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# MOTORCYCLE ACCIDENTS AND MOTORCYCLE INJURIES— A REVIEW

Robert E. Scott

JULY 1983
FINAL REPORT

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16. Abstract

This report provides information on the relationship between motorcycle helmet laws and usage, describes more than a decade of motorcycle accident experience in Michigan, and examines the relation between helmet usage and the cost of injury and the incidence and severity of injuries to the head, face, and neck.

Several states have repealed or weakened their helmet laws in the past eight years and studies of the consequences have been conducted in a number. The results of such studies in Colorado, Kansas, South Dakota, and Louisiana are reviewed. In each state, helmet usage dropped, typically to near 50 percent. Fatality rates increased as did the incidence of serious to fatal head injury.

A description of the fatal accident experience of Michigan over the last twelve years is provided, along with a study of all motorcycle accidents which have occurred from 1978 through 1982.

The National Accident Sampling System (NASS) provides nationally representative information on traffic accidents that includes detailed injury descriptors and the costs of trauma as measured by length of hospital stay and days work lost. The consequences of motorcycle accidents as they are related to helmet use is evaluated using the NASS data of 1980 and 1981.

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# 1.0 INTRODUCTION

Beginning in the mid-60s many states began adopting laws mandating the use of approved helmets by all motorcycle riders. By 1975, all but three states had enacted such laws. In 1979, Congress prohibited NHTSA from using sanctions against states which did not require helmets to be used by riders aged 18 or over. State legislatures then faced pressures to repeal helmet legislation from several organizations and for a variety of reasons.

Michigan has resisted such pressures, and thus is one of the states that still require helmets to be used by all riders. Nearly every year, however, the pressures from groups who desire repeal of the law are renewed. This report has been prepared with the hope that it might provide decision-makers with current information on the societal implications of helmet usage. The experiences of several states which have repealed or modified their laws are reviewed.

Particular emphasis, however, is devoted to characterizing and describing the motorcycle experience in Michigan in recent years.

Information is also presented on comparisons of the patterns of injury sustained by helmeted and non-helmeted riders. This information has been derived from the computer files of the National Accident Sampling System (NASS), the most recent nationally representative accident data with appropriate injury detail.

The author intends that this report will summarize the more recent information on motorcycle accidents in a convenient form for considering the call for changes in the motorcycle helmet usage legislation.

## 2.0 SUMMARY OF FINDINGS

This section of the report contains a brief summary of the findings which are reported in more detail in sections 3, 4, and 5. Section 3 consists primarily of a review of literature regarding experience in other states--particularly with respect to changes in the motorcycle helmet usage laws. Section 4 is based on analyses of Michigan fatal and non-fatal accident data. Section 5 is based on data provided by the National Accident Sampling System, and permits conclusions regarding the types and severities of injuries sustained by helmeted and non-helmeted riders.

The statements given in this section are concise, and the reader is encouraged to study the more detailed supporting information and definitions.

### 2.1 EXPERIENCE OF OTHER STATES

Studies of the experience of other states which have repealed or weakened their helmet laws have all reported similar results.

Helmet usage has dropped from high levels--usually over 90 percent--to typically near 50 percent. There is evidence that when older riders are exempt from mandatory usage, younger drivers (who are still required by law to use the helmets) show substantial reductions in usage.

The motorcyclist fatality rates in such states have risen markedly after repeal. Nationally, the fatality rate per registered motorcycle fell dramatically--by one third--as usage laws were enacted in the late 60s. The rate increased again as states began to repeal their laws.

The incidence of serious or fatal head injuries increased with repeal, and the total cost per injured rider was much higher for those not wearing helmets.

## 2.2 MICHIGAN MOTORCYCLE ACCIDENT EXPERIENCE

Both the total number of motorcycle registrations and the number of motorcyclist fatalities have been dropping slightly since 1974. It is not known if either trend will continue in the future.

The fatality rate (expressed in terms of fatalities per motorcycle involvement in a reported accident) is 10 times as great for motorcycle riders as for passenger car occupants for the aggregate of all types of accidents in which each is involved.

Motorcycle involvements and fatalities are both more frequent in the afternoon, evening, and early morning hours. The fatality rate (as defined above) is highest in the later night and early morning hours.

The number of reported motorcycle accident involvements in rural and urban areas (defined in Michigan as "townships" vs. incorporated areas) are about the same. Rural accidents, however, are about 1.6 times as likely to involve a fatal injury.

The fatality rate on limited access roads is about twice as high as on non-limited access roads, although only a small proportion (three percent) of the involvements occur on such roads. Fatality rates are generally higher on rural, high-speed roads.

The most noticeable trend that has occurred over the last 12 years has been a gradual increase of the average age of drivers in fatal accidents. The proportions of drivers in the 1-17 year bracket and in the 18-25 year bracket have both decreased from 1971-1982. Only the proportion over 26 years has increased. A similar change has occurred in the age distribution for motorcycle drivers involved in all reported crashes over the period 1978 through 1982.

## 2.3 FINDINGS FROM THE NATIONAL ACCIDENT SAMPLING SYSTEM DATA

The fatality rate (fatalities per involved rider) is six times as great for non-helmeted riders as for those wearing helmets.

Substantially more (47 percent) helmeted riders in accidents lose no time off work. Likewise, 10 percent more of the helmeted riders spend no time in a hospital, i.e., are not admitted.

Serious head injury (defined as an AIS-3[1] or greater) is reduced 40 percent among the helmeted riders relative to those who are not helmeted. Serious neck injury is reduced even more by helmets, but is of very low incidence regardless of helmet use--less than two percent of the serious injury.

The incidence of the head as the most severely injured body region is reduced 65 percent by the use of helmets.

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[1]The Abbreviated Injury Scale (AIS) - 1980 Revision, American Association of Automotive Medicine, 1980. the serious injury.

## 3.0 EXPERIENCE OF STATES THAT HAVE REPEALED OR WEAKENED HELMET LAWS

### 3.1 HISTORY

A brief history of motorcycle helmet laws in the United States is appropriate background to the discussion of the experience of specific states. A number of states passed laws requiring the use of helmets by motorcycle riders before the Federal Highway Safety Program Standards became effective. New York and Georgia, for example, passed such laws in 1966.[2] In June 1967, the National Highway Traffic Safety Administration (NHTSA) of the Department of Transportation issued Federal Highway Safety Program Standard Number 3, which required the adoption of laws mandating the use of approved helmets by motorcycle riders.[3] Most other states then rapidly adopted such laws. The Michigan law became effective in 1967.

By 1975, all but three states had such laws. California never adopted such legislation. Illinois adopted a law in 1967, but it was ruled unconstitutional by the State Supreme Court and repealed in 1969. Utah's law required helmets only on roads with a speed limit above 35 mph.

The Secretary of Transportation began action against California, Utah, and Illinois in 1975 under the provisions of the Highway Safety Act of 1966. However, the Federal Highway Act of 1979 prohibited DOT from using sanctions against states which did not have laws requiring helmets by motorcyclists aged 18 or over.

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[2] A Report to Congress on the Effect of Motorcycle Helmet Use Law Repeal--A Case for Helmet Use, NHTSA, Department of Transportation, Report No. DOT-HS-805-312, April 1980.

[3] Ruschmann, Paul A. "Mandatory Motorcycle Helmet Laws in the Courts and in the Legislatures," Proceedings, International Motorcycle Safety Conference, May 1980, Motorcycle Safety Foundation, Washington, D.C.

Through the efforts of several organizations, many states soon repealed or modified their laws. By December, 1979, eight states had repealed their laws (Colorado, Connecticut, Indiana, Iowa, Maine, Nebraska, Rhode Island, and Washington). Twenty others limited the legislation to minors. Two states have modified the requirements even more recently. South Carolina limited the requirement to those under 18 in 1980, and Wyoming took similar action in 1983.[4] A notable exception is Louisiana, which after limiting the law to those under 18, readopted the universal requirement effective January 1, 1982.

Following widespread repeal of the laws, Congress became concerned with the increase in fatalities in 1977, and in the Surface Transportation Act of 1978, included a requirement for NHTSA to study the effect of repeals.

As a consequence, NHTSA sponsored studies in Colorado, South Dakota, and Kansas. Each of these studies was similar, with the goals of examining changes in helmet usage before and after repeal, studying changes in the characteristics of accidents and injury patterns, and establishing differences in the costs of accidents to those riding with and without helmets. The studies were based on police-reported data, helmet use surveys, and medical and cost data from cooperating hospitals. The following paragraphs of this section will provide brief summaries of the findings of each of these studies. In addition, a review of a study concerning of the effects of repeal in Louisiana will be included, as well as a synopsis of an NHTSA study of fatality changes based on the Fatal Accident Reporting System (FARS) maintained by NHTSA. Lastly, a brief examination of data from a state requiring use only by minors (Texas) will be presented.

## 3.2 COLORADO

Colorado was originally selected by NHTSA to serve as a "control" state, i.e., a state which had a helmet law since 1969 and in which the experience could be compared with several states that had repealed their laws. However, during the study--on May 20, 1977--Colorado also

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[4]Personal communication from Lou Buchanan of NHTSA.

repealed its law. Consequently, the effect of the repeal became a secondary objective.[5]

During 1976, 1977, and 1978, a total of over 57,000 observations of helmet usage were obtained from roadside surveys. Helmet usage was 99.7 percent before repeal. This dropped to 57.7 percent in the first year after repeal, and to 49.3 percent in the second year after repeal.

The fatality rate for riders not using helmets was 5.1 per 100 injured riders, but only 2.69 per 100 injured helmeted riders. Only injured riders were included because of incomplete coverage of property-damage involvements.

Riders not using helmets were more than twice as likely to suffer fatal head injuries (3.80 per 100 injured riders) as those using helmets (1.64 per 100 injured riders).

Hospital stays were also longer for non-helmeted riders; 19.8 percent without helmets were hospitalized four or more days compared with 16.7 percent wearing helmets.

### 3.3 SOUTH DAKOTA

A Study similar to Colorado's was conducted in South Dakota, which changed its law to apply only to those under 18 on July 1, 1977.[6]

Usage surveys of 48,000 riders were conducted in 1976, 1977, and 1978. Before repeal in 1976 usage among drivers and passengers was 99.5%. In the transition year usage dropped to 57.9%, and then down to 49.9% in 1978. Thus the effect of repeal was to cut usage from near 100 percent to one-half even though the the law still applied to one segment of the population.

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[5]Krane, S. W., Winterfield, L. A. Impact of Motorcycle Helmet Usage in Colorado: A Three Year Study, Division of Highway Safety, Colorado Department of Highways, Report No. DOT-HS-805-627, July 1980.

[6]Struckman-Johnson, Cynthia, and Ellingstad, V. S. Impact of Motorcycle Helmet Law Repeal in South Dakota 1976-1979: Executive Summary, Human Factors Laboratory, Department of Psychology, University of South Dakota, Report No. DOT-HS-805-621, June 1980.

The proportion of motorcycle accidents which were fatals increased 32 percent after repeal. Of 908 accident victims for whom medical reports were available, head trauma was the most severe injury to eight percent of the helmeted riders, but 17 percent of those not using helmets.

Accident costs were not significantly different for the two groups, but the lack of statistical significance may have been a consequence of the small sample of only 136 riders for which cost data were available.

## 3.4 KANSAS

Kansas repealed its helmet law on July 1, 1976. While helmet usage data were not available for all riders in the "before" period, it was observed to be only 47.1 percent in 1977.[7] Among those who were in accidents, helmet use dropped from 94.5 percent before repeal to 32.7 percent after.

The fatality rate (based on fatalities per 100 thousand registrations) increased from 42.1 in 1975 to 64.6 in 1978--an increase of 53.4 percent. The incidence of head injury increased by 77 percent, but no significant increase in neck injury rate was detected.

Costs were significantly different for the two groups. The average total cost for non-helmeted hospital admissions was $14,906, but only $6,956 for helmeted admissions, i.e. 214% more for the non-helmeted group.

## 3.5 LOUISIANA

Since October 1, 1976, Louisiana's helmet law has not applied to riders over 17 years of age.[8] The fatality rate (fatalities per 100 involvements) increased from 1.6 in 1975 (prior to repeal) to 2.52 in

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[7]Lummis, M. L. and Dugger, C., Impact of the Repeal of the Kansas Mandatory Motorcycle Helmet Law: 1975-1978, University of Kansas College of Health Sciences, Report No. DOT-HS-805-773, October 1980.

[8]Dart, Olin K. Jr., "Motorcycle Helmet Effectiveness in Louisiana," Proceedings, International Motorcycle Safety Conference, May 1980, Motorcycle Safety Foundation, Linthicum, Maryland.

1977 and 3.05 in 1978, an increase of 190 percent. Since the law was changed (to apply only to those under 18), the helmet usage rate has shown a reduction of about 50 percent in all accidents, and about 75% in fatal accidents. Dart also reports that

> "The 1978 fatal head injury rate is over three times as great for non-helmeted riders as compared to helmeted riders. The overall fatal head injury rate since repeal is 45 percent greater than the rate before repeal."

The law which exempted riders over 17 years from the requirement to wear helmets was repealed and replaced with a law requiring helmets on all riders effective January 1, 1982. Louisiana is the only state that has reinstituted its original law after either repealing or weakening the statute.

No reports on the effect of the new law have been published. However, a study of usage and the medical and cost consequences is now in progress under sponsorship of NHTSA. Unpublished roadside survey results indicate that helmet usage by all riders has risen to over 90 percent, near the usage prior to repeal in 1976.[9]

### 3.6 NHTSA

NHTSA has conducted a number of studies regarding the effect of motorcycle helmets, addressing many subjects which have been raised during the controversy over mandatory helmet laws. Opponents of mandatory helmet laws have argued that helmets may increase the incidence of injury, or reduce the riders hearing and vision capabilities. The latter two issues have been mentioned as possible accident causal factors.[10] NHTSA has concluded from its studies that none of these factors can justify not using helmets.

Probably the most striking evidence that has been presented is a simple curve of national fatalities per 10,000 registered motorcycles

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[9]Personal communication with Dr. Norman McSwain, Project Director, Tulane University.

[10]A Report to the Congress on the Effect of Motorcycle Helmet Use Law Repeal--A Case for Helmet Use, NHTSA, DOT, Report DOT-HS-805-312, April 1980.

that was derived from FHWA registration data and the FARS data of NHTSA representing a period of 22 years. The figure from NHTSA is reproduced here because of its strikingly graphical message.

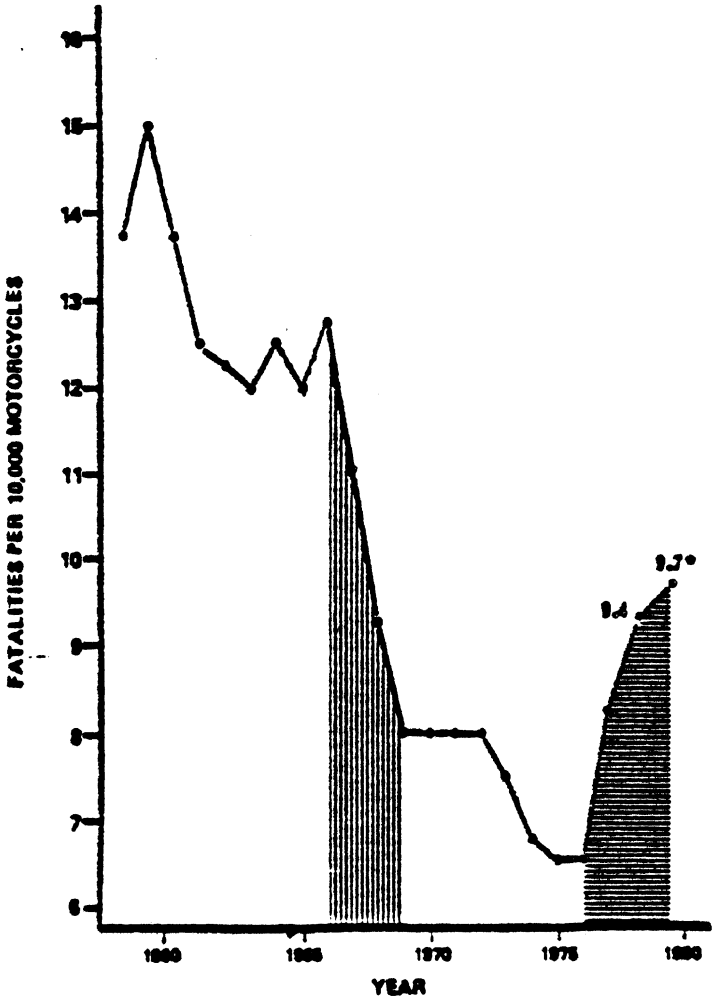


Figure 1. Motorcycle Fatalities Per 10,000 Motorcycles, 1958-1979

The vertically shaded interval (Figure 1) is the period from 1966 through 1969 during which helmet laws were enacted in 40 states. During the horizontally shaded interval from 1976-1979, the laws were repealed or weakened in 27 states.

## 3.7 TEXAS

The University of Michigan Transportation Research Institute has maintained computer files of subsets of accidents in Texas for a number of years. Texas is one of the states that weakened its helmet law to

apply only to riders under 18 years of age. These files permit a look at the helmet usage in such a state using recent data (1981) that presumably represent a stable situation three years after the law was changed in 1977. Since enforcement of an age-specific law is difficult, the reported usage by young riders is of particular interest.

The file which consists of a 5% random sample of all Texas accidents contains 698 motorcycle involvements. Among riders of these motorcycles, helmet usage information is missing (unknown) on 21.5 percent. However, it is missing on only 6.7 percent of the young (1-17 years) riders. Excluding the missing data cases, the usage rate among the 1-17 year old riders was 59.6 percent--slightly over half. Among the 18-25 year old riders the reported usage rate was only 33.4 percent, while it was 44.8 percent among the 26 and older group. Thus, the law did not effectively encourage usage among the target population. The total usage rate is similar to that in states with no requirement. Usage differences in rural versus urban and on roads of various classes were not statistically significant.

# 4.0 MICHIGAN MOTORCYCLE EXPERIENCE

## 4.1 MICHIGAN DATA

The University of Michigan Transportation Research Institute (UMTRI) has maintained files of Michigan traffic accident data for many years. Prior to 1978, files consisted of all fatal accidents, all accidents involving large trucks, and a file of a random 5% sample of all accidents in the state. Since motorcycles constitute a minority group of vehicles, the sample files do not contain enough cases to give a representative picture of the motorcycle experience.

Starting in 1978, several noteworthy changes took place. the basic accident reporting form was changed considerably. In addition, UMTRI began maintaining census files of all traffic accidents in 1978. The Michigan data used in this study, then, is of two groups which lead to two different but related analyses. Fatal accidents are readily available from both periods; hence one group of analyses will be based on all fatal involvements from 1971 through 1982. The second group will be based on all police-reported motorcycle involvements from 1978 through 1982. While the first group can be used to describe the characteristics of fatal accidents, only the second group may be used to examine fatality rates. The characteristics of the motorcycle accident experience in Michigan that are provided by each of these data sets are presented separately below.

## 4.2 FATAL INVOLVEMENT DATA

A "fatal involvement" in the context used here connotes a motorcycle in an accident in which at least one rider of the subject cycle was fatally injured. In the period from 1971 through 1982, there were 1,784 fatal motorcycle involvements in Michigan. These involvements led to 1,852 fatalities among motorcycle riders. The number of fatalities per year is shown in Figure 2. Fatalities reach a peak in 1973 and 1974, and while they appear to be somewhat cyclical in nature, they have a generally decreasing trend which is shown by the dashed regression line in the figure. Although the reasons for the dips in 1976 and 1979 are not known, the general features of the fatality

experience are similar to the history of registrations. Registrations for the same years is shown in Figure 3.[11]

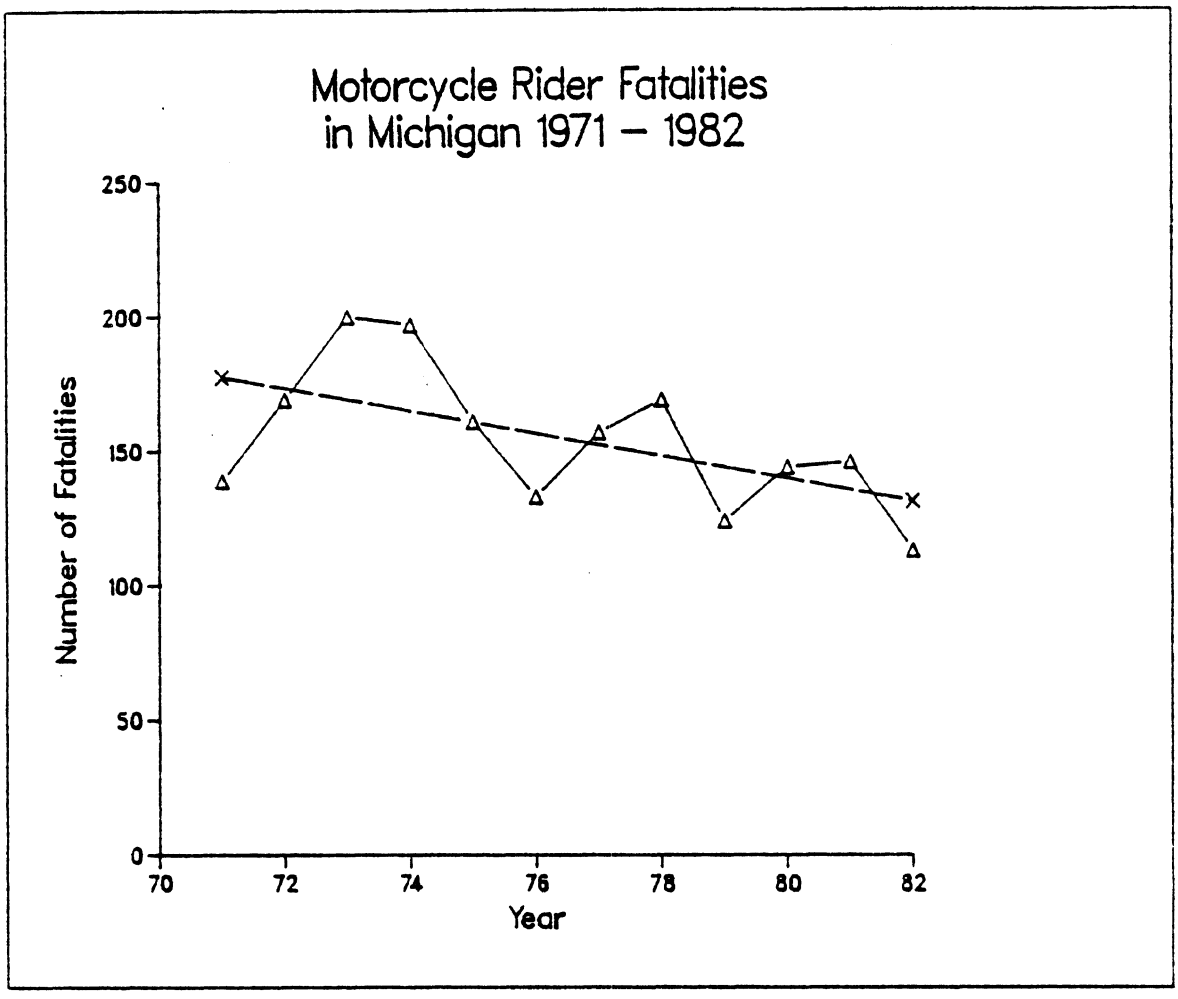


Figure 2. Motorcycle Rider Fatalities in Michigan 1971-1982

Motorcycle registrations rose rapidly in the later 1960s and early 1970s--from 39,000 in 1964 to a peak of 300,000 in 1974. Since 1974 the registrations have gradually declined to 244,000 in 1981. The decline in registrations since 1974 may account for much of the decline in fatalities shown in Figure 2.

The incidence of motorcycle fatalities varies strongly with season. Later it will be shown that this is true of all motorcycle involvements. While it may seem natural to seek the monthly distribution of

[11]The registration data are from "Michigan Traffic Accident Facts," Michigan Department of State Police, 1969-1981.

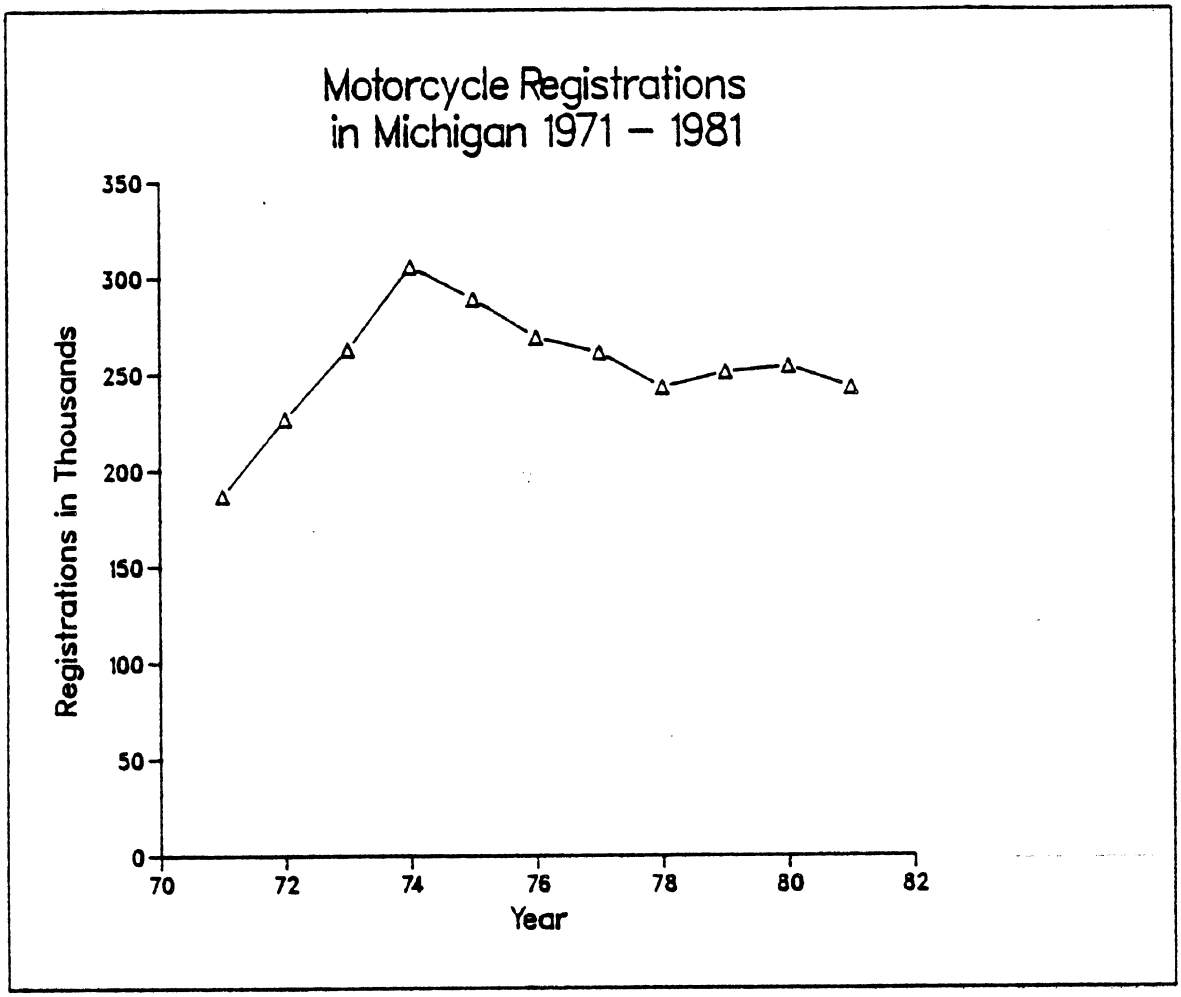


Figure 3. Motorcycle Registrations in Michigan 1971-1981

fatalities, aggregating the fatalities into only 12 groups masks much of the detail available. McDole used a three-week moving mean of the week of the year to report on fatalities that occurred in 1964 through 1969.[12] He found that the fatalities were much higher in the summer, with almost none in the winter months. They were above average from the 19th to the 39th week. Even though smoothed by a moving mean, the week of the year presentation provides much more detail than would be given by a simple monthly plot.

The pattern of fatalities which occurred in the twelve-year period from 1971 through 1982 is shown in Figure 4. A three-week moving mean

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[12]McDole, Thomas L. "Motorcycles: Random Particles in the Traffic Stream," Hit Lab Reports, Highway Safety Research Institute, The University of Michigan, December 1970.

has been used for smoothing. This pattern is very similar to the one found by McDole. The horizontal broken line represents the mean rate. The weekly fatality count is above the mean from the end of the 16th week (April 22) through the 39th week (September 30). Over 50 percent of the fatalities occurred in the twelve-week period from May 21 to August 20. This pattern has been relatively stable over the twelve-year period. To illustrate, Figure 5 shows the proportion of fatalities which occurred during the high-incidence "season" for each of the years. The high-incidence season as used here refers to the period above the mean in Figure 4, i.e., the 17th through 39th weeks inclusive. Except for 1973, which had 72.6 percent in the "season," the proportions for the other years only range by 4.3 percent. The small range indicates the pattern of Figure 4 is stable, since the slope at each end of the season is high. A small change in the duration of a high-incidence season would produce a substantial change in the proportion shown in Figure 5.

Fatalities are shown by hour of day in Figure 6. It is convenient to consider the hourly data in three-hour blocks. The distribution across the eight blocks of three hours each is given in Table 1 for each year. Most of the fatalities occur from 1500 hours to 0259, and are low from 0300 until noon. There are some minor changes across the years, but generally the greatest change is an increase in fatalities in the hours between 2100 and 0259. Before 1976, 32 percent occurred in this period, while 41 percent occurred in the same period from 1976 through 1982.

The collision configuration of the fatal accidents has changed over the years. The greatest change has been in the proportion which are single-vehicle involvements. This proportion, shown in Table 2, has increased through the years, with a slight decrease since 1980. The multi-vehicle impacts are about equally divided between head-on (15.5 percent) and angle impacts (16.8 percent). Another 15.8 percent were unclassifiable two-vehicle collisions.

Averaged over the twelve-year period, the "other" vehicle in two-vehicle fatal motorcycle accidents was most often a passenger car (67.6% of the time), next most often a truck (26.3% of the time). Although

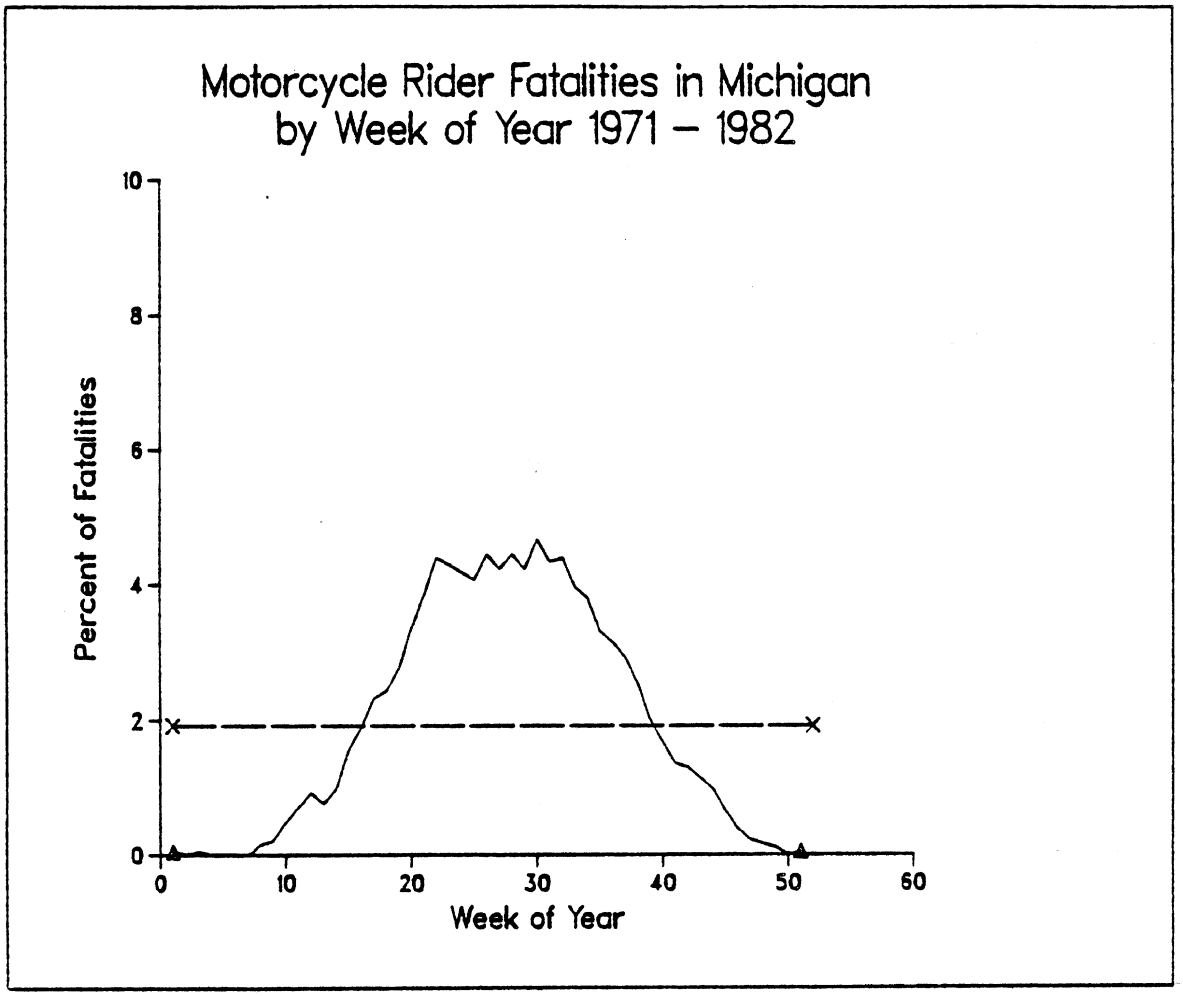


Figure 4. Motorcycle Rider Fatalities in Michigan by Week of Year 1971-1982

cyclists often ride together, only 3.8% of the "other vehicles" were also motorcycles. A small proportion of two-vehicle collisions did not identify the other vehicle (2.4%).

Of the accident attributes which have been examined, the one which exhibits the greatest change during the twelve-year period--other than the decrease in fatalities shown in Figure 2--is the age of the driver. The mean age of the driver increased (with some fluctuation) from a low of 24.2 years in 1971 to a high of 29.3 years in 1981. While a change in the average age of five years may not seem great, such a change suggests a pronounced shift in the distribution of ages. The drivers of fatal vehicles are grouped into three age categories in Figure 7, and the distributions among the three groups is shown for each year. The proportions that were in both 1-17 and 18-25 year groups decreased over

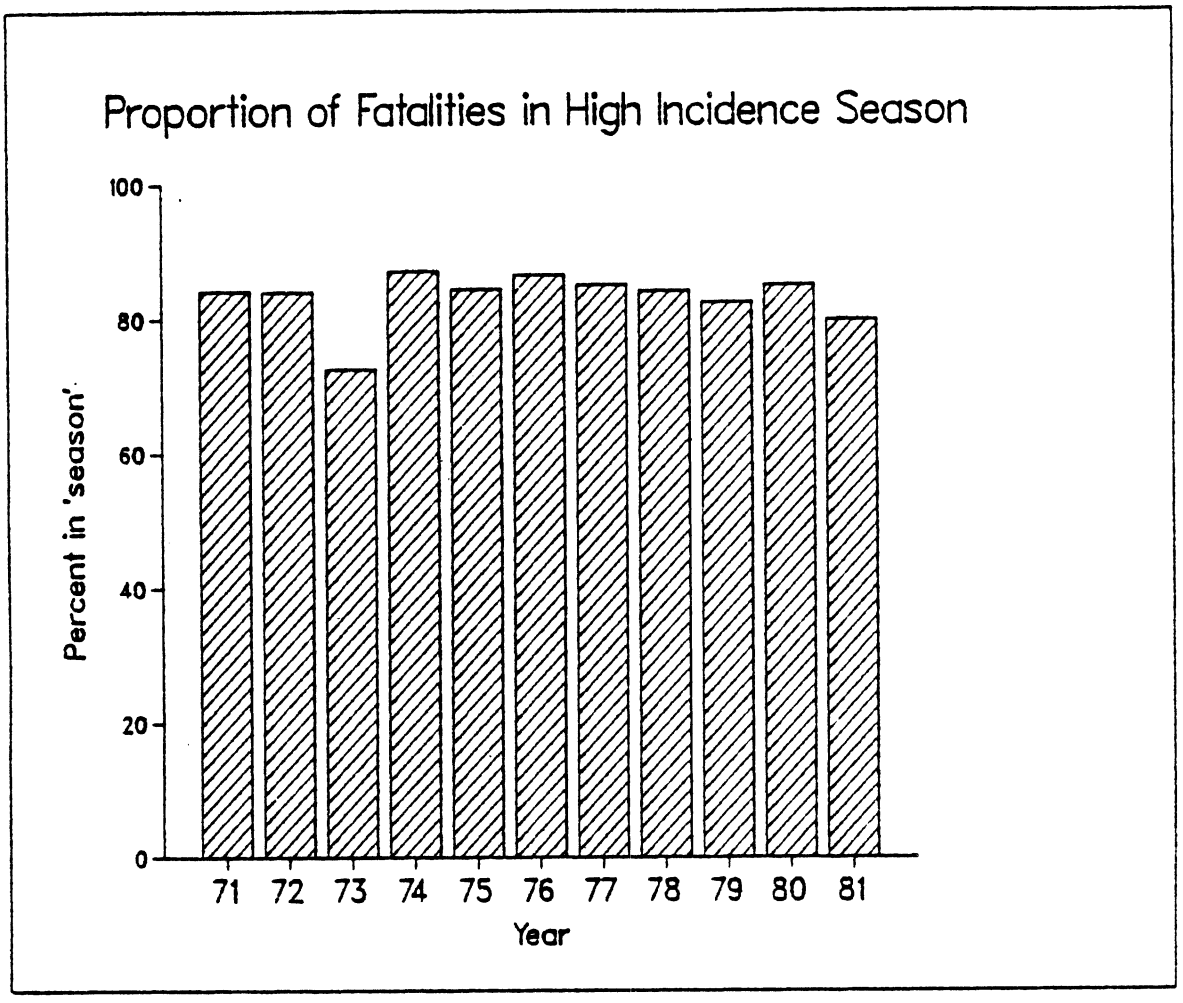


Figure 5. Proportion of Fatalities in High Incidence Season

the twelve years. Conversely, those over 26 years of age constitute an increasing proportion of the drivers.

The decreasing motorcycle registrations shown in Figure 3, together with the reduction in fatalities and the increase in drivers age (Figures 2 and 7), suggest the inference that fewer motorcycles are being purchased, particularly by young people, and that the cycling population is stabilizing to a more fixed, aging group. It would be inappropriate, however, to assume that these trends can provide the basis of reliable predictions into the future.

Motorcycles involved in accidents in which a cyclist was killed were nearly always driven by a male. Females drove only 2.4 percent of the fatally-involved vehicles over the twelve-year period. The average

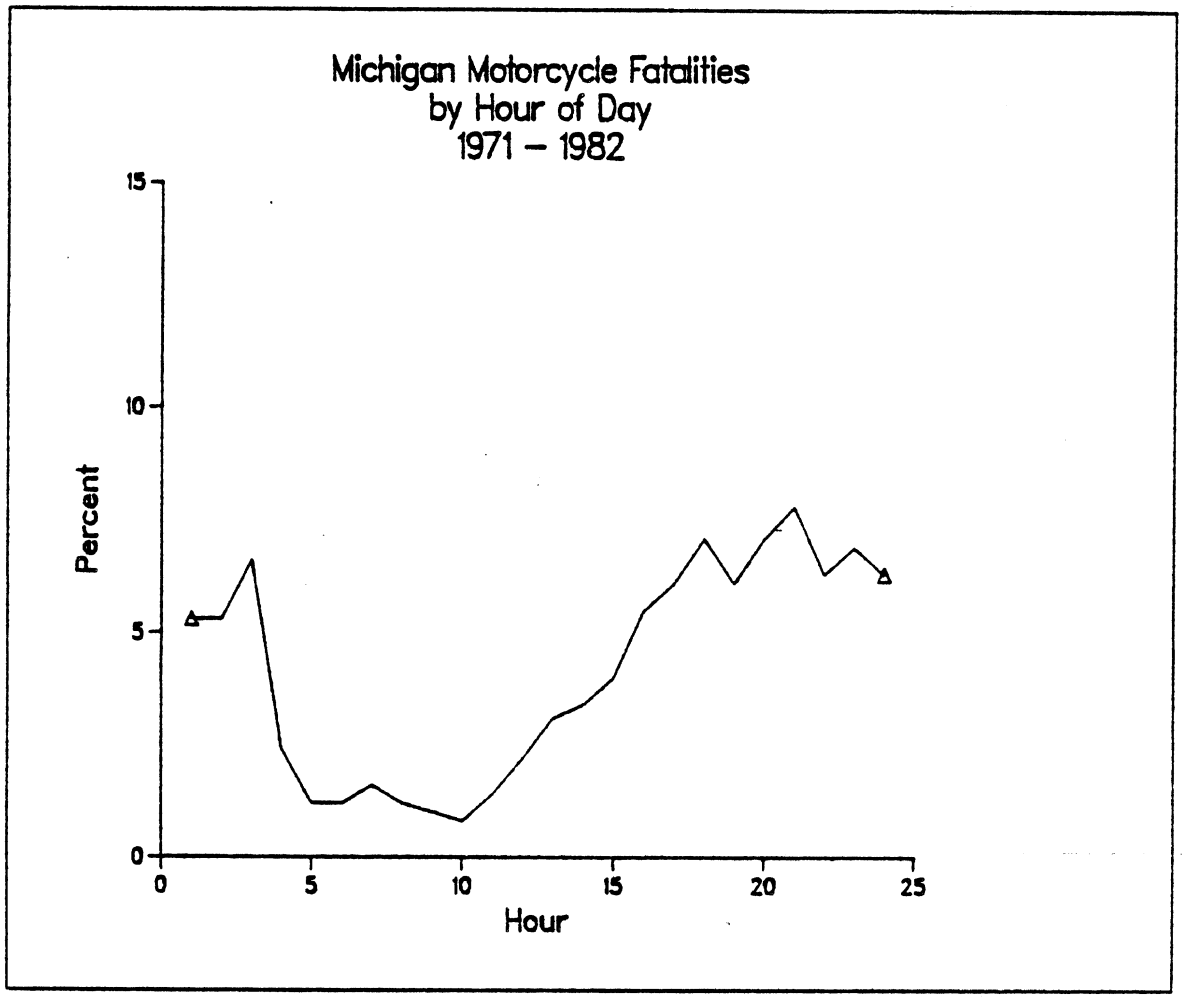


Figure 6. Michigan Motorcycle Fatalities by Hour of Day 1971-1982

number of female drivers was less than four per year, so small that year-to-year fluctuations in the proportions are meaningless.

## 4.3 ALL MICHIGAN MOTORCYCLE INVOLVEMENTS, 1978-1982

The Transportation Research Institute has maintained files of all accidents in the state (Census files) since 1978. These files allow examination of all motorcycle involvements in accidents, not just fatals. They also allow comparisons of fatal with non-fatal involvements, i.e., fatality rates, which are not possible using only the fatal files of 1971-1977 data. This section is devoted to examination of the characteristics of all motorcycle involvements using the accident experience from 1978 through 1982.

Table 1
Distribution of Motorcycle Fatalities by Time of Day

| Year | Percentage of Fatalities by Time Block Hour | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0000 0259 | 0300 0559 | 0600 0859 | 0900 1159 | 1200 1459 | 1500 1759 | 1800 2059 | 2100 2359 |
| 1971 | 9.0 | 6.8 | 5.3 | 6.0 | 13.5 | 24.1 | 20.3 | 15.0 |
| 1972 | 13.4 | 2.4 | 2.4 | 4.9 | 20.1 | 25.0 | 15.9 | 15.9 |
| 1973 | 16.8 | 4.2 | 3.2 | 5.3 | 15.8 | 16.3 | 22.1 | 16.3 |
| 1974 | 16.0 | 5.3 | 3.2 | 3.7 | 10.7 | 24.6 | 16.6 | 19.8 |
| 1975 | 18.1 | 4.5 | 2.6 | 7.1 | 7.1 | 20.6 | 22.6 | 17.4 |
| 1976 | 20.9 | 4.7 | 6.2 | 3.9 | 5.4 | 12.4 | 22.5 | 24.0 |
| 1977 | 16.2 | 5.8 | 1.9 | 5.2 | 10.4 | 14.9 | 24.7 | 20.8 |
| 1978 | 14.6 | 5.7 | 3.8 | 3.2 | 6.3 | 14.6 | 26.6 | 25.3 |
| 1979 | 15.1 | 4.2 | 5.9 | 1.7 | 9.2 | 16.8 | 28.6 | 18.5 |
| 1980 | 19.3 | 6.4 | 4.3 | 3.6 | 7.9 | 19.3 | 20.0 | 19.3 |
| 1981 | 22.4 | 4.9 | 5.6 | 4.9 | 7.0 | 18.2 | 14.0 | 23.1 |
| 1982 | 27.8 | 2.8 | 3.7 | 2.8 | 10.2 | 13.9 | 18.5 | 20.4 |
| Total | 17.2 | 4.8 | 3.9 | 4.4 | 10.6 | 18.7 | 20.9 | 19.6 |

Table 2
Single-Vehicle Impacts of Motorcycles

| Year | Percent of Fatal Impacts Which are Single Vehicle |
|---|---|
| 1971 | 33.6 |
| 1972 | 31.1 |
| 1973 | 39.5 |
| 1974 | 36.4 |
| 1975 | 38.1 |
| 1976 | 35.9 |
| 1977 | 37.3 |
| 1978 | 42.4 |
| 1979 | 42.9 |
| 1980 | 50.0 |
| 1981 | 44.4 |
| 1982 | 43.3 |
| Aggregate of 12 years | 39.3 |

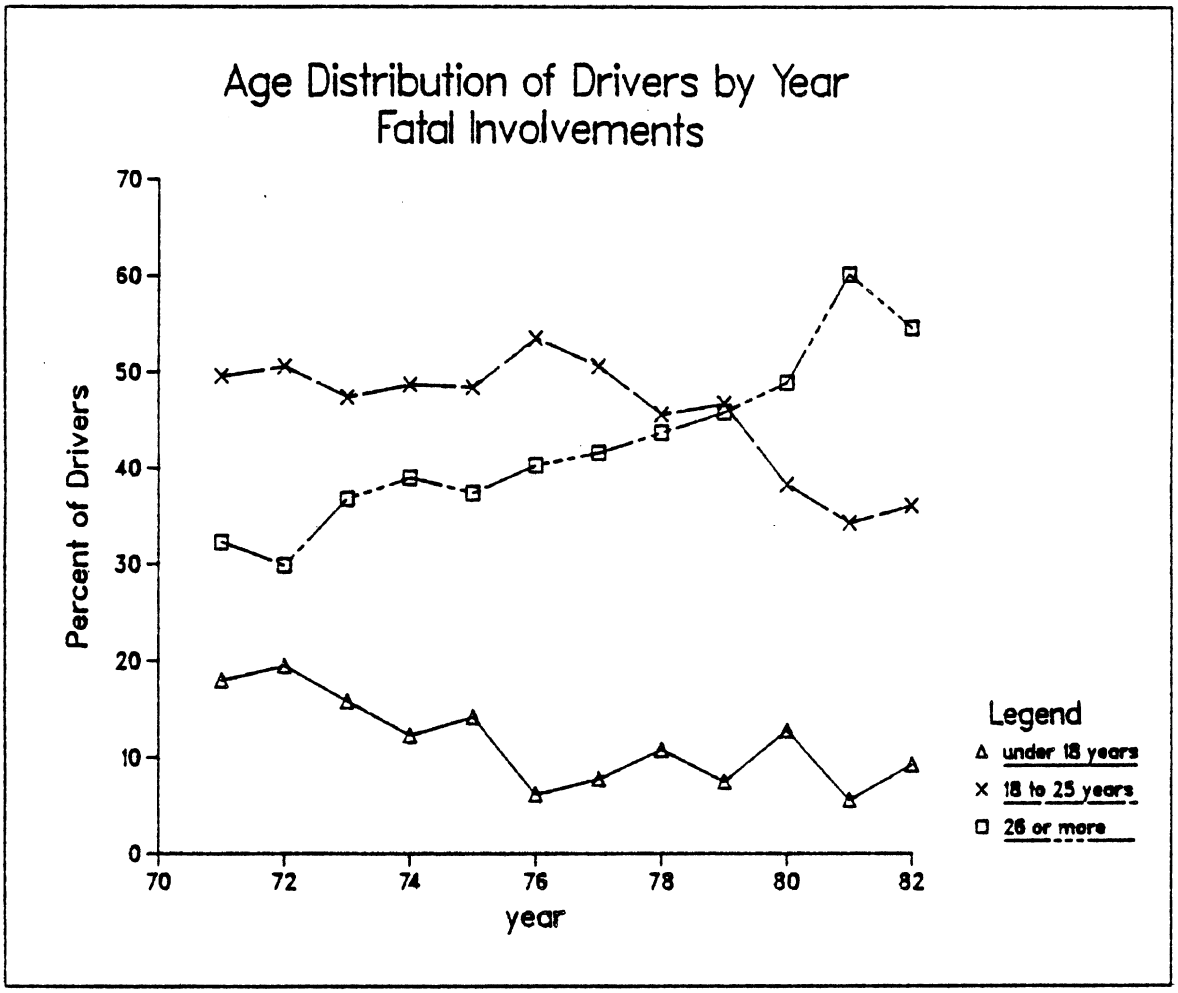


Figure 7. Age Distribution of Drivers by Year Fatal Involvements

Involvements by year are shown in Table 3. The general 15 percent decrease from 1978 to 1982 is similar to the drop in fatalities shown in Figure 2 and Table 2, except the fatalities show a greater drop over the same period (33 percent), and the involvements do not show the pronounced dips that fatalities had in 1979 and 1982. The relation between involvements and fatalities is shown as the fatality rate (in fatalities per 100 involvements). For reasons which are not yet apparent, the rates were substantially lower in 1979 and 1982 than in adjacent years.

The fatality rates are high. For comparison, and to help place the figures in perspective, the rate for occupants of passenger cars in Michigan in 1981 was 0.241 fatalities per 100 passenger car

Table 3
Motorcycle Involvements and Fatality Rates in Michigan, 1978-1982

| | Year | | | | | Total |
|---|---|---|---|---|---|---|
| | 1978 | 1979 | 1980 | 1981 | 1982 | |
| Involvements | 7126 | 7180 | 6681 | 6373 | 6041 | 33,401 |
| Fatalities | 169 | 124 | 144 | 146 | 113 | 696 |
| Fatality Rate (Fatalities/100 Inv.) | 2.37 | 1.73 | 2.16 | 2.29 | 1.87 | 2.08 |

involvements. Thus the likelihood of fatality given a reported accident is nearly ten times as great for motorcycle riders as for passenger car occupants.

In the discussion of the seasonal occurrence of fatalities over the period from 1971-1982, the week-of-year was used rather than months to show more detail in the seasonal pattern. Seasonal variations in all motorcycle involvements are shown in Figure 8 using the same technique. The distribution of fatalities for 1978-1982 is also shown for comparison. The latter pattern is very similar to that of involvements except the slopes at the beginning and end of the motorcycle season are even greater, with only one fatal involvement before the 11th week and only two after the 46th week.

The distribution of involvements by day of week is given in Table 4. One-third of the motorcycle involvements occurred on weekends, while 49.5 percent occurred from Friday through Sunday. With a uniform distribution we would expect 14.3 percent per day, with 42.9 percent on Fridays through Sundays. The fatality rate (fatal involvements per 100 involvements), is also higher on weekends.

Figure 9 shows the accident involvement by hour of day. Similar to the pattern for fatalities shown in Figure 6, the involvements are low from 0300 to noon, with a gradual rise from 1000 to about 1700. Whereas fatalities remain high from 1800 to 0300, involvements have a definite peak at 1700 hours then drop during the remainder of the night.

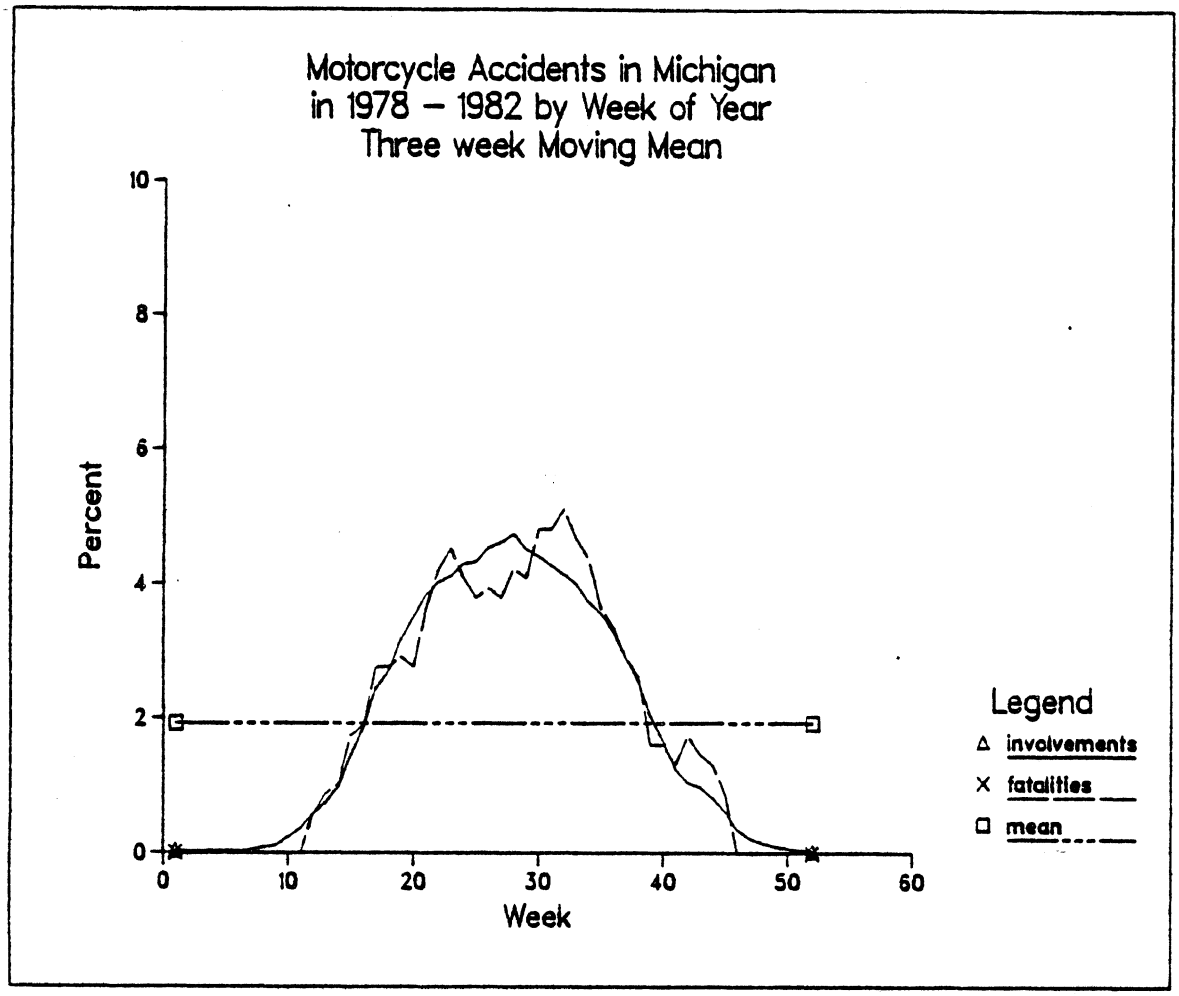


Figure 8. Motorcycle Accidents in Michigan in 1978-1982 by Week of Year

Table 4
Motorcycle Involvements by Day of Week, 1978-1982

| Day | Number of Involvements | Percent | Fatal Involvement Rate (per 100 Inv.) |
|---|---|---|---|
| Sunday | 5156 | 15.4 | 2.17 |
| Monday | 4074 | 12.2 | 1.91 |
| Tuesday | 4047 | 12.1 | 1.61 |
| Wednesday | 4219 | 12.6 | 1.78 |
| Thursday | 4516 | 13.5 | 1.95 |
| Friday | 5456 | 16.3 | 2.03 |
| Saturday | 5933 | 17.8 | 2.41 |

Comparison of the two curves indicates that late-night/early-morning accidents are more dangerous than mid-day involvements. The ratio of fatal involvements per 100 involvements is 1.82 in the period from 0500-1100 hours, while the corresponding rate between 2000 and 0300 hours is 2.98--1.6 times as great as the former.

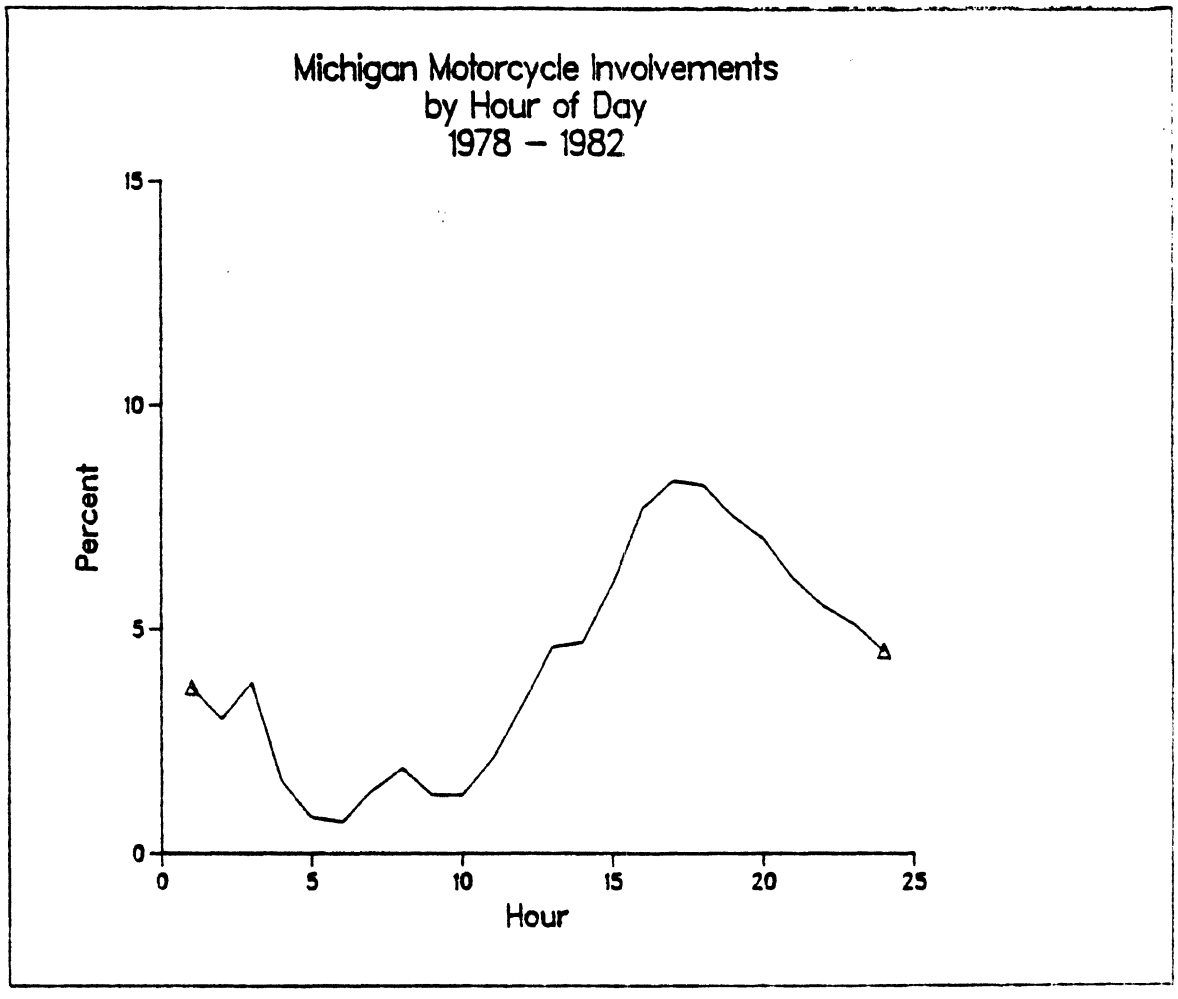


Figure 9. Michigan Motorcycle Involvements by Hour of Day 1978-1982

McDole found that the motorcycle fatalities in 1964-1969 occurred predominantly in the populous counties--Wayne, Oakland, Macomb, Genesee, and Kent. Not surprisingly, the same is true today and has not changed appreciably through the years.

The proportion of the involvements and of the fatal involvements which occurred in each of the five counties with the greatest numbers is listed in Table 5.

Table 5
Proportion of Involvements in the Five Highest Counties, 1978-1982

| County | Percent of Involvements | Percent of Fatal Involvements |
|---|---|---|
| Wayne | 16.4 | 16.8 |
| Oakland | 8.2 | 8.6 |
| Kent | 6.3 | 5.4 |
| Macomb | 5.6 | 4.2 |
| Genesee | 5.0 | 5.8 |

The five top counties in involvements are also the top five in fatal accidents, although Genesee would be third in fatals. Wayne County has more involvements and fatals than the next two counties together, approximately one-sixth of the entire state experience.

Motorcycle accidents in Michigan occur with nearly equal frequency in rural[13] and urban areas, as shown in Table 6. Little change in the distribution is exhibited over the five-year period. The relative rates of fatal involvements are presented in Table 7, with rural involvements 1.6 times as likely to be fatal.

The distributions over the type of road, and location relative to the road, are not nearly so uniform as is urbanization. Table 8 indicates that 97 percent of the involvements are on non-limited access roads, with over 75 percent occurring <u>on</u> such roadways. Only 2.9 percent were on limited access highways. Over the aggregate of both types of roads, 77.6 percent were on the roadways, while 22 percent were off-road accidents. The proportion which occurred on limited access roads did increase over the five years, from 2.0 percent in 1978 to 3.6 percent in 1982--still a small fraction. Accidents on limited access highways were more serious, however. Table 8 also gives the fatal involvement rate (fatal involvements per 100 involvements), with a rate on limited-access roads over twice as great as on other roads.

[13]The rural classification used here is the same as used by the Michigan State Police: Rural locales are those in townships or jurisdictions with a population of less than 2500.

Table 6
Involvements by Urbanization of Locality and Year, 1978-1982

| Locality | Year | | | | | Total |
|---|---|---|---|---|---|---|
| | 1978 | 1979 | 1980 | 1981 | 1982 | |
| Rural | | | | | | |
| N | 3659 | 3560 | 3335 | 3244 | 3075 | 16,873 |
| % | 51.3 | 49.6 | 49.9 | 50.9 | 50.9 | 50.5 |
| Urban | | | | | | |
| N | 3467 | 3620 | 3346 | 3129 | 2966 | 16,528 |
| % | 48.7 | 50.4 | 50.1 | 49.1 | 49.1 | 49.5 |
| Total | | | | | | |
| N | 7126 | 7180 | 6681 | 6373 | 6041 | 33,401 |
| % | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Table 7
Fatality Rate by Urbanization, 1978-1982

| | Rural | Urban |
|---|---|---|
| Total Involvements | | |
| N | 16,873 | 16,528 |
| % | 50.5 | 49.5 |
| Fatal Involvements | | |
| N | 420 | 252 |
| % | 62.5 | 37.5 |
| Fatal Involvement Rate (Fatal Involvements/ 100 Involvements) | 2.49 | 1.52 |

Apparently motorcycle accidents (and perhaps motorcycle riding) are local phenomena, and this, as well as the high relative safety of limited access roads, may account for the small number of accidents there. The majority of involvements (69.4%) occurred on county roads, city streets, connectors, service drives, or unknown classes of roads--

Table 8
Accident Location, 1978-1982

| Location | Number of Involvements | Percent | Fatal Involvement Rate |
|---|---|---|---|
| Non-Limited Access Road | 32,424 | 97.1 | 1.95 |
| On Roadway | 25,329 | 75.8 | 1.60 |
| Off Roadway | 7095 | 21.2 | 3.20 |
| Limited Access Road | 977 | 2.9 | 4.09 |
| On Roadway | 575 | 1.7 | 2.78 |
| Off Roadway | 402 | 1.2 | 5.97 |

primarily local in nature. Another 3.2 percent were on business routes (including Interstates, U.S., or M-routes)--again generally local. Only 27.4 percent were on interstate, U.S., or M-routes routes with only 10 percent on federally designated highways.

Table 9 gives the distribution of driver ages in the same three categories used in the previous section for each of five years. Again the ages of drivers has gradually increased. The proportions represented in both the 1-17 and 18-26 year old groups have decreased. Only the over 26 year group has increased.

The distribution of driver ages for all five years along with the fatality rate by age of driver are given in Table 10. It is interesting that the fatality rate is higher for the older group of drivers. This may not be so much a result of relative experience or maturity, but a consequence of the type and location of their driving. Other information that has been presented suggest that night-time driving, and high speed rural roads are also implicated in high fatality rates.

Female drivers represent only 3.3 percent of those involved in accidents, and only 2.7 percent of the drivers in fatal involvements. However, the number of female drivers in fatals is so low (18 in five years) that the latter proportion may have little stability.

Table 9
Age of Motorcycle Drivers Involved in Accidents

| Driver Age | Year | | | | |
|---|---|---|---|---|---|
| | 1978 | 1979 | 1980 | 1981 | 1982 |
| 1-17 Years | | | | | |
| N | 877 | 774 | 638 | 604 | 601 |
| % | 12.7 | 11.1 | 9.9 | 9.8 | 10.3 |
| 18-25 Years | | | | | |
| N | 3643 | 3540 | 2968 | 2779 | 2475 |
| % | 52.6 | 50.7 | 46.1 | 45.1 | 42.6 |
| 26 or Older | | | | | |
| N | 2408 | 2664 | 2831 | 2785 | 2732 |
| % | 34.8 | 38.2 | 44.0 | 45.2 | 47.0 |

Table 10
Accident and Fatal Involvement Rate by Age
1978-1982

| | Driver Age | | | Total |
|---|---|---|---|---|
| | 1-17 | 18-25 | 26 or Older | |
| Involvements | | | | |
| N | 3494 | 15,405 | 13,420 | 21,319* |
| % | 10.8 | 47.7 | 41.5 | 100.0 |
| Fatalities | | | | |
| N | 62 | 270 | 338 | 670 |
| % | 9.3 | 40.3 | 50.4 | 100.0 |
| Fatality Rate (Fatalities/100 Inv.) | 1.77 | 1.75 | 2.50 | 2.07 |

*An additional 1082 drivers were of unspecified age.

# 5.0 MOTORCYCLE DATA IN THE NATIONAL ACCIDENT SAMPLING SYSTEM

## 5.1 NATIONAL ACCIDENT SAMPLING SYSTEM

The National Accident Sampling System (NASS) is a large accident investigation program conducted by the National Center for Statistics and Analysis (NCSA) of the National Highway Traffic Safety Administration (NHTSA). The program is staffed by 50 teams of teams of accident investigators across the U.S. collecting data for a sample of accidents in geographic regions selected to provide a truly nationally representative body of accident data. This is the first truly national data that traffic safety researchers have had available. Case information has been collected by trained investigators using rigorous protocols so that the data are uniform and relatively free of investigator differences or biases. The data also contain much more detail and information than are provided by most police investigations.

Of particular value to this study is the detailed injury information collected and documented using the Occupant Injury Classification (OIC)[14] and the Abbreviated Injury Scale (AIS)[15]. These injury data are supplemented by information on the number of days in the hospital and the number of work days lost as a result of injury. These last two items provide useful measures of the cost of the accident.

Since the data were collected in a number of states with differing laws regarding helmet usage--from Michigan with a mandatory use law to California with no statutory requirement--motorcycle riders with and without helmets are represented. Thus the data may be used to compare the consequences to helmeted and non-helmeted riders; both in regard to the length of hospitalization and time off work, and the type of injury received by both groups of riders. The sampling procedure used in the

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[14]Marsh, J. C. "Vehicle Occupant Injury Classification," Hit Lab Reports, Vol. 4, No. 1, Highway Safety Research Institute, 1973.

[15]The Abbreviated Injury Scale (AIS) - 1980 Revision, American Association of Automotive Medicine, 1980.

program is complex, with the result that many sampling fractions are encountered. In order to expand the data to provide nationally representative estimates, each case must be weighted by the appropriate factor which is included in the data file. After weighting, very large numbers of cases result, much larger than the actual number of observations or cases investigated. However, the weighted data does provide valid estimates of the distribution of characteristics across the nation. Consequently, only proportions will be presented here.

Both 1980 and 1981 NASS data were used for this study, while 1979 data are available, they were not used because the data format differs from the latter two years and presents difficulties in integrating the data sets. The 1980 and 1981 data contain information on 796 riders of 765 motorcycles. Injury information is provided on 2889 distinct lesions or injuries to these occupants. It is also worth noting that none of the occupants were free of injury, although many sustained only minor injuries.

The use of the NASS data which is reported here is divided into four subject areas. These are (1) fatality rate by helmet usage, (2) alcohol involvement by the driver as it relates to helmet usage, (3) accident cost in terms of hospital stay and work lost, and (4) the incidence of head, face and neck injury (and their severities) by helmet usage.

## 5.2 FATALITY

Fatality is one level of the "treatment/mortality" variable coded for each person identified in the NASS data. Rather than look at the fatality rate alone, it is illuminating to tabulate all levels of injury provided by this variable. The distributions for both helmet-use categories are given in Table 11. Fatalities are much less likely among the helmeted riders--this is the most striking inference to be drawn. Helmets apparently reduce the likelihood of fatality by 84 percent. It should also be noted that the injuries requiring hospital admissions are also reduced significantly. Conversely, helmet wearers are more likely to be treated and released, or to utilize other treatment (either first aid or to seek a physician or clinic) or to require no treatment. Seven

percent of the unhelmeted and four percent of the helmeted riders were coded as "outcome unknown." The proportions shown in Table 11 are based on only the valid responses; the unknowns have been excluded.

Table 11
Fatality and Treatment
NASS 1980-81 Motorcycle Riders

| Treatment/Fatality | Helmet | |
|---|---|---|
| | Not Used | Used |
| Fatal | 8.7% | 1.4% |
| Hospitalized (Admitted) | 36.6% | 28.1% |
| Treated and Released | 29.0% | 38.2% |
| Other Treatment | 7.1% | 11.0% |
| No Treatment | 18.6% | 21.3% |
| Total | 100.0% | 100.0% |

## 5.3 ALCOHOL INVOLVEMENT

Usage of alcohol by the motorcycle driver was reported for 23.2% of those riding without helmets, but only for 6.3 percent for those wearing helmets. The data have not been partitioned according to the local statutory requirements for each driver, but regardless of whether the individual had free choice or was subject to sanctions, there is a strong association between the use of alcohol and non-use of helmets.

## 5.4 LENGTH OF HOSPITAL STAY AND WORK LOST

Figure 10 gives the cumulative distribution of the length of hospital stay in days for helmeted and unhelmeted riders. Eighty percent of the riders, both helmeted and unhelmeted, were hospitalized for less than five days. The curve for helmeted riders is higher for

all periods greater than eight days, indicating that any given proportion of the riders above 88 percent had shorter stay if they were helmeted. The differences between the curves are not great, however, except for long stays (between about 20 days and 31 which was the maximum that could be documented by the protocol) and 0-2 days. While 65.8 percent of the non-helmeted riders were not hospitalized (0 days), 72.5 percent of those using helmets were not. This difference becomes more striking when we realize that 8.6 percent of the non-helmeted drivers were not admitted because they were early fatalities (within two days) while only 1.4 percent of the helmeted riders were in this category.

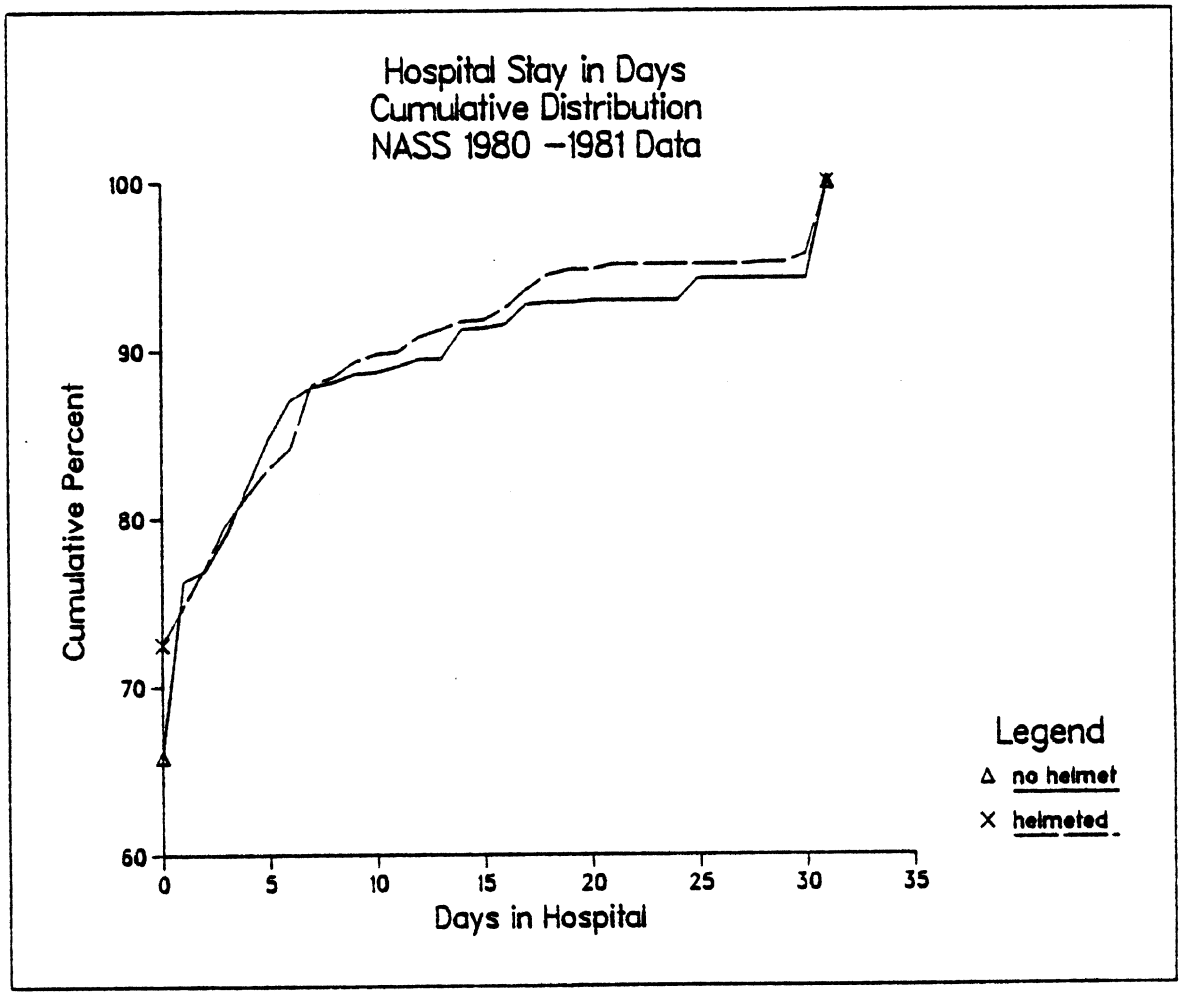


Figure 10. Hospital Stay in Days, Cumulative Distribution, NASS 1980-81 Data

Figure 11 gives the distribution of work days lost. Here, 31 days represents 31 or more. The distributions for work lost are quite

different. While 60 percent of the helmeted riders lost no more than one day, the same proportion of the unhelmeted lost up to nine days. The difference between the values at 31 days and 100 percent is the proportion in each group that were fatals, 10.3 percent with no helmet and 1.5 percent using helmets. The reason these latter two figures differ from those given for fatals in Table 11 is that the cases with missing data on hospital stay and work lost have been omitted from the derivations of Figure 10. Although non-helmeted riders lost more work time and had longer hospital stays, all motorcycle accident victims have higher costs from these factors than do passenger car occupants. For comparison, among the passenger car occupants in the 1981 NASS data, after weighting for national representation, 98.2 percent had less than one day in the hospital and 92 percent lost less than one day of work.

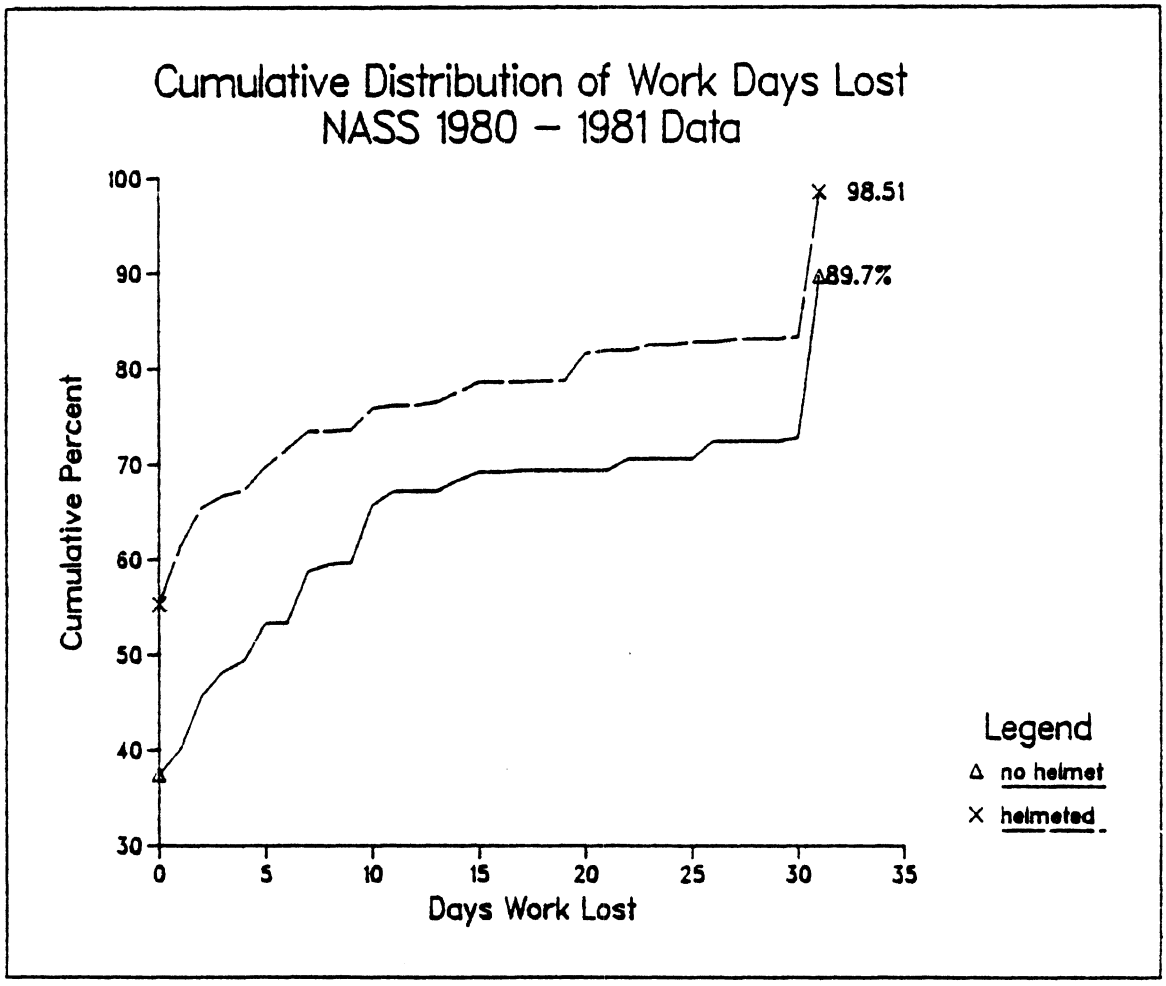


Figure 11. Cumulative Distribution of Work Days Lost
NASS 1980-81 Data

Table 12 presents a summary of the costs in terms of days in hospital and work lost.

Table 12
Summary of Days in Hospital and Work Lost

| | No Helmet Used | Helmet Used |
|---|---|---|
| Days in Hospital | | |
| No Hospital Stay | 65.9% | 72.5% |
| No Hospital Stay excluding fatals | 58.7% | 72.3% |
| Less Than 7 Days | 87.1% | 84.2% |
| Working Days Lost | | |
| No Days Lost | 37.5% | 55.3% |
| Less Than 7 Days Lost | 53.4% | 71.7% |
| Less Than 14 Days Lost | 68.4% | 77.6% |

## 5.5 HEAD, NECK, AND FACE INJURIES

The injury information provided by the NASS permits a comparison of head, neck, and face injuries, and the severity of these injuries. Protection of the head, of course, is the principal role of the helmet. Neck injuries have been included here because some have claimed helmets may actually produce neck injury. The face has been included because most helmets, particularly those with full face coverage, provide considerable protection of the face. While facial injuries are seldom life threatening, they can be very disfiguring and costly and may result in severe emotional trauma.

Table 13 gives the relative frequency of severe to non-survivable injuries (AIS=3-6) to motorcycle riders in the 1980-1981 NASS. The

proportions given are based on individual injury counts. Thus if individual riders had several severe injuries (up to six injuries are documented), the distributions of all of them across all riders are shown in the table.

Table 13
Severe to Non-survivable Injuries, AIS=3-6

| Body Region Injured | No Helmet | Helmet |
|---|---|---|
| Head-Skull | 28.0% | 17.0% |
| Neck | 1.9% | 0.2% |
| Face | 10.3% | 0.9% |
| Other | 59.8% | 81.9% |
| Total (all regions) | 100.0% | 100.0% |

The incidence of serious head injuries was reduced 40 percent among helmet users. Serious neck injury was reduced even more, but was of very low incidence among either group of riders. Serious face injuries were more frequent than neck injury among the non-helmeted riders, but were nearly eliminated (to less than one percent) by helmets. With the reduction of head, neck, and face injury, injuries to other body regions by necessity became a greater proportion of the total.

The proportions given in Table 13 are based on counts of injuries, not of riders. Even though a rider may have had a severe injury to the head, for example, it may not have been that rider's only severe injury or even the most severe injury received. The body region receiving the most severe injury to the rider, regardless of its severity, is listed in Table 14. Here the reduction of head injury as the most threatening injury is even greater, 65 percent. While neck injury incidence were not reduced greatly by helmets, they were seldom the most severe injury

to riders of either group. Facial injuries, as the most severe received, were reduced by 41 percent.

Table 14
Body Region of Most Severe Injury to Occupant
NASS 1980-1981

| Body Region | Percent of Occupants | |
|---|---|---|
| | No Helmet | Helmet |
| Head-Skull | 19.5% | 6.9% |
| Neck | 0.9% | 0.7% |
| Face | 11.7% | 6.9% |
| Other | 67.9% | 85.5% |
| Total | 100.0% | 100.0% |