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MINNESOTA MOTORCYCLE FATALITY RATES AND  
THE MOTORCYCLE HELMET LAW REPEAL:  
A SUMMARY REPORT

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JUNE, 1981

STATE OF MINNESOTA  
HOUSE OF REPRESENTATIVES  
RESEARCH DEPARTMENT

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## PREFACE

This report summarizes the results of a study done within the House Research Department to measure the impact of the 1977 legislation to partially repeal the Minnesota motorcycle helmet law. The study used statistical models to determine whether, and to what extent, the partial repeal affected the motorcycle fatality rate in the years 1977-1980. It is intended to assist legislators in evaluating various options available for dealing with the results of the 1977 action. The full analysis is presented in a separate report, entitled: Motorcycle Fatalities and the Helmet Law Repeal: A Policy Impact Study.

This study was performed by John Williams, Legislative Analyst, and James Cleary, Research Methodologist, of the House Research Department. Any questions or comments should be addressed to either of the authors at 612-296-6753.

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## SUMMARY

In 1977 the Minnesota Legislature amended its ten year old mandatory motorcycle helmet law to make it applicable only to motorcycle operators and passengers under age 18. Since this partial repeal (effective April 7, 1977) motorcycle fatalities in Minnesota have increased from an average of 56 per year to 103 per year. To determine the extent to which this rise in fatalities is the result of the change in the helmet law, a series of statistical models have been fitted to available data on motorcycle use and fatalities.

Models using annual and seasonal data on motorcycle fatalities from 1970-76 indicate that the increase in post-repeal fatalities is not simply the result of a continuation of pre-repeal trends. A model which statistically controls for motorcycle usage indicates that the helmet law repeal has resulted in 40 additional fatalities per year. A subsequent model, substituting motorcycle accidents for all other usage indicators, shows that the helmet law repeal has resulted in at least 32 fatalities per year, and possibly more, depending on the extent to which the repeal may have contributed to the increase in accidents. The study concludes by suggesting some possible alternative legislative approaches to the problem.

## INTRODUCTION

In 1967 the Minnesota Legislature, responding to a federal mandate under the National Highway Traffic Safety Act of 1966, enacted legislation to require all motorcycle operators and passengers to wear a safety helmet, of a type approved by the Commissioner of Highways (later Public Safety), at all times when the motorcycle is in motion.

In 1976 Congress removed from the U.S. Department of Transportation the authority to enforce the motorcycle helmet requirement against the states, and a number of states responded by repealing all or part of their mandatory helmet laws. In 1977 Minnesota joined this trend by amending its helmet law to make it apply only to operators and passengers under the age of 18 (a requirement still retained in the federal safety standards).

The partial repeal of the helmet law became effective April 7, 1977. As Table I shows, in the period 1977-80 motorcycle fatalities (operators and passengers) averaged 103 per year, compared to 56 per year in the six years prior to 1977. The fatality rate for motorcycles in the post-repeal period represents an 84 percent increase in average annual motorcycle fatalities, while non-motorcycle highway fatalities over the same period declined by an average of 9 percent per year.

From this data the most obvious conclusion would be that the 1977 helmet law repeal resulted in a significant increase in motorcycle fatalities. However, such a conclusion cannot be

drawn solely from the figures in Table I since those figures do not take into account factors other than the statutory change nor the extent to which these other factors might explain the increase in fatalities. The present study deals with the identification and measurement of some of these other factors and the role they may have played in the increased motorcycle fatality rate, and seeks to determine whether, and to what extent, the helmet law revision itself may have contributed to the rise in motorcycle fatalities.

One central assumption of this study is that there is an actual relationship between the existence of a mandatory motorcycle helmet law and use of helmets by operators and passengers. Major support for this assumption is found in the 1979 report of the Minnesota Department of Public Safety on the effects of the 1977 statutory change. That study reported that motorcycle helmet usage in Minnesota declined from near 100 percent in 1976 (the last full year before the statutory change) to about 53 percent in 1979. This experience is consistent with findings in other states: the National Highway Traffic Safety Administration has reported that most states have estimated a compliance rate with their helmet laws of 95 - 100 percent during the time they were in effect, while the use of helmets following a repeal of the legal requirement generally falls to between 40 and 60 percent. These figures strongly indicate that there is a very high level of helmet use when helmet laws are in effect and a substantially lower level of helmet use after their repeal.

## DATA AND METHODS

The analysis in this study begins with the development of three alternative computer trend models to determine the level of motorcycle fatalities for the post-repeal period (1977-80) which would have been predicted from the pre-repeal trend data of 1970-76. These models are called "univariate" because they take into consideration only one variable, in this case motorcycle fatalities.

### Model A: 1970-76 Univariate Linear Trend Model

The first such model was developed by the Department of Public Safety in its 1979 report. It utilizes the motorcycle fatality data from 1970 through 1976 to predict the 1977-79 experience, and it forecast a total of 90 fewer fatalities than actually occurred. An extension of this analysis for an additional year (1980) showed a difference between predicted and actual fatalities of 132 over the four years following the helmet law revision (Table II, Model A).

### Model B: 1971-76 Univariate Linear Trend Model

A second model uses motorcycle fatality data from 1971 through 1976, dropping the 1970 data: this is done as a "check" on Model A, because the relatively low number of fatalities in 1970 (40) might have a disproportionately strong influence on the forecasting. Model B predicts a total of 155 fewer fatalities for 1977-80 than actually occurred (Table II, Model B).



### Model C: 1971-76 Seasonal Trend Model

Models A and B are called "linear trend models" because they represent the pre-repeal fatality trend by means of a straight line fitted through the data. These two models both suffer from the same drawback of having only a relative handful of figures (data points) with which to work. This deficiency can be alleviated by fitting a non-linear, seasonal trend model to monthly rather than annual figures, an approach which has the added advantage of being better suited to the data (since, as one might expect in Minnesota, motorcycle fatalities tend to follow a highly seasonal pattern). The annual summaries of predictions for this seasonal model are shown under Model C in Table II, which forecasts an even greater difference (198) between predicted and actual fatalities than either of the previous two models.

The fact that each of these three models predicts a somewhat different level of fatalities for the post-statutory revision years is not surprising since each model is actually utilizing different figures (seven years of annual data, six years of annual data, and six years of monthly data). What is striking is that each of the three models predicts substantially fewer fatalities for 1977-80 than actually took place. This strongly suggests that, whatever the explanation for the sharp increase in fatalities in 1977 and subsequent years, it does not lie in a continuation of trends from previous years. But while the univariate models explain this much, they do not explain what did cause the post-1976 increase in motorcycle fatalities.

To answer this question it is necessary to utilize a "multivariate" model which simultaneously can take into account a number of possible causal factors.

Model D: 1971-76 Multivariate Usage Model

The first multivariate model (Model D) attempts to explain the post-repeal increase in motorcycle fatalities as a function of increased motorcycle usage. It involves first constructing a model to represent the relationship between fatalities and usage based on the relevant 1971-76 data, and then computing the expected post-repeal fatalities from the actual post-repeal usage data. If increased motorcycle usage was the cause of the increase in post-repeal fatalities, then there should be little difference between the actual number of fatalities and the number predicted by this model.

Since motorcycle usage could not be directly measured, two proxy measures of usage were chosen for use in this model: 1) the total number of registered motorcycles for each given year, and 2) the average temperature (i.e., Fahrenheit degrees above freezing) during the peak motorcycle riding season (i.e., April through October).

Using regression analysis to fit the multivariate model to annual motorcycle fatality figures between 1971 and 1976, it is found that there are approximately 1.6 additional fatalities for each one-degree increase in average above freezing temperature for the motorcycle season, and approximately 13 additional fatalities for each 100,000 increase in registered motorcycles. These numbers (1.6 and 13) are expressions of the degree of

change in fatalities per unit change in a variable, and are called regression coefficients. By applying these pre-repeal coefficients to the post-repeal registration and temperature data, the expected average annual number of post-repeal fatalities is computed to be 61.3 (Model D in Table III). This forecast of average annual fatalities is somewhat fewer than expected using the univariate trend models A and B (70.3 and 64.5, respectively) and somewhat more than the seasonal univariate model C (49.5). Again the significant finding is that this more sophisticated multivariate model, like the univariate models tested, did not predict the sharp actual increase in fatalities following the 1977 helmet law revision (an average of 103 fatalities annually for the years 1977-80). Thus, it appears that the increased motorcycle usage since 1977 cannot explain the post-repeal increase in fatalities.

#### Model E: 1971-80 Multivariate (Usage) Model

The next step in this analysis is to construct a multivariate model (Model E) for the full 1971-80 time period and including both the two usage variables (i.e., registrations and temperature) as well as the presence or absence of the mandatory helmet law as the final variable. This model determines the separate effect on fatalities of each of these three predictor variables while controlling for the effects of the other two.

The regression coefficients for Model E are .00019 for the registered-motorcycles variable and 1.3 for above-freezing temperature, meaning that there are about 19 additional

fatalities for every 100,000 additional motorcycles and approximately 1.3 additional fatalities for each degree change in average temperature; these coefficients have remained reasonably stable (compared to Model D) while adding the statutory change variable to the model and extending the data to 10 years. The regression coefficient for the helmet law variable for the 1971-80 model is 40.29, meaning that the statutory change has been responsible for about 40 additional fatalities per year since 1977, even after controlling for the effects of usage as measured by the number of motorcycles and temperature.

Model F: 1971-80 Multivariate (Accident) Model

One reasonable criticism of multivariate models D and E is that they may not include enough indicators of actual motorcycle usage and thus might overestimate the number of fatalities due to the helmet law revision. Data limitations notwithstanding, it is desirable to address this possible criticism. One method for doing so involves using the number of motorcycle accidents as a proxy for all other contributors to motorcycle fatalities which could have changed in 1977, coincidentally with the helmet law revision. Then, while statistically controlling for the number of accidents, one may find the effect of the statutory change to be much less than the additional 40 deaths per year.

Table IV clearly shows that there has been a step increase in accidents beginning in 1977 coincident with the helmet law repeal. The accident total leveled off to between 2,400 and 2,500 in the years 1973-76 and then jumped sharply to a new

plateau between 2,700 and 2,900 for the years 1977-79. This represents an increase of roughly 14 percent. As noted earlier, motorcycle fatalities increased by approximately 84 percent at that same time. Thus, the increase in accidents beginning in 1977 might account for some of the corresponding rise in fatalities.

Again, the relative importance of these variables can be assessed using regression analysis. The multivariate Model F replaces all other usage variables with the number of motorcycle accidents and then statistically determines the separate effects on fatalities of the helmet law revision and the increased number of accidents, where each variable's contribution is computed while statistically controlling for the other variable. The regression coefficients reveal that fatalities increased by approximately 25 per 1000 additional accidents and by 32.2 per year due to the statutory revision.

For the years 1977-80 the total number of accidents was 11,366, and for the years 1973-76 (the comparable pre-repeal period, during which a "plateau" of between 2,400 and 2,500 accidents was reached) the total number of accidents was 9,671, for a difference of 1,695. Given the rate of 25 additional fatalities for each 1,000 additional accidents, this indicates that a total of 42.4 additional fatalities in 1977-80 are attributable to the increase in accidents. When added to the number of fatalities attributable by this model to the helmet law repeal (32.2 coefficient times 4 years = 128.8), a total of 171.2 fatalities, or 42.8 per year, are attributable to the combined effect of increased accidents and the helmet law repeal.

The combined average of 42.8 annual fatalities estimated by Model F for the 1977-80 period is quite close to the combined average annual 42.0 indicated by Model D (Table III) as being unanticipated. Model F estimates that of these 42.8 annual fatalities, 32 are attributable to the helmet law repeal, while Model E estimates that 40 are attributable to this factor.

#### Findings of the Models

From the helmet-law coefficients as established by the two multivariate models it is possible to conclude that the range of fatalities attributable to the helmet law repeal is between 32 and 40 per year. The exact figure within the range would depend on the extent, if any, to which the helmet law repeal increased the total number of accidents -- the low figure would assume no relationship between the two while the higher number would assume that the repeal was solely responsible for the increase in accidents. While the latter assumption is unlikely given the obvious relationship between the number of motorcycles on the road and the number of accidents (a correlation of +.96 where +1.0 is a perfect correlation), there are some reasons to think that the repeal did contribute to the higher accident rate:

1. Whatever the cause or causes are for the accident increase they seem unique to motorcycles, since the patterns of motorcycle and all-vehicle accidents since 1971 are quite dissimilar.
2. The reduction in helmet use after 1976 would have exposed more motorcyclists to flying objects resulting in greater loss of vehicle control.

3. The repeal may have resulted in an increase in reportable accidents by making accidents more dangerous (one measure of the danger of motorcycle accidents, the ratio of fatalities to total accidents, rose by 49 percent from 1976 to 1977).

There is not now sufficient information to decide this question finally.

#### DISCUSSION

The findings up to this point may be summarized as follows:

1. There was a sharp increase in the number of motorcycle fatalities following the 1977 helmet law repeal, and the level of fatalities has remained at this high level in the years since 1977.
2. The univariate linear regression and seasonal models (Models A, B and C) show that this increase could not have been predicted by pre-1977 trends.
3. A model which includes two proxy measures of motorcycle use and one representing the helmet law repeal (Model E) shows a total of 168 fatalities for the period 1977-80, or about 42 per year, which were not expected on the basis of the usage variables alone. Of these 42 unanticipated fatalities the model shows about 40 may be attributed to the helmet law repeal.
4. A model using motorcycle accidents as a substitute for all other usage variables (Model F) shows that in the years 1977-80, approximately 128.8 fatalities (32.2

per year) can be attributed to the helmet law repeal and roughly 35 (8.75 per year) to the increase in accidents.

5. The range of fatalities the models attribute to the helmet law repeal is roughly between 32 and 40 per year. This is a range for an annual figure based on averages and should not be construed as a conclusion or prediction for any single past or future year.

This range is significant because it represents about one-third of the average annual motorcycle death rate in Minnesota for 1977-80, and roughly 4 percent of all the highway fatalities in Minnesota in 1979. What makes these fatalities particularly costly for society is the fact that they are disproportionately concentrated in lower age groups. In 1979 almost two-thirds of the persons killed in motorcycle accidents were under age 25 and over 90 percent were under age 30.

It remains for the Legislature to decide among four basic options regarding motorcycle helmets:

1. It can make the present helmet law apply to all operators and passengers.
2. It can make no changes in the present helmet law but can direct efforts to encourage the voluntary use of helmets, such as expanded training and public education.
3. It can shift the costs of helmet non-use away from society as a whole and more onto motorcyclists, through expanded insurance requirements for motorcycles.
4. It can decide that the final impact of the helmet



law repeal is still not clear, or that questions of state involvement in requiring self-protection outweigh issues of fatality rates, and take no action with regard to motorcycle helmets.

It is hoped that this study will assist the Legislature in evaluating these options.

TABLE I

MINNESOTA MOTORCYCLE FATALITIES 1970-80

1970	40
1971	48
1972	54
1973	63
1974	51
1975	63
1976	57
1977	94
1978	106
1979	97
1980	116*

\* As of October 31, 1980

TABLE II

## FATALITY PREDICTIONS OF UNIVARIATE MODELS A, B AND C

Year	Actual Fatalities	MODEL A Linear Regression (1970-76)		MODEL B Linear Regression (1971-76)		MODEL C Seasonal (1971-76)	
		Predicted	Difference	Predicted	Difference	Predicted	Difference
1977	94	66	+28	62	+32	53	+41
1978	106	69	+37	64	+42	54	+52
1979	97	72	+25	65	+32	54	+43
1980	116	74	+42	67	+49	54	+62
TOTAL	413	281	+132	258	+155	215	+198
Average	(103.3)	(70.3)	(+33.0)	(64.5)	(+38.8)	(53.8)	(+49.5)

TABLE III

FATALITY PREDICTIONS OF MULTIVARIATE (USAGE) MODEL 1971-76  
(MODEL D)

Year	Actual Fatalities	Predicted Fatalities	Difference
1977	94	63	+31
1978	106	61	+45
1979	97	58	+39
1980	116	63	+53
TOTAL	413	245	+168
ANNUAL AVERAGE		61.3	42.0

TABLE IV  
MOTORCYCLE ACCIDENTS AND FATALITIES 1971-80

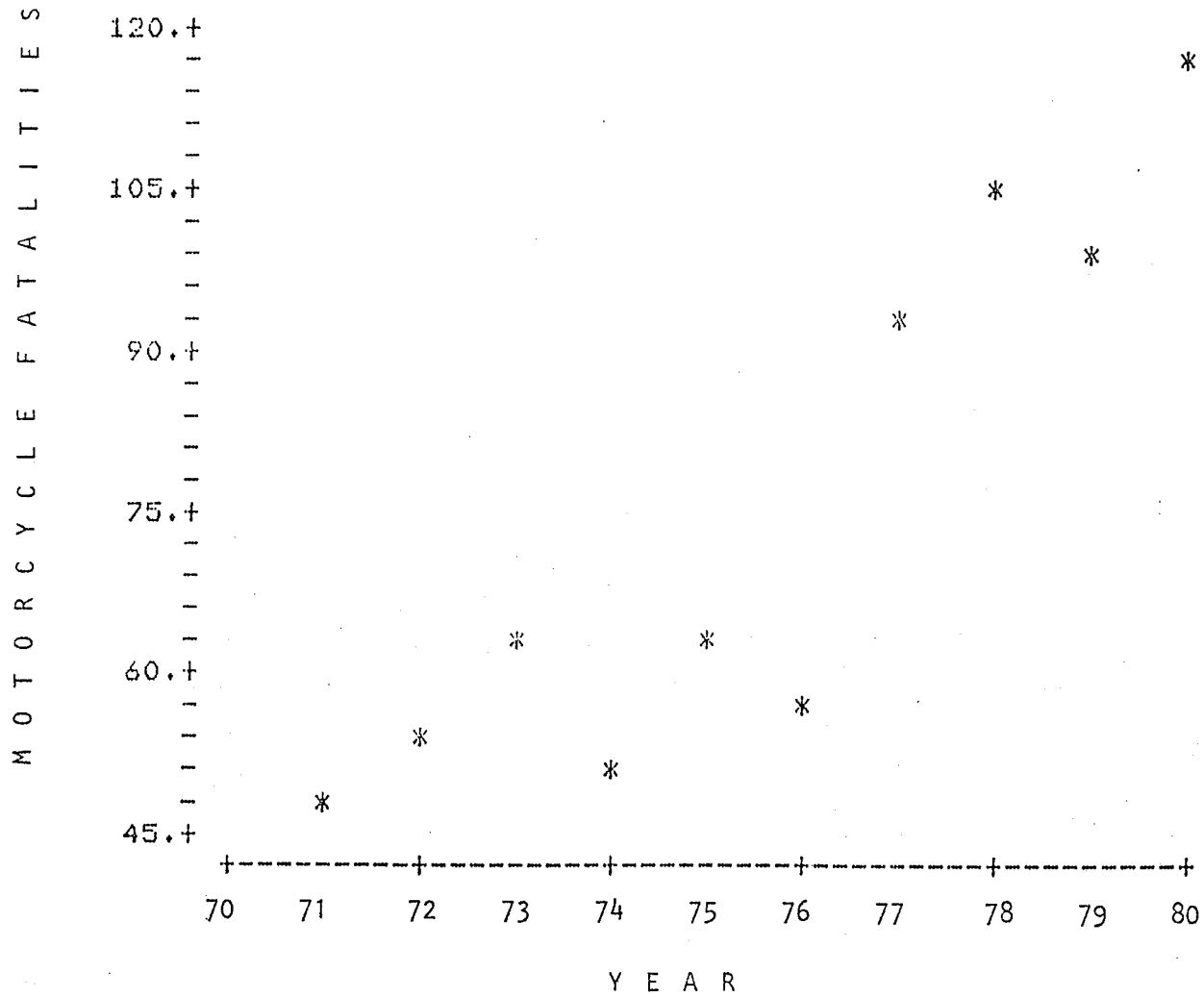
	<u>Accidents</u>	<u>Fatalities</u>
1971	1,689	48
1972	2,013	54
1973	2,411	63
1974	2,400	51
1975	2,400	63
1976	2,460	57
1977	2,718	94
1978	2,827	106
1979	2,872	97
1980	2,949*	116**

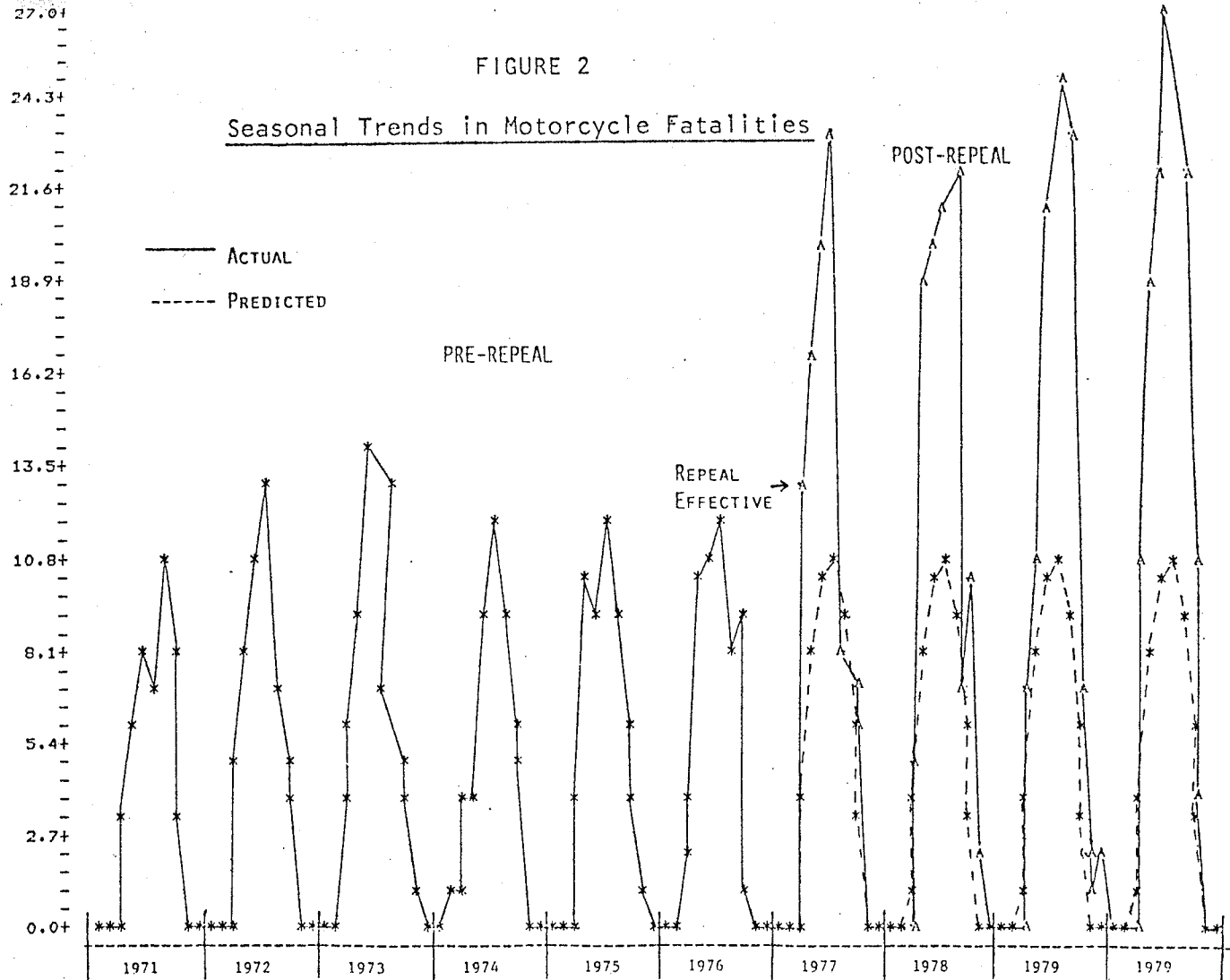
\* Projected on basis of average annual increase in motorcycle accidents 1971-79.

\*\* As of October 31, 1980

FIGURE 1

MINNESOTA MOTORCYCLE FATALITIES 1971-1980





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