10$) F_{Bi} (1,2435) = 5.53 ($p < .025$)

$G_{Bi} = -0.185$, $s(G_{Bi}) = 0.079$

The geographical peculiarities of this state are such that they might well preclude detection of any effects that might exist. The eastern part of the state is essentially flat, while the western third is in the Appalachian range. Thus any differences in daylight that might obtain if both areas were at sea level might possibly be canceled by the presence of mountains in the west. Consequently, even though no differences were found related to longitude, the terrain of North Carolina is such that any differences might not be detected.

Table B1. North Carolina Counties (Central 1/3 Omitted)

Eastern 1/3	Western 1/3
Beaufort	Ashe
Bertie	Avery
Brunswick	Buncombe
Camden	Burke
Carteret	Caldwell
Chowan	Cherokee
Craven	Clay
Currituck	Cleveland
Dare	Graham
Duplin	Haywood
Edgecombe	Henderson
Franklin	Jackson
Gates	Macon
Greene	Madison
Halifax	McDowell
Hertford	Mitchell
Hyde	Polk
Johnston	Rutherford
Jones	Swain
Lenoir	Transylvania
Martin	Watauga
Nash	Yancey
Northhampton	
Onslow	
Pamlico	
Pasquotank	
Pender	
Perquimans	
Pitt	
Sampson	
Tyrrell	
Warren	
Washington	
Wayne	
Wilson	

Table B2. North Carolina Bicycle Fatalities and Non-Fatalities

		FATAL			NON-FATAL		
		Eastern	Western	All State (including central)	Eastern	Western	All State (including central)
AM							
12M	12:59	1	0	1	1	0	5
1:00	1:59	0	0	0	1	0	2
2:00	2:59	0	0	0	0	0	1
3:00	3:59	0	0	0	0	0	0
4:00	4:59	0	0	0	0	0	1
5:00	5:59	0	0	0	2	0	2
6:00	6:59	0	0	0	3	1	9
7:00	7:59	0	0	2	16	1	44
8:00	8:59	0	0	1	25	3	83
9:00	9:59	2	1	5	12	3	39
10:00	10:59	3	0	4	29	10	85
11:00	11:59	1	1	4	35	11	99
		(7)	(2)	(17)	(124)	(29)	(370)
PM							
12N	12:59	1	0	5	32	9	137
1:00	1:59	4	1	9	39	8	111
2:00	2:59	1	6	10	36	10	138
3:00	3:59	1	1	7	60	24	275
4:00	4:59	3	1	11	69	25	307
5:00	5:59	1	0	13	96	27	358
6:00	6:59	4	3	12	71	15	261
7:00	7:59	4	0	5	53	14	181
8:00	8:59	4	2	9	18	6	86
9:00	9:59	3	1	5	13	3	35
10:00	10:59	1	0	3	3	1	14
11:00	11:59	0	1	1	6	6	26
		(27)	(16)	(90)	(496)	(148)	(1929)

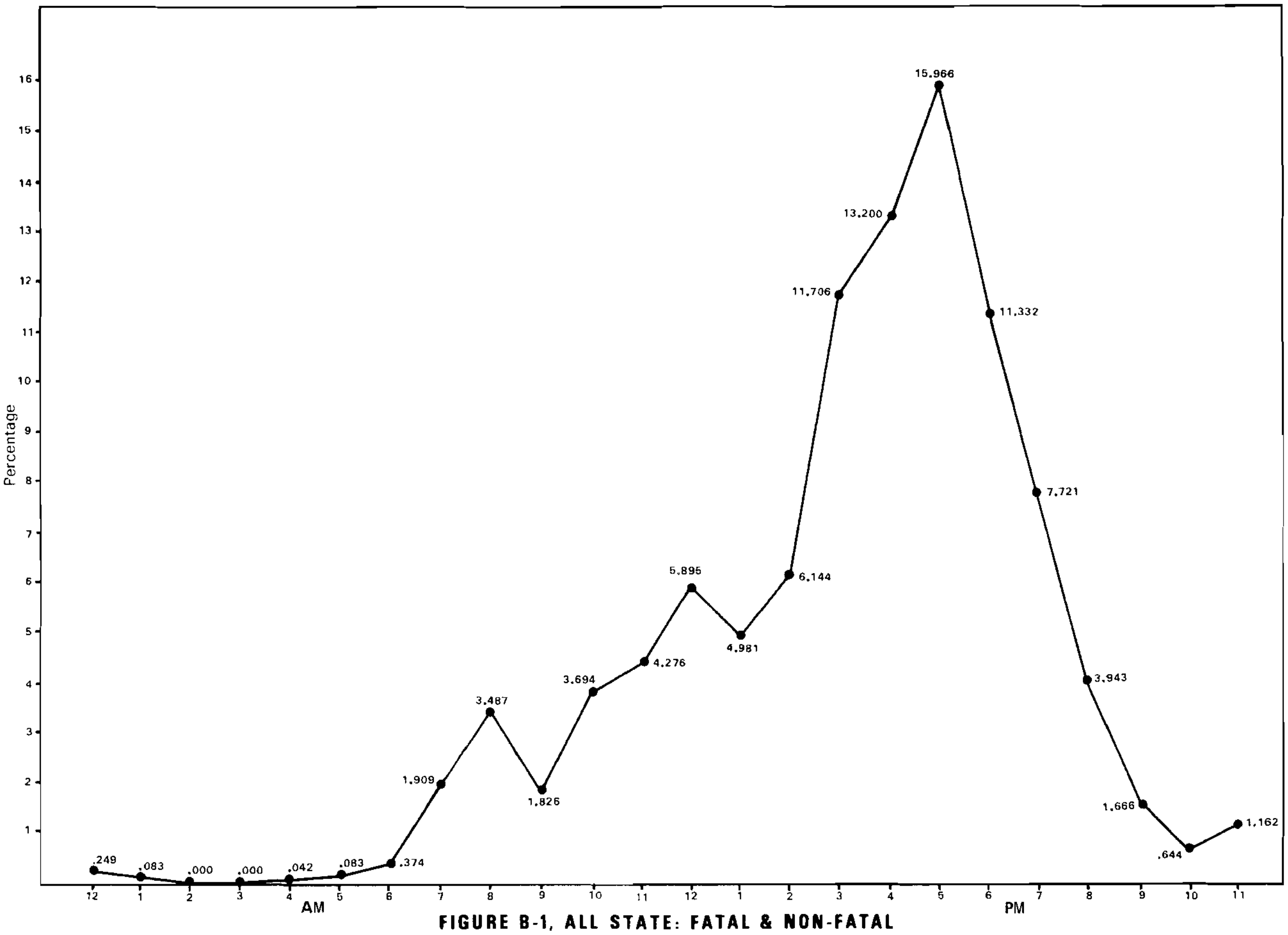

FIGURE B-1, ALL STATE: FATAL & NON-FATAL

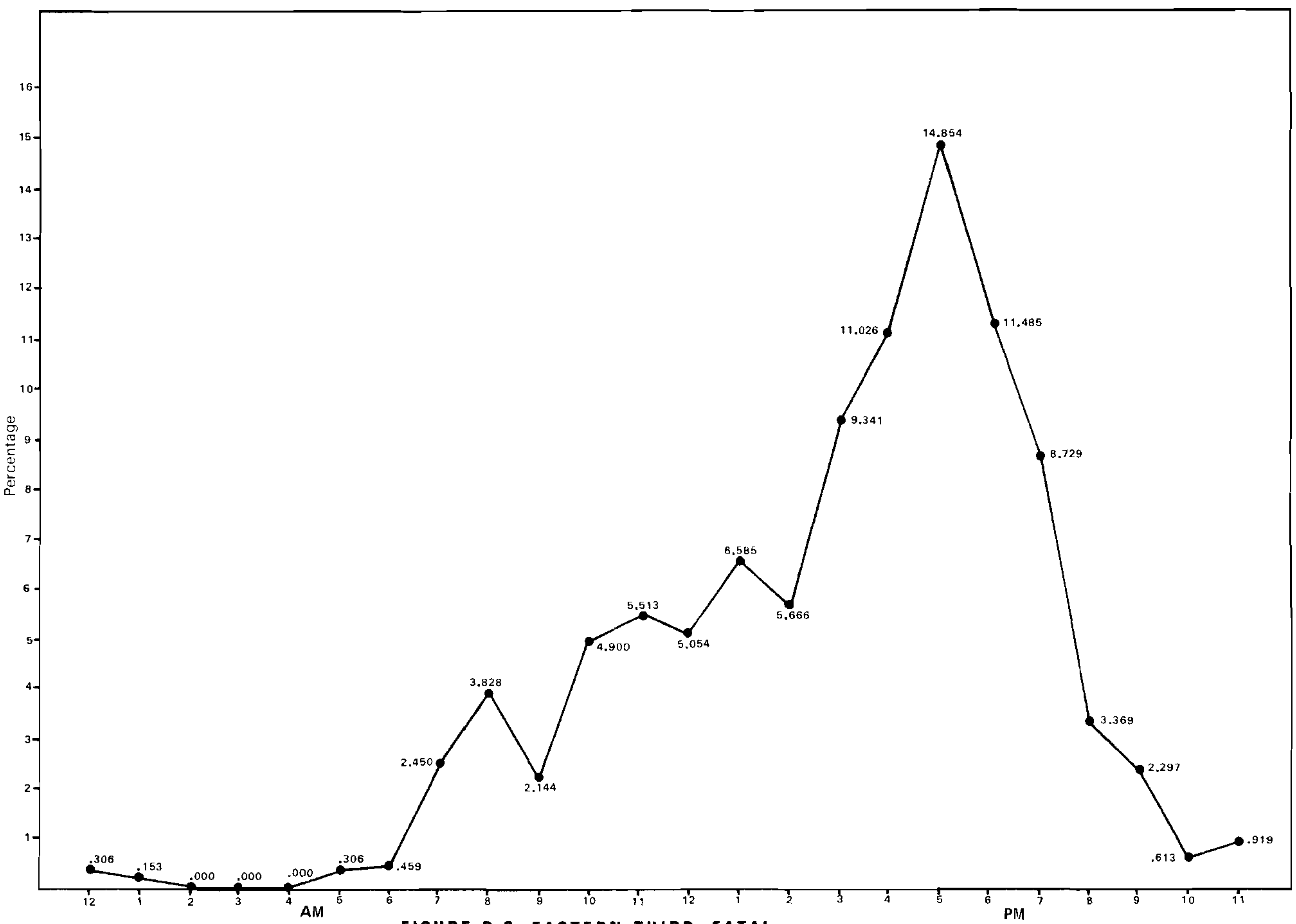

FIGURE B-2, EASTERN THIRD: FATAL

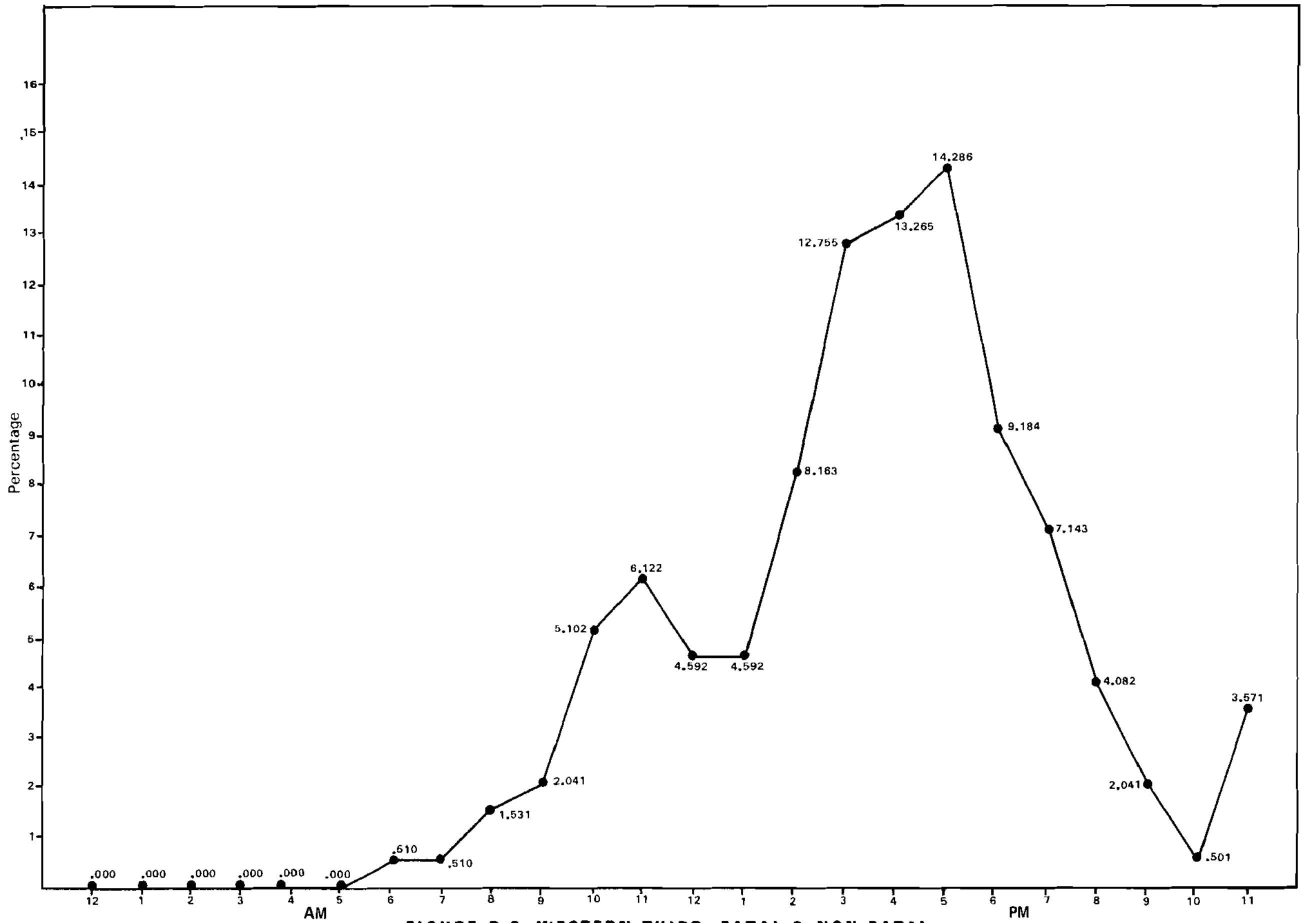

FIGURE B-3, WESTERN THIRD: FATAL & NON-FATAL

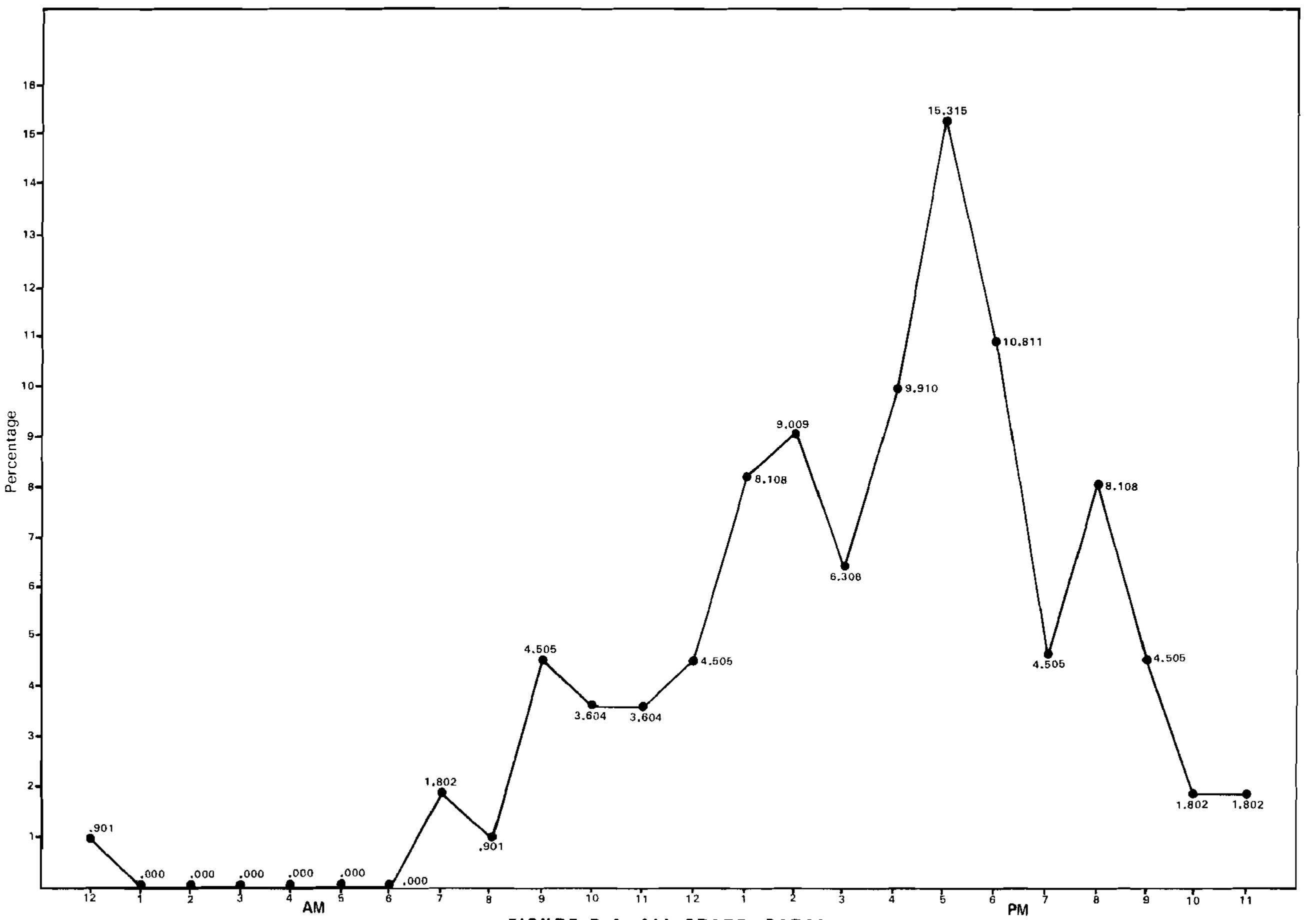

FIGURE B-4, ALL STATE: FATAL

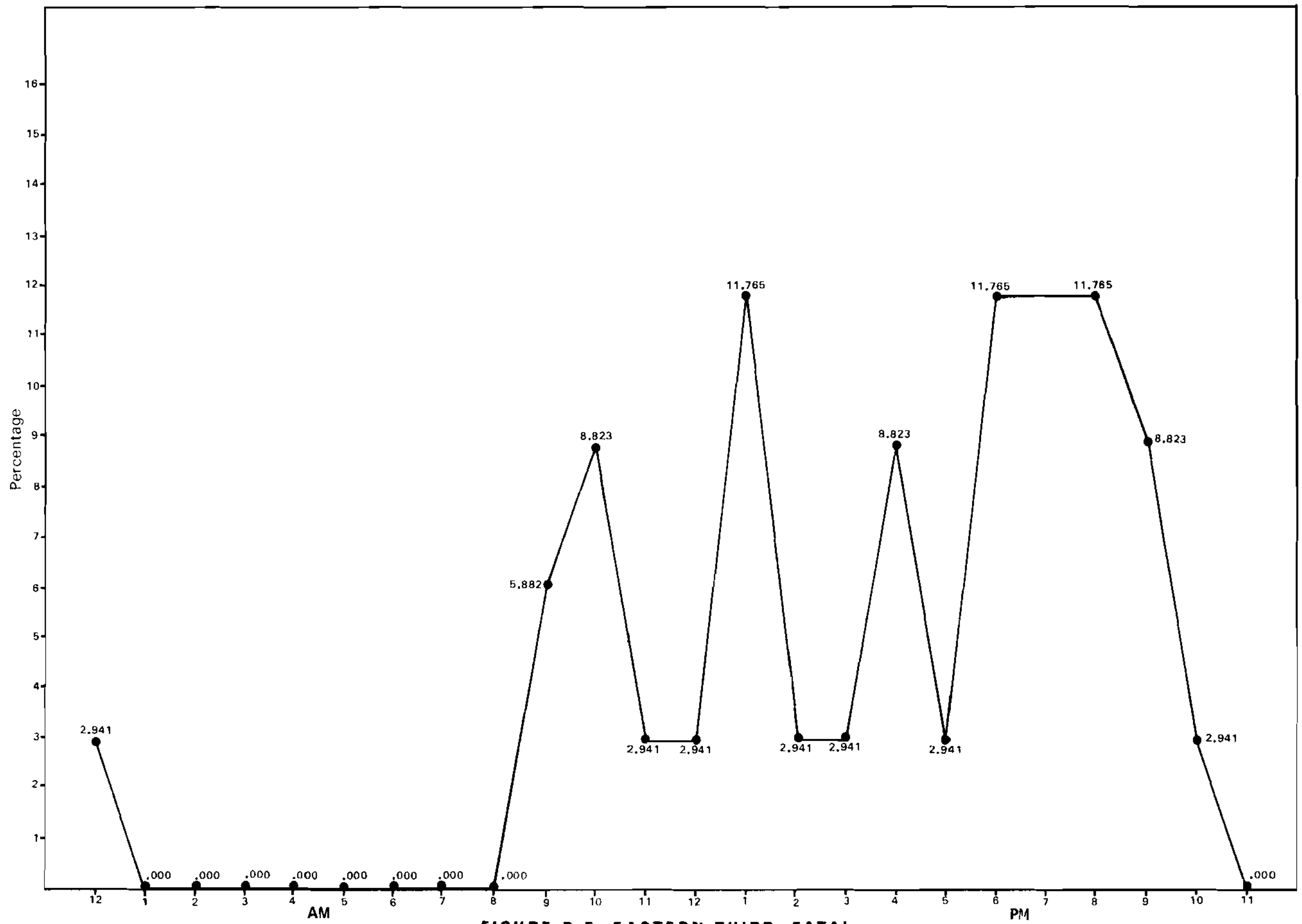

FIGURE B-5, EASTERN THIRD: FATAL

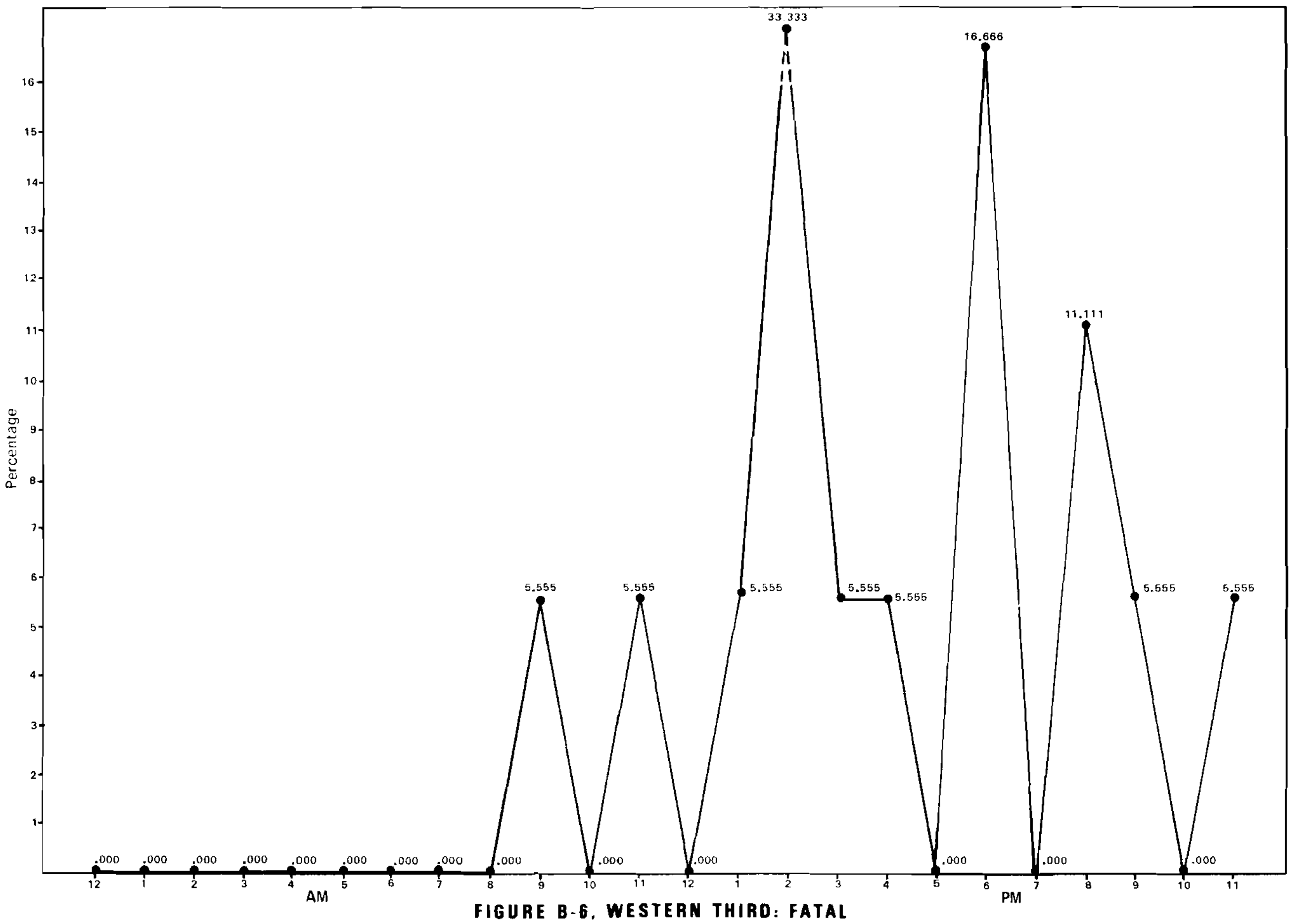

FIGURE B-6, WESTERN THIRD: FATAL

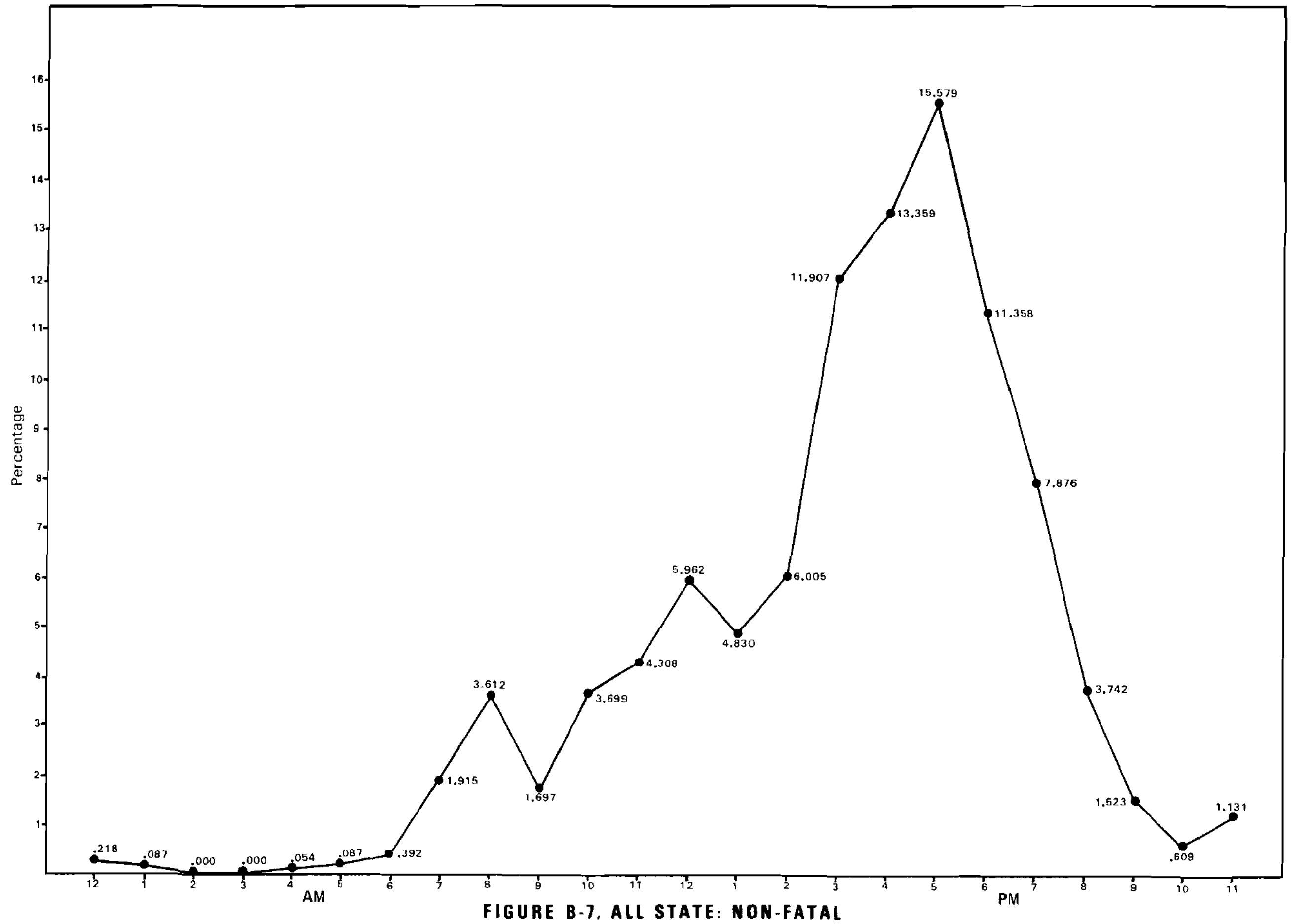

FIGURE B-7. ALL STATE: NON-FATAL

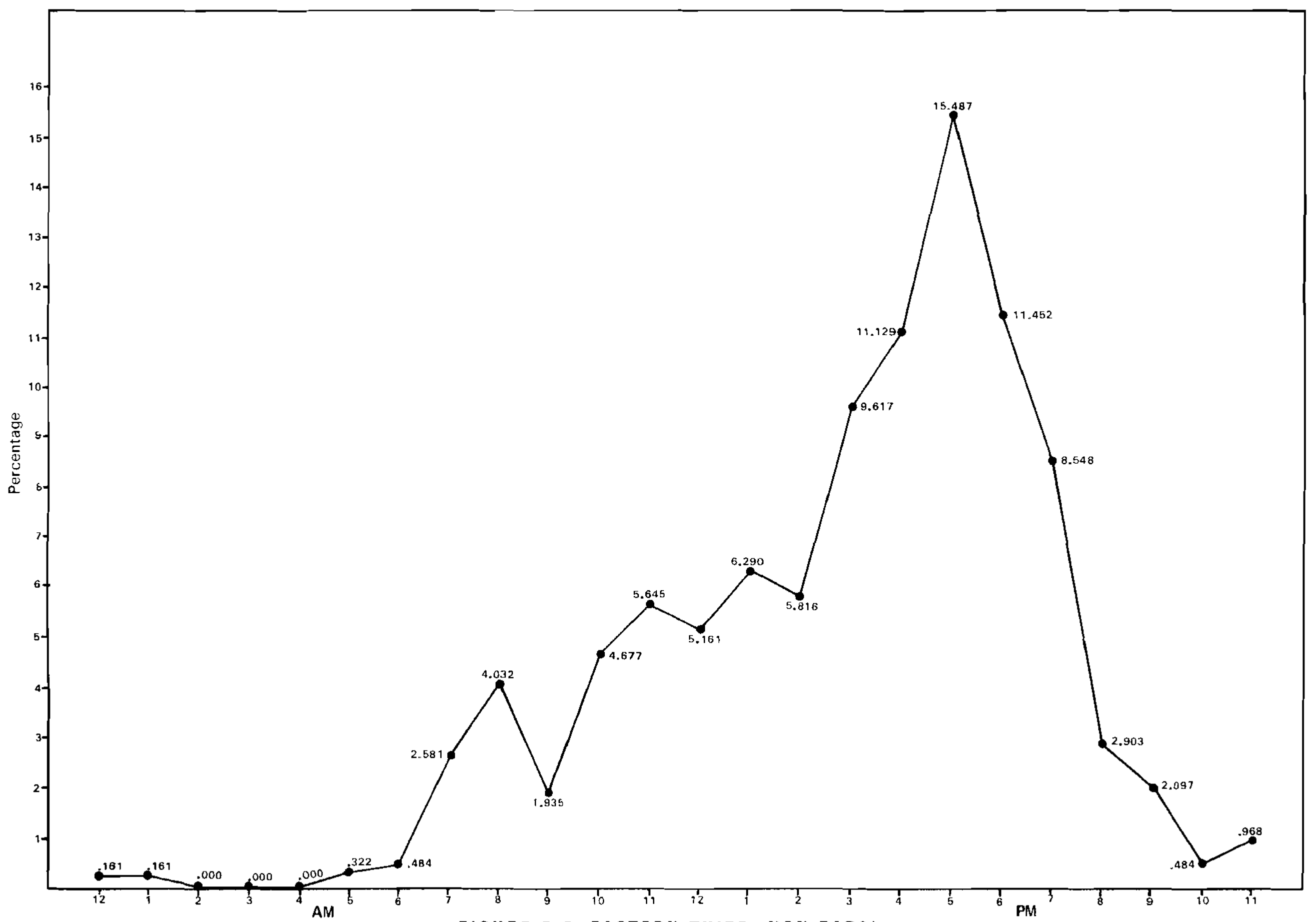

FIGURE B-8. EASTERN THIRD: NON-FATAL

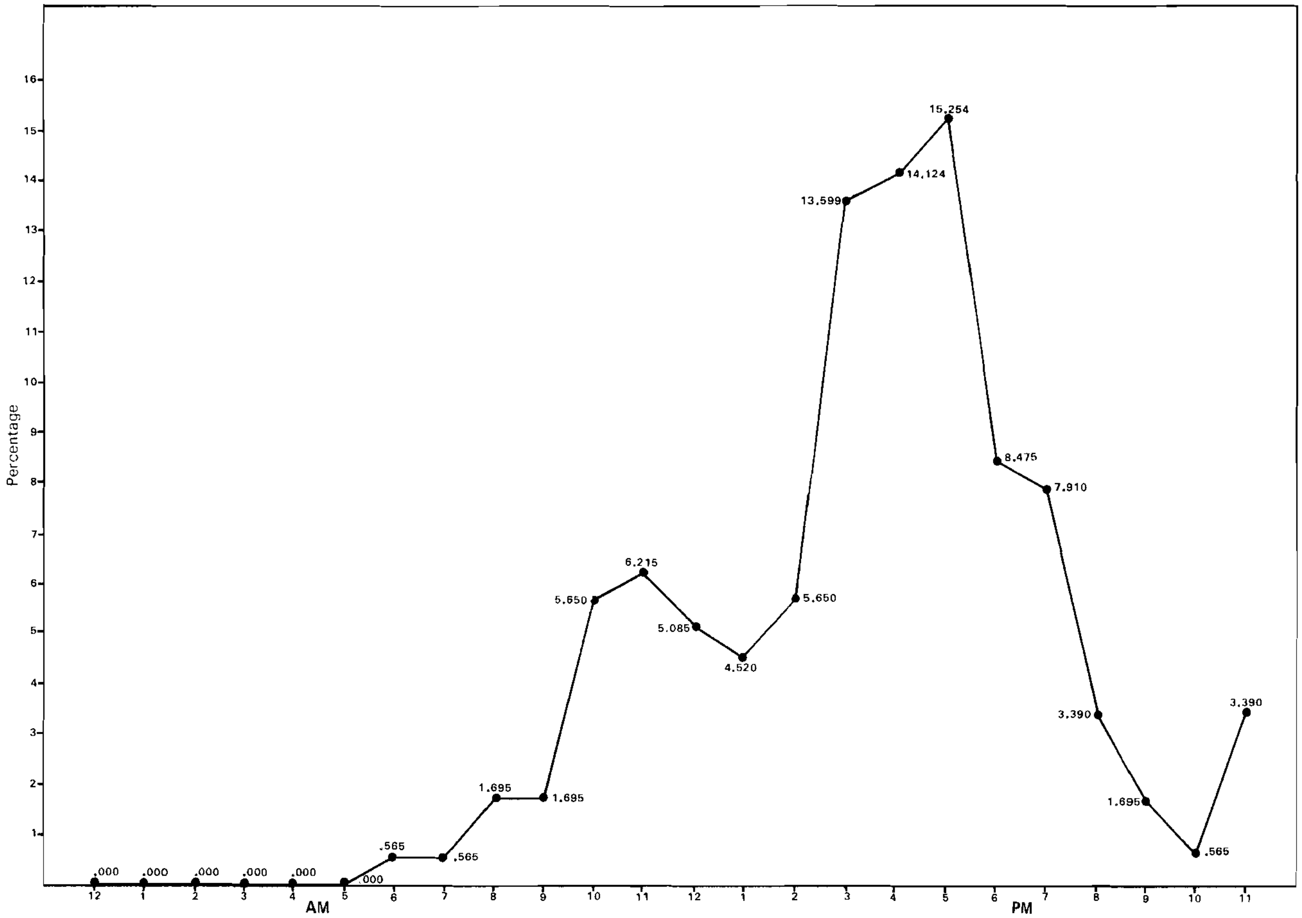

FIGURE B-9, WESTERN THIRD: NON-FATAL