AN IMPACT ASSESSMENT OF ARIZONA'S LOWERED LEGAL DRINKING AGE

AND A REVIEW OF THE PREVIOUS RESEARCH

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INTRODUCTION

In August of 1972, the Arizona State Legislature lowered the minimum legal drinking age from 21 to 19 years. Evaluations of similar drinking age changes have produced important results. The impact of Arizona's revised statute has not yet been adequately examined, as indicated by recent legislative debate to reinstate a legal drinking age of 21.[1] The Department of Public Safety's Statistical Analysis Center initiated this research to fill this gap and to supply the State's lawmakers with an impact assessment of the lowered legal drinking age in Arizona.

The purpose of this report is to provide reliable and current information on the effect of the lowered drinking age on traffic accidents, injuries and fatalities, and alcohol consumption. The scope of the study is more narrowly defined as the impact on drinking and driving resulting from the 1972 statutory change, with only general references to the overall drinking-age issue. Based on previous research findings, the study hypothesized that lowering the minimum legal drinking age in Arizona had resulted in increased fatalities, increased fatal accidents, and increased drinking among law-affected youths. Through the use of a proven statistical technique (Interrupted Time-Series Analysis), this hypothesis was confirmed. The analysis found that the change in drinking age produced a 23 percent increase in beer sales, a 26 percent increase in fatal crashes, and most significant of all, a 36 percent increase in traffic deaths.

This report is comprised of three sections. Section one is a general overview of youth drinking-and-driving issues, drawing upon previous research and relevant literature. Section two describes the research methods used and the findings of this study. The third section presents a summary of the important points discussed in the report. Conclusions presented here are not intended as a definitive statement on the larger drinking age issue. Instead, they may be interpreted as supporting evidence to one segment of an entire spectrum of required research on this important and complicated subject.

SECTION I

YOUTH-RELATED DRINKING AND DRIVING: A LITERATURE OVERVIEW

A. Extent of the Problem

The literature on youth related drinking and driving emphasizes a definite relationship between age, alcohol consumption and traffic accidents. Indeed, many researchers have concluded that young alcohol-impaired drivers constitute the major influence on drinking-and-driving problems in general. For example, a random sample of 753 alcohol-related fatalities in Wisconsin revealed that 45 percent of drivers killed were 16 to 25 years of age.[2] This same age group accounted for only 23 percent of the total licensed Wisconsin drivers during the same time period. Likewise, in Nassau County, New York, it was discovered that although only 20 percent of licensed drivers were 24 years of age or younger, 40 percent of the county's alcohol-related accidents involved drivers in this same age bracket.[3] This same relative pattern is evidenced throughout both national and international research.[4] As reported in Tables 1a and 1b, Arizona's accident data yield comparable results.

It is estimated that at any given time one out of every 50 (two percent) drivers is legally intoxicated. Moreover, of the 50,000 fatalities that occur annually on the nation's highways, approximately 50 percent are alcohol-related. In other words, two percent of the driving population may account for almost 50 percent of traffic fatalities.[5] Of further and even more serious consideration is the fact that the 15-to-24-year-old driver accounts for about 40 percent of the total alcohol-related fatal accidents.

TABLE 1a

ARIZONA TRAFFIC ACCIDENTS, 1978 to 1980

	Number of Licensed Drivers 16 to 24 Years Old	Drivers 16 to 24 as a percentage of All Licensed Drivers	Number of Drivers Age 16 to 24 in Alcohol-Related Accidents	Drivers 16 to 24 as a Percentage of All Drivers in Alcohol-Related Accidents
1978	375,377	23.23%	5,158	41.31%
1979	413,029	23.67%	5,517	41.51%
1980	456,944	22.38%	5,227	40.23%

TABLE 1b

ARIZONA FATAL ACCIDENTS, 1978 to 1980

	Number of Licensed Drivers 16 to 24 Years Old	Drivers 16 to 24 as a Percentage of All Licensed Drivers	Number of Drivers Age 16 to 24 in Alcohol-Related Fatal Accidents	Drivers 16 to 24 as a Percentage of All Drivers in Alcohol-Related Fatal Accidents
1978	375,377	23.23%	155	42.82%
1979	413,029	23.67%	153	44.61%
1980	456,944	22.38%	131	41.32%

SOURCE: Arizona Department of Transportation, Safety Projects

B. Blood Alcohol Concentration and the Young Driver

Blood alcohol concentration (BAC) is defined as a measure of the amount of alcohol present in a person's blood. In the United States it is measured in terms of "percent alcohol," which is the weight of a quantity of alcohol per unit volume of blood. Technically the measurement is given in grams per 100 millileters, so a BAC of .08 grams of alcohol in a 100 milliliter sample of blood will appear as a BAC of .08 percent or 80 mg/100. In Arizona, as in many states, a BAC of .10 percent legally defines intoxication. Due to biological variations among people, however, a fixed level such as .10 percent may seem arbitrary. But although the degree of driver impairment at the .10 percent level varies, that BAC provision is not unreasonable since most drivers, particularly younger drivers, are noticeably impaired at lower BACs. Behavioral effects expected at different levels of blood alcohol concentration are summarized in Table 2. Table 3 indicates the relationship between an individual's biological makeup, the amount of alcohol consumed, and the resulting BAC level.

Studies of blood alcohol concentration support several findings that can be generalized to the entire drinking-driver population. The likelihood of a serious accident occurring sharply increases on a risk potential scale in relation to increasing BAC;[6] and as Figure I-1 shows, setting the probability of a sober driver being responsible for a fatal accident at 1.0, the risk of a drinking driver being responsible for a fatal crash is seven times more likely with a BAC of .10 percent, twenty-five times more likely at .15 percent, and one hundred times more likely at a level of .20 percent. As an example, a 100 pound woman consuming four glasses of wine in an hour may be about seventy-five times more likely to cause a fatal car accident than her non-drinking counterpart. A further alarming fact is that the average BAC for convicted drunk drivers and drivers fatally injured in accidents is approximately .20 percent (suggesting that many may be driving with considerably higher blood alcohol levels).

TABLE 2

BLOOD ALCOHOL CONCENTRATION AND
BEHAVIORAL EFFECTS

Percent Blood Alcohol Concentration	Behavioral Effects
0.05	Lowered alertness, unually good feeling, release of inhibitions, impaired judgment
0.10	Slowed reaction times and impaired motor function, less caution
0.15	Large, consistent increases in reaction time
0.20	Marked depression in sensory and motor capability, decidedly intoxicated
0.25	Severe motor disturbance, staggering, sensory perceptions greatly impaired
0.30	Stuporous but conscious - no comprehension of the world around them
0.35	Equivalent of surgical anesthesia; minimal level causing death
0.40	Possible death

SOURCE: RAY, O., Drugs, Society and Human Behavior, 2nd Edition, Saint Louis: The C.V. Mosby Company, 1978.

TABLE 3

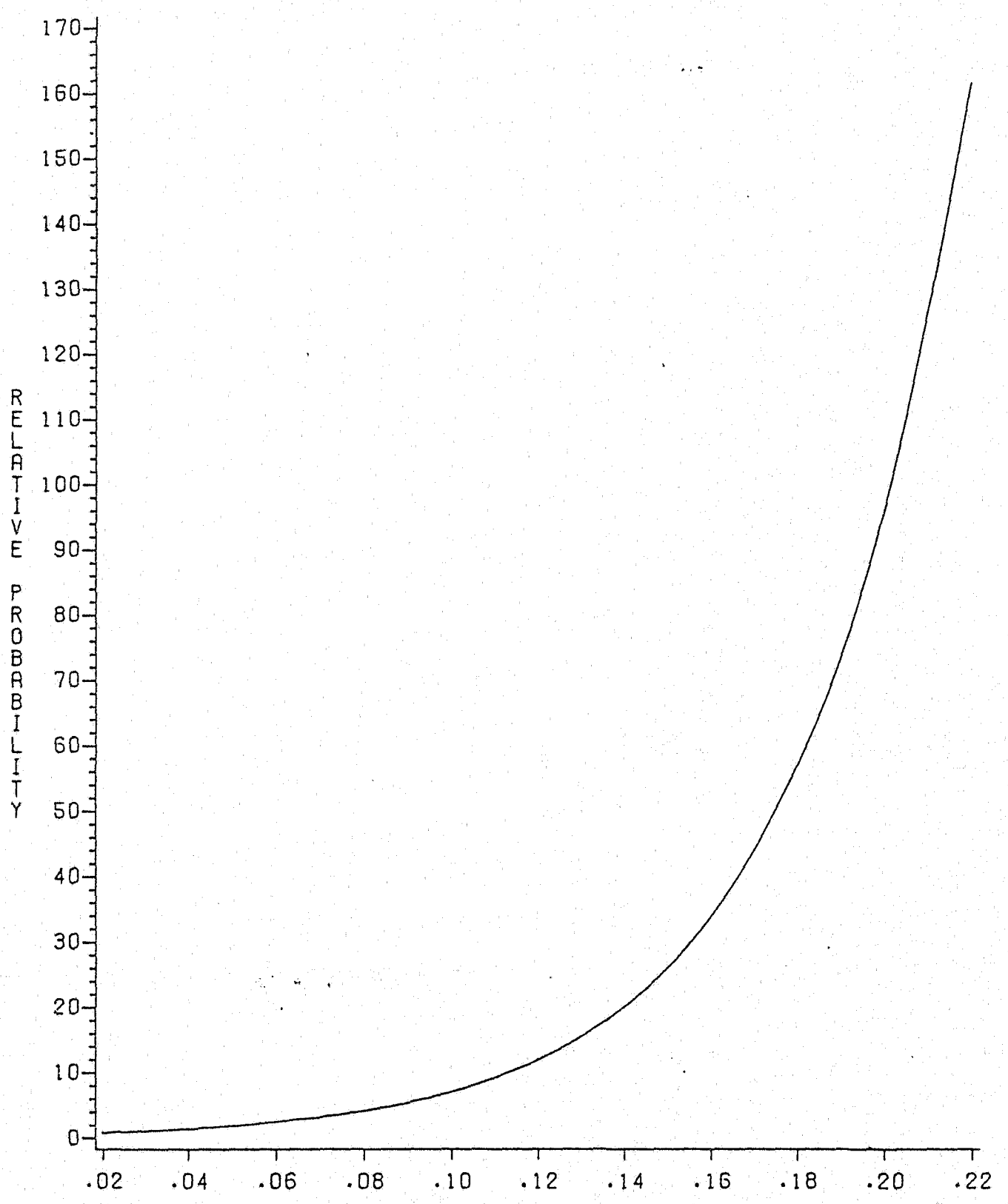
RELATIONSHIPS AMONG SEX, WEIGHT, ORAL ALCOHOL CONSUMPTION, AND BLOOD ALCOHOL CONCENTRATION

Absolute Alcohol (ounces)	Beverage Intake*	Blood Alcohol Concentration (mg/100 ml)			
		Female (100 lb)	Female (150 lb)	Male (150 lb)	Male (200 lb)
1/2	1 oz spirits** 1 glass wine 1 can beer	0.045	0.030	0.025	0.019
1	2 oz spirits 2 glasses wine 2 cans beer	0.090	0.060	0.050	0.037
2	4 oz spirits 4 glasses wine 4 cans beer	0.180	0.120	0.100	0.070
3	6 oz spirits 6 glasses wine 6 cans beer	0.270	0.180	0.150	0.110

* In 1 hour
** 100-proof spirits

SOURCE: RAY, O., Drugs, Society, and Human Behavior, 2nd Edition, Saint Louis: The C.V. Mosby Company, 1978.

Figure I–1. Relative Probability of Being Responsible for a Fatal Crash as a Function of Blood Alcohol Concentration



SOURCE: M.W. Perrine, J.A. Waller and L.S. Harris "Alcohol and Highway Safety: Behavioral and Medical Aspects." NHTSA Report DOT–HS–800–599. U.S. Dept. of Transportation (1971).

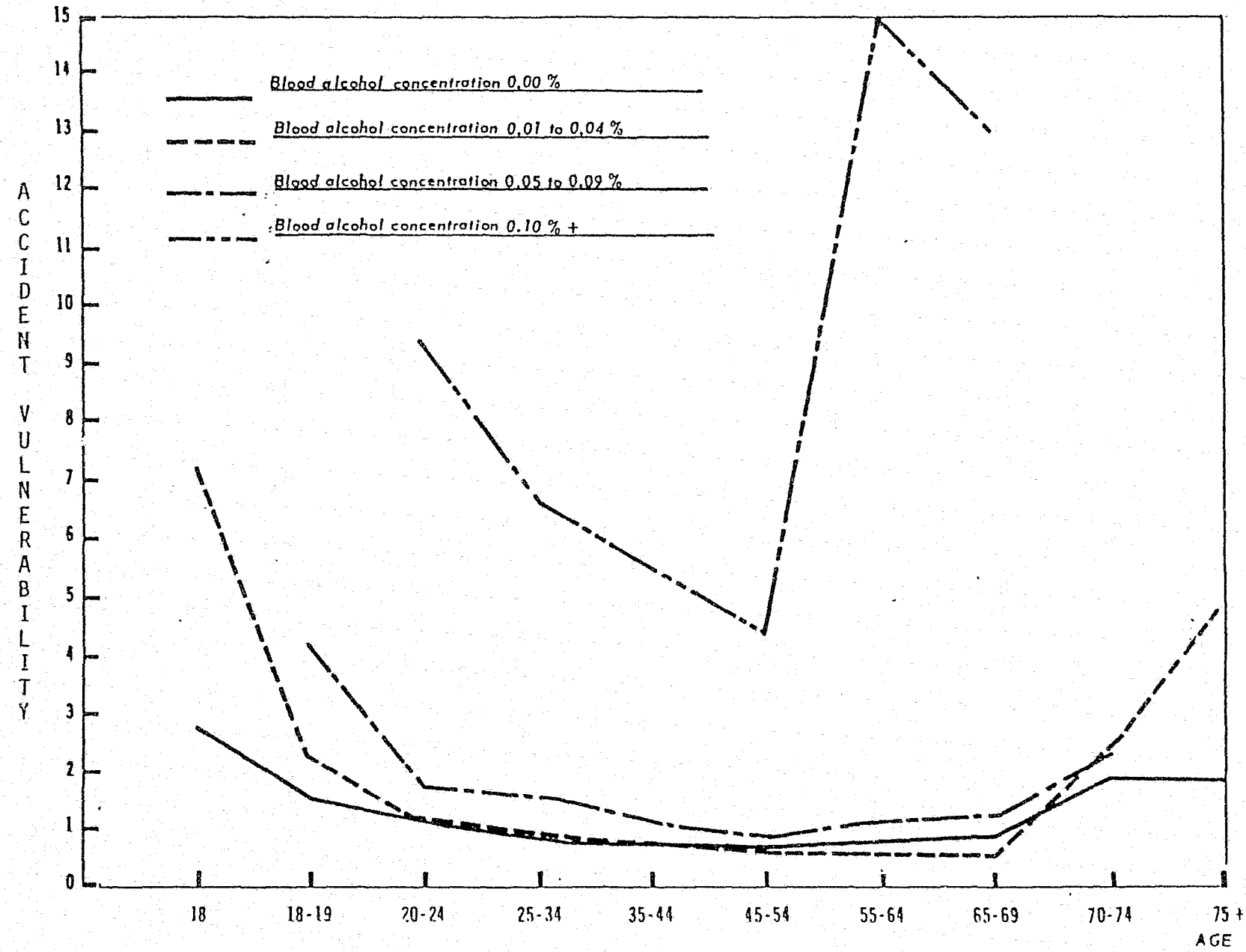
The important concept supported by this research is that driver BACs increasing above .08 percent may result in much larger disproportional increases in fatal crash risk.[7]

Studies investigating the relationship between age and blood alcohol concentration consistently demonstrate that the probability of accident involvement increases at a greater rate, and is significantly higher for younger drivers. Allsop,[8] for example, uncovered a pattern whereby the youngest and the oldest drivers in his study exhibited a higher likelihood of causing an accident--given the same BAC level--as middle-aged drivers. This discrepancy was especially pronounced for teenage drivers.

Oftentimes, studies examining the relationship between alcohol consumption and driver accident rates include an analysis of "risk potential," which is the probability of an alcohol-impaired driver becoming involved in a collision, an injurious accident, or a fatal crash. Numerous studies show that alcohol consumption increases the probability of teenage accident involvement at a much higher rate than that for older drivers.[9] A Canadian study comparing non-accident involved drivers with fatally-injured drivers revealed a probability of death 165 times greater for 16 and 17 year old drinking drivers than for non-drinking drivers.[10] Reported in Figure I-2 are the results of a Michigan study relating accident vulnerability to age and BAC. Clearly demonstrated is the relationship between BAC and accident vulnerability. More important to this study, however, is the apparent increased potential for accident involvement among young drivers.

An analysis of fatal accidents in California disclosed that 49 percent of fatally-injured drivers under age 20 had been drinking, compared with 61 percent of their over-20 counterparts.[11] Of further interest, however, is that of the fatalities under 20, only 18 percent were legally intoxicated (BAC of .10 percent). In comparison, of the drivers over 20 years of age killed in alcohol-related accidents, 50 percent were legally intoxicated. In other words, 82 percent of the under-20 driver fatalities had a BAC less than .10 percent, while 50 percent of those fatalities over 20 exceeded a BAC of .10 percent. This supports

Figure I-2: Accident Vulnerability as a Function of Age and Blood Alcohol Concentration



SOURCE: O.E.C.D., Road Research on Young Driver Accidents, O.E.C.D., Paris, 1975.

the argument that it takes less alcohol to impair a younger driver than it does an older one. Thus, young drinking drivers are more likely to be involved in fatal crashes at lower levels of blood alcohol as shown in Figures I-3 and I-4.

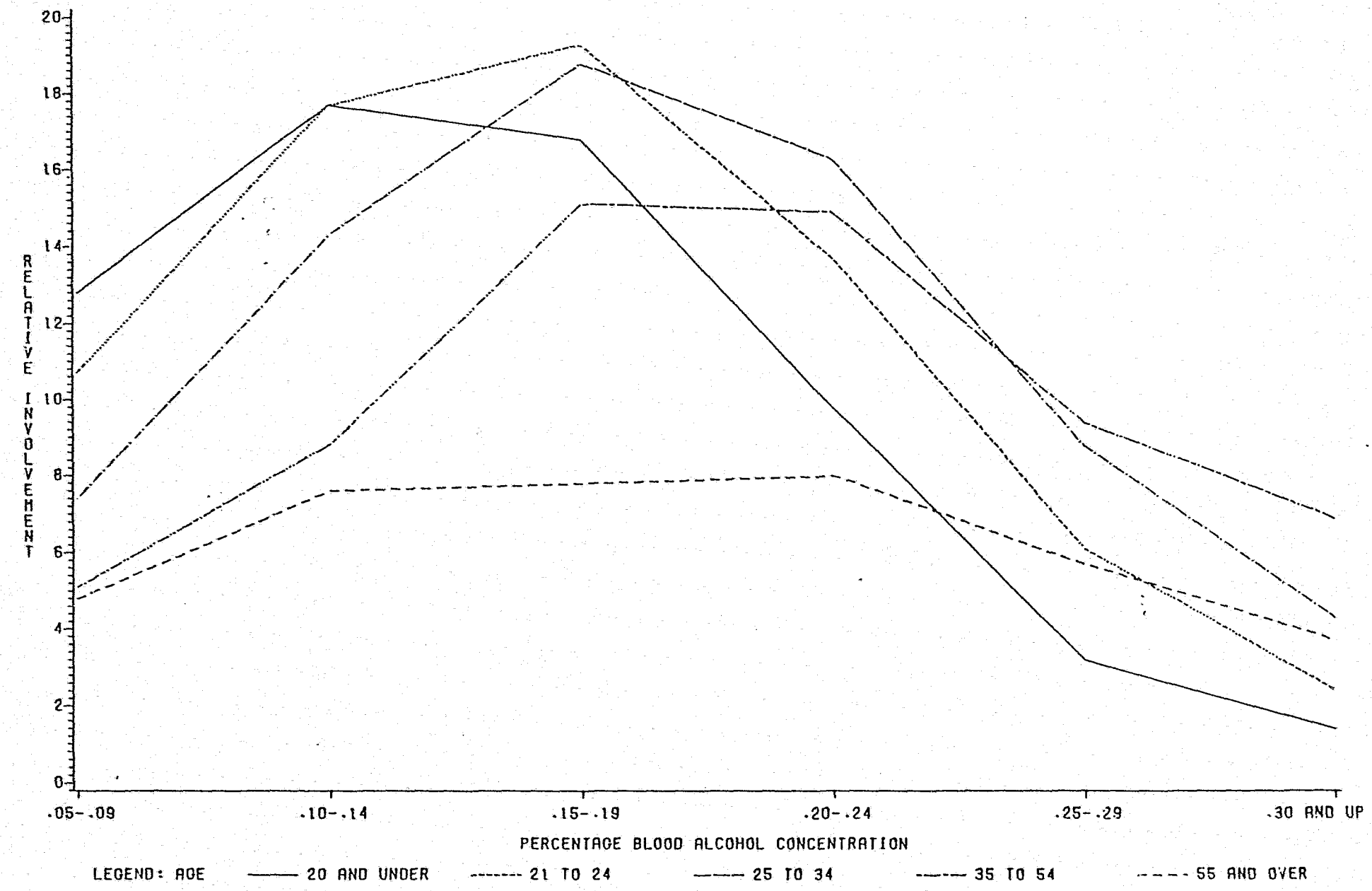
To this point, Section I has provided a review of the drinking-and-driving literature which describes a very real difference in traffic accident probabilities between the young drinking driver and the general driving population. It has attempted to establish through the documentation of relevant research the consequential relationship between the young driver, consumption of alcohol, and traffic accidents, injuries and fatalities. This report will now focus on those factors thought to have a direct impact on this relationship.

C. Factors Contributing to the Problem

Researchers have empirically examined many factors thought to have an effect upon traffic accidents. With regard to drinking and driving, there are essentially two classes of variables that assume major importance: internal individual factors, and external environmental factors. Internal factors are those variables which are derived from each individual and include such things as personality, level of maturity, perceptual capabilities, physical development and emotional balance. These factors are qualitatively oriented and as such are very difficult to measure. External factors are defined as those variables in the driver's environment which influence his drinking-and-driving behavior. These factors are somewhat more quantitative in nature and lend themselves more readily to measurement. Both internal and external factors may exert influence upon the youthful driver simultaneously.

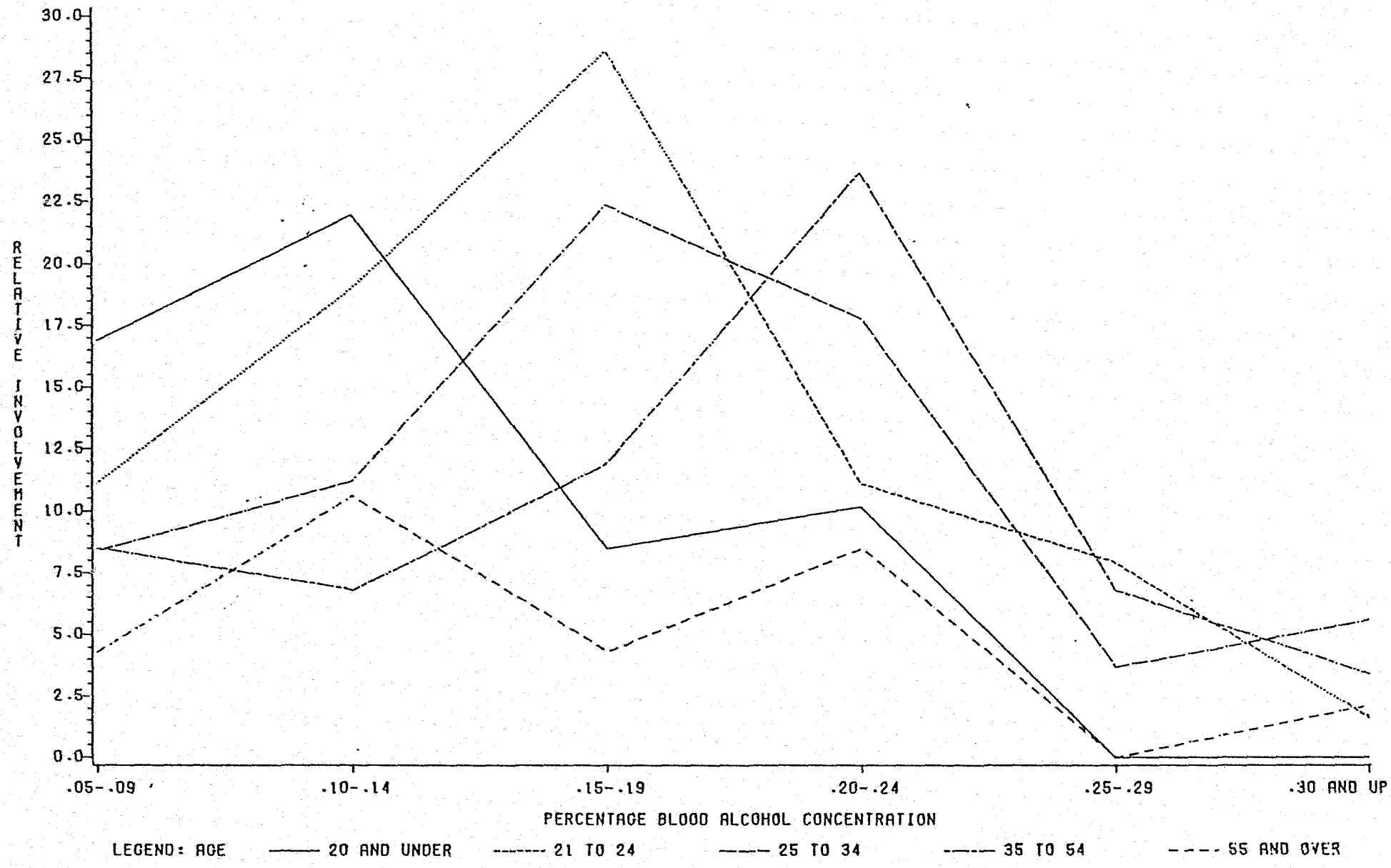
The absence of experience is most often cited as the critical variable in the young drinking-driver problem.[12] Experience may be further broken down into both driving and drinking experience. Clearly, driving inexperience is a contributing factor to the increased potential for accident involvement. Young inexperienced drivers are disproportionately

Figure I–3. U.S. Driver Involvement in Fatal Crashes at Increasing Blood Alcohol Levels, 1980



A 0.0 relative involvement means that no drivers were involved

Figure I–4. Arizona Driver Involvement in Fatal Crashes at Increasing Blood Alcohol Levels, 1980



A 0.0 relative involvement means that no drivers were involved

involved in both non-alcohol and alcohol-related accidents. Attainment of proper driving competence is achieved through familiarization and practice, normally acquired with time and maturity. This situation contributes heavily to the accident involvement attributed to youthful drivers as depicted in Figures I-5 and I-6. When driving deficiency is compounded with alcohol, the risk for accident involvement increases substantially.[13]

The young person is not only learning how to drive, but is also learning how to drink. While alcohol consumption is not usually considered a skilled behavior, inexperience at drinking has been found by researchers to be an important determinant in alcohol-related accidents. Naive drinkers must learn to adjust to their personal cognitive limitations as well as their physical tolerance for a relatively unfamiliar drug. The level of physical toleration is often cited in the literature as an influential factor in drinking-driving behavior. Goodwin et al.[14] found that motor performance was more impaired for normally-light drinkers than for normally heavy drinkers when both groups were administered the same amount of alcohol. Similarly, a study by Burns and Moskowitz[15] examined performance measures in light, moderate and heavy drinkers at BACs ranging from .03 to .13 percent. Their results indicated that those who drink less frequently show greater impairment at lower BAC levels than do frequent (or experienced) drinkers.

A recent national survey discovered that within three driving age groups--16 and 17 year olds, 18 to 25 year olds, and 26 years and older--the highest frequency of drinking occurred in the 18-to-25-year age group.[16] The lowest frequency of drinking was by the 16 and 17 year olds. One may conclude from the information presented thus far that 18 to 20 year olds are generally inexperienced drivers, inexperienced drinkers, and within the most active drinking group. Combining these three factors can result in a situation both alarming and potentially dangerous.

Today's lifestyle is a conspicuous factor externally influencing us all.[17] "Weekends were made for Michelob" seems to have become the ideology of the young who are more apt

Figure I–5. U.S. Drivers Involved in Fatal Crashes Per 10,000 Licensed Drivers, 1980

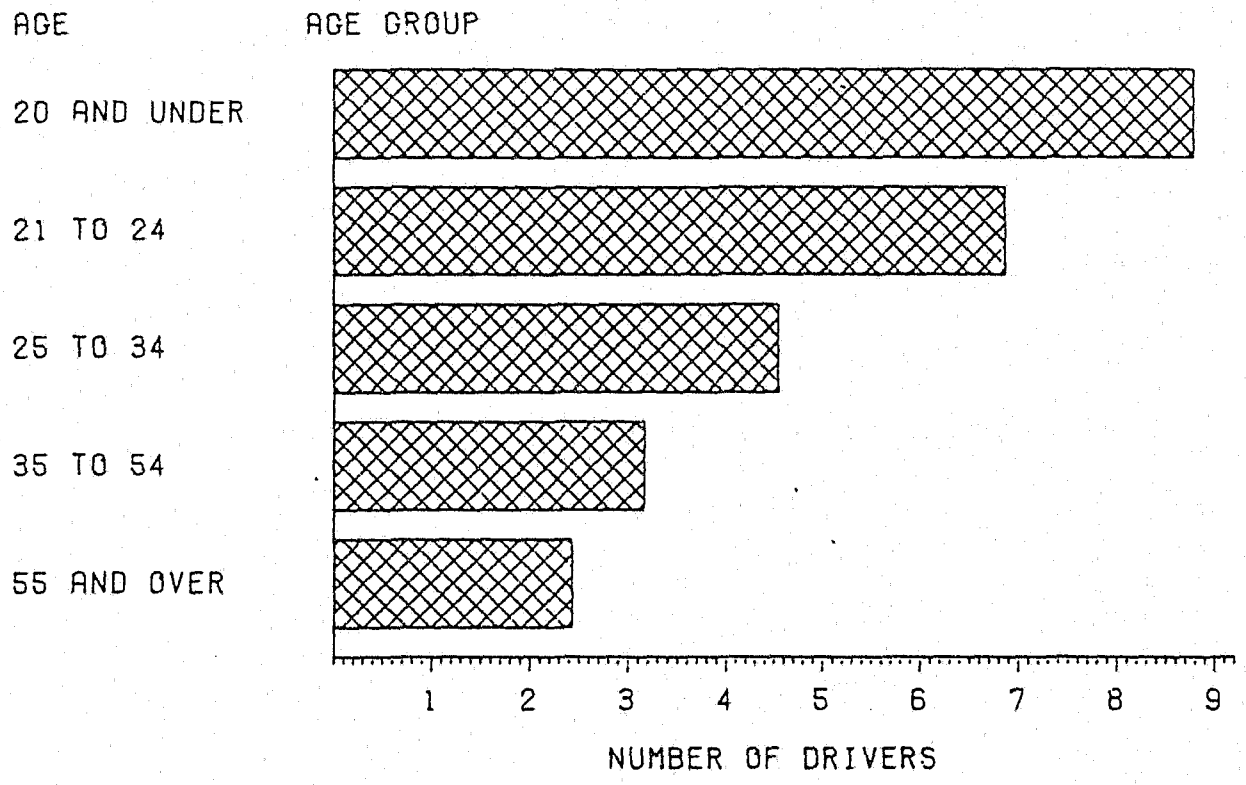
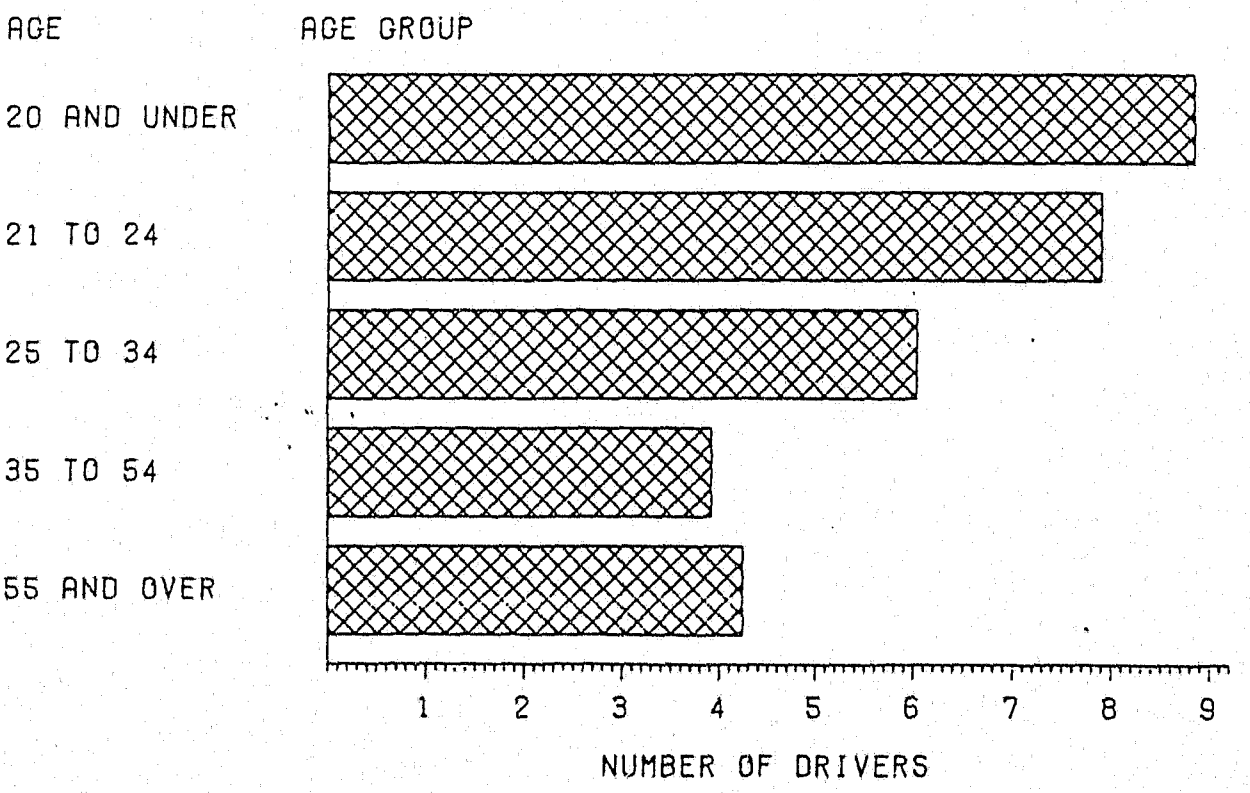


Figure I–6. Arizona Drivers Involved in Fatal Crashes Per 10,000 Licensed Drivers, 1980



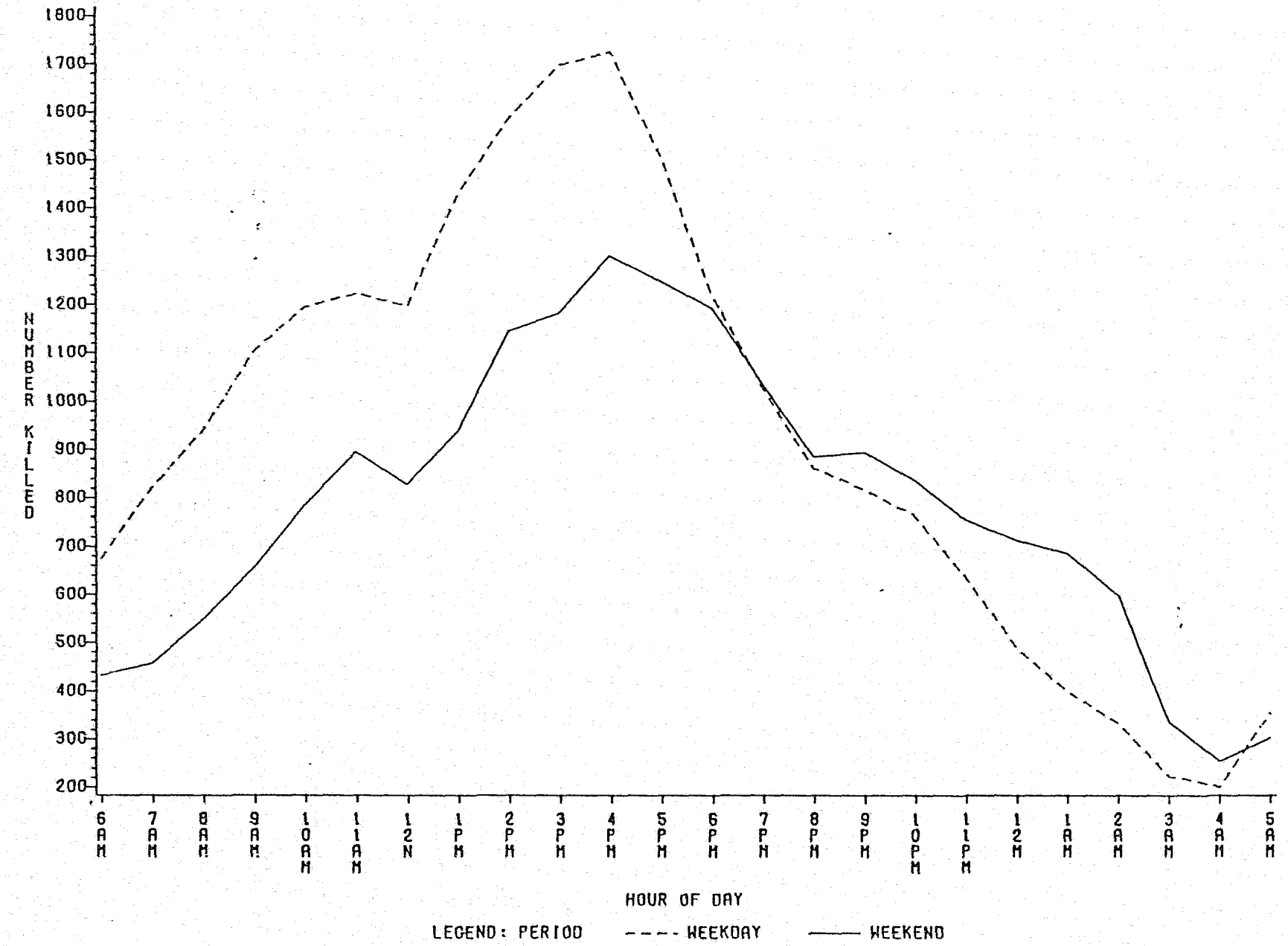
SOURCE: Fatal Accident Reporting System, National Highway Traffic Safety Administration

to be drinking and/or driving at night and on weekends. Jones and Jocelyn[18] surveyed the relevant research and concluded that the frequency of alcohol-related accidents is greatest on Friday and Saturday nights between 8:00 p.m. and 4:00 a.m. For those 45 years or older (see Figure I-7) the peak fatality rate occurs during the afternoon hours on weekdays and slightly later on weekends. In contrast, the highest fatality rate during the week for young adults 21 to 44 years of age (see Figure I-8) occurs just before midnight. This rate jumps dramatically on weekends with the greatest frequency around 1:00 and 2:00 a.m. Those drivers from 14 to 20 years of age display an even more extreme skewing of the fatality rate during night hours (see Figure I-9). Drivers between 14 and 20 years of age have fewer afternoon accidents, especially on weekdays, but a relatively high rate of nighttime fatalities.

Numbers of vehicles on the roads, weather conditions, roadway characteristics, commuting versus recreational driving, as well as individual driver variables are all factors of fatal traffic accidents that affect the overall driving population. Figure I-10 reports the average annual miles driven per licensed driver by age and sex. Drivers 16 to 19 years of age reported less than average annual mileage rates. This age category also represents a low percentage of the total driving population. Nevertheless, random roadside surveys conducted on weekend nights (8:00 p.m. to 4:00 a.m.) in several locations throughout the United States have revealed that drivers in their teens and twenties are greatly over-represented at these times.[19]

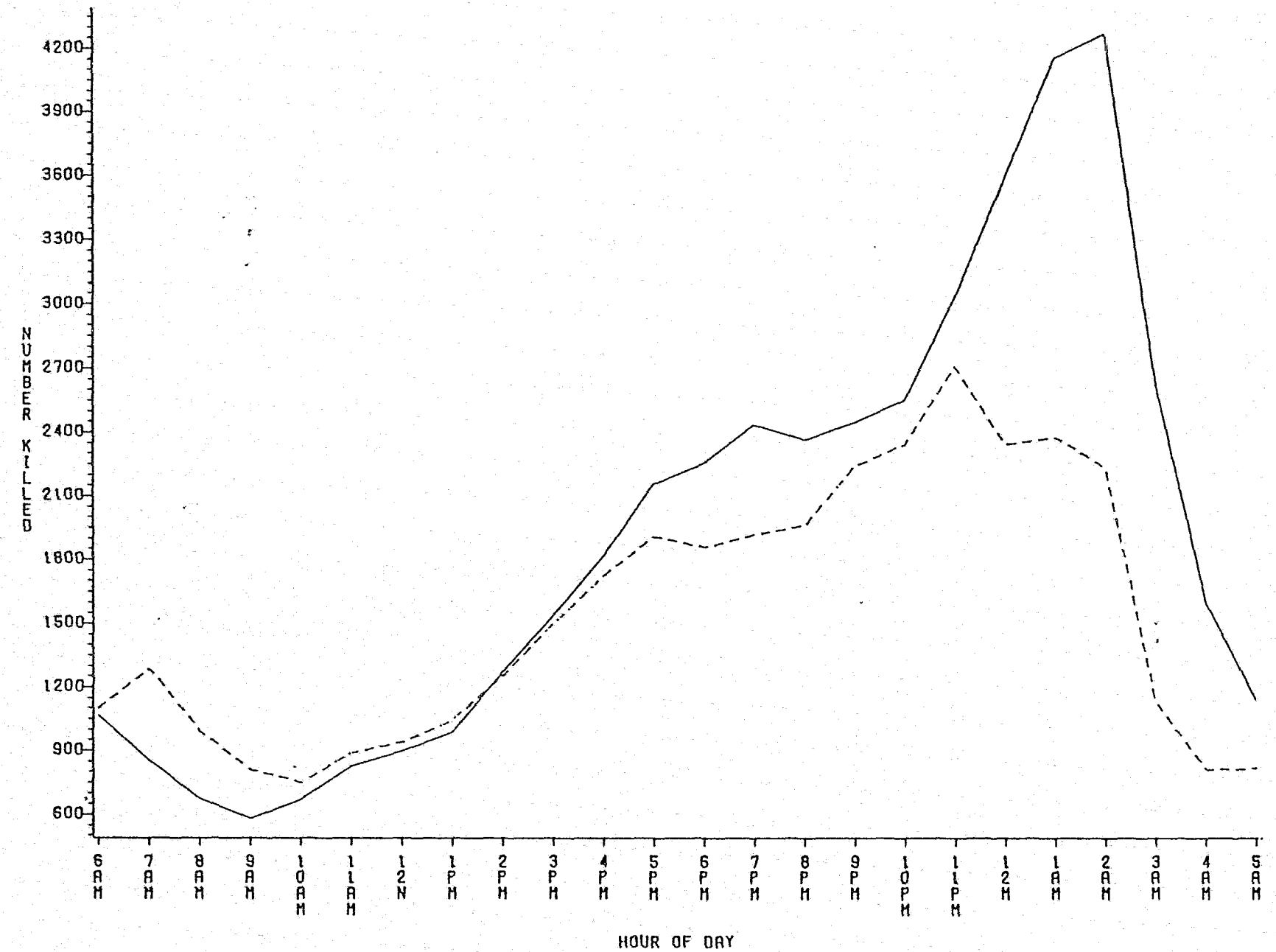
The above referenced studies indicate that most alcohol-related accidents occur at night, particularly on weekend nights; that the highest fatality rates for young drivers occur during that same time frame; and that drivers under 30 years of age are on the road on weekend nights more frequently than their numbers in the general driving population would account for. Although young people do indeed drive less often than their seniors they drive most often on weekends and evenings when the highest rates of fatal accidents and alcohol-related

Figure I–7. U.S. Fatalities by Hour of Day for Drivers Aged 45 and over, 1975–1980



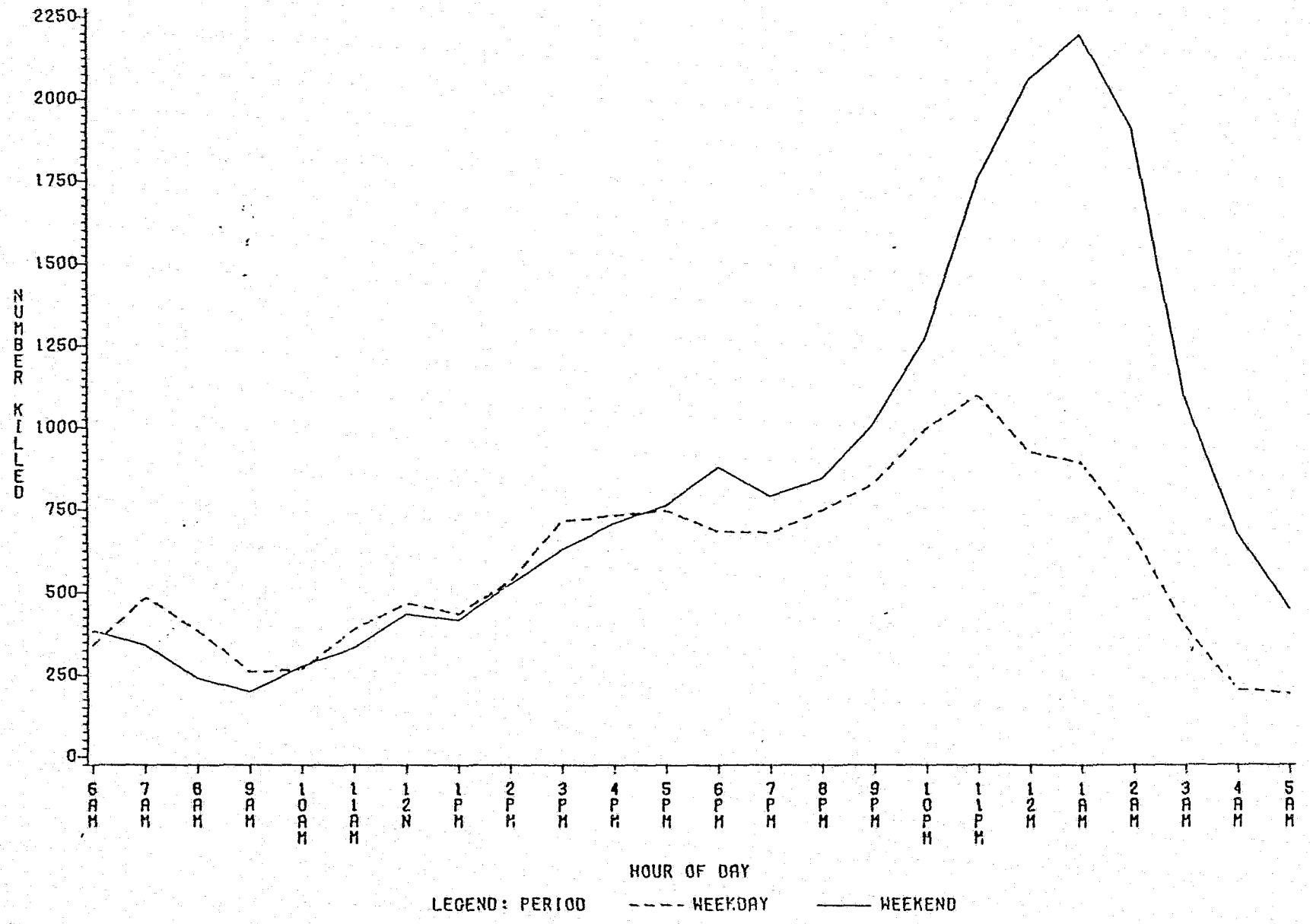
SOURCE: Fatal Accident Reporting System, National Highway Traffic Safety Administration

Figure I–8. U.S. Fatalities by Hour of Day for Drivers Aged 21 TO 44, 1975–1980



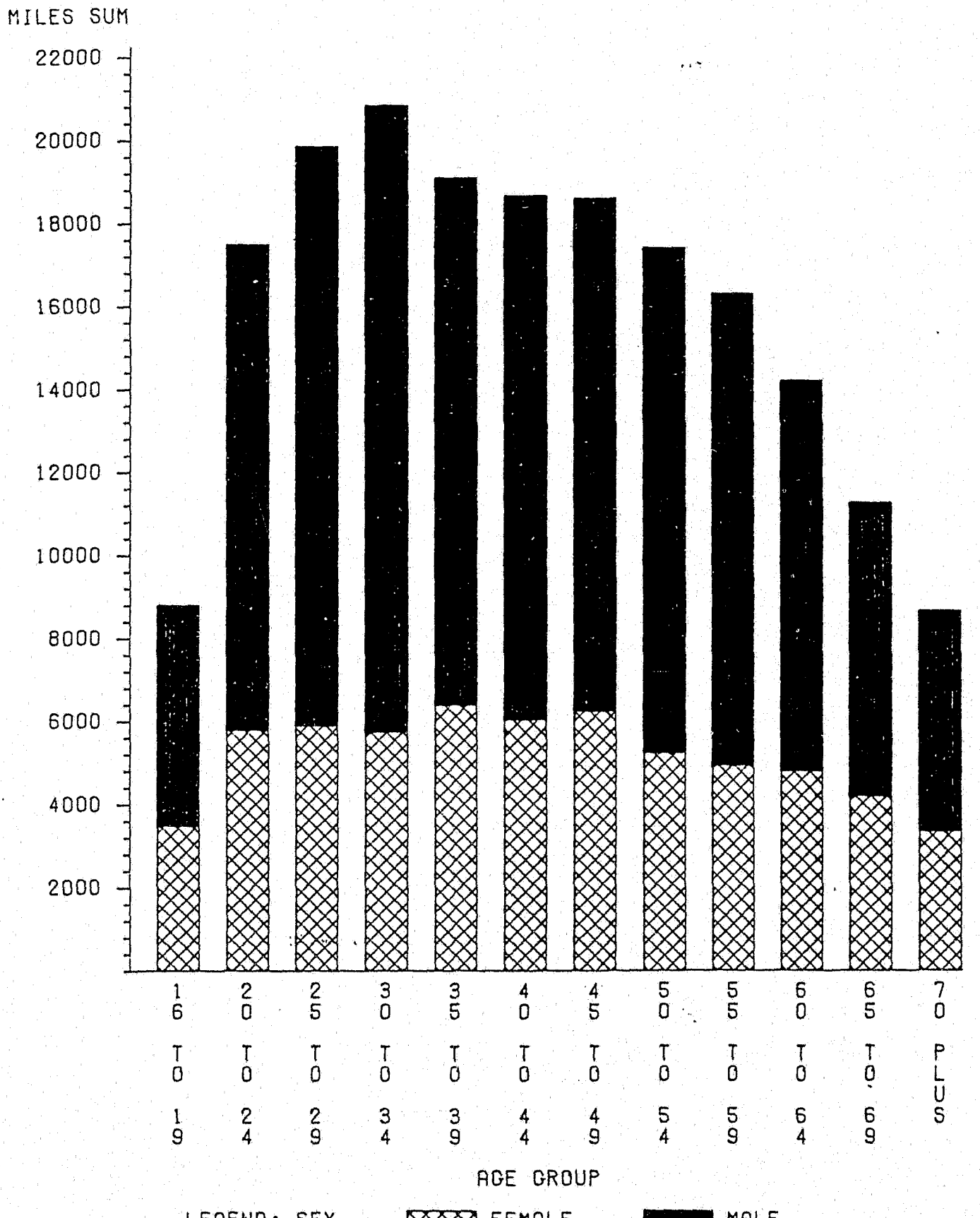
SOURCE: Fatal Accident Reporting System, National Highway Traffic Safety Administration

Figure I–9. U.S. Fatalities by Hour of Day for Drivers Aged 14 TO 20, 1975–1980



SOURCE: Fatal Accident Reporting System, National Highway Traffic Safety Administration

Figure I–10. Estimated Average Annual Miles Driven Per Licensed Driver, by Age and Sex



SOURCE: Wechsler, H., MINIMUM DRINKING–AGE LAWS, Toronto: D.C. Heath and Company, 1979.

accidents occur. Young drivers appear to drive at the times of highest risk, both for causing an automobile crash and for being victimized in an accident caused by another. When such risk exposure is coupled with alcohol consumption, the young drinking driver, relatively inexperienced with both the automobile and liquor, faces a high probability of involvement in a serious, possibly fatal accident.

D. Review of Research Assessing the Impact of Minimum Drinking Age Laws on Traffic Accidents

Two phenomena have played a large role in making the legal drinking age in America a controversial issue; the Prohibition movement, and the social unrest of the 1960's. Prior to Prohibition, adolescent drinking was regulated by the family rather than by state mandate.[20] When Prohibition was repealed in 1933, concerned groups and legislators focused their efforts to control the consumption of alcoholic beverages on "high risk" groups--primarily young people. Age restrictions for alcohol consumption were generally accepted until the late 1960's. Social unrest and public fervor concerning young people in Vietnam brought many age-related issues to the legislative conscience. As a consequence, between 1970 and 1975, 26 states responded by reducing their minimum drinking age[21] (see Table 4).

Three schools of thought exist regarding the impact of lower drinking ages. Rooney and Schwartz[22] and Smart and Goodstadt[23] have identified them as follows:

Null Hypothesis - This school argues that changing the minimum drinking age will have no significant effect on youth alcohol consumption. Since many young people were already drinking prior to statutory age changes, the lowered legal age may only legitimize the current practice.[24] No appreciable increase in alcohol-related collision rates would be expected by proponents of this hypothesis.

Restriction Hypothesis - The basic premise of this school of thought is that higher minimum drinking ages will delay the use of alcohol by young people.

TABLE 4

1970-1975 CHANGES IN MINIMUM DRINKING AGE BY STATE

From 21 to 18

Connecticut (1972)
Florida (1973)
Georgia (1972)
Iowa (1972-73)
Maryland (1975)*
Massachusetts (1973)
Michigan (1972)
Minnesota (1973)
Montana (1971-73)
New Hampshire (1973)
New Jersey (1973)
Rhode Island (1972)
Tennessee (1971)
Texas (1973)
Vermont (1971)
West Virginia (1972)
Wisconsin (1972)

From 21 to 19

Alabama (1975)
Arizona (1972)
Idaho (1972)
Wyoming (1973)

From 21 to 20

Delaware (1972)

From 20 to 18

Hawaii (1972)
Maine (1972)

From 20 to 19

Alaska (1970)
Nebraska (1972)

*Beer and light wine only

TABLE 5

NUMBER OF DRIVERS AGED 18 AND 19 YEARS INVOLVED IN FATAL CRASHES IN MICHIGAN, AND PERCENTAGE ANNUAL CHANGE

YEAR		NUMBER INVOLVED	PERCENT CHANGE
1962		133	
1963		148	+11.3
1964		200	+35.1
1965		231	+15.5
1966		323	+39.8
1967		229	-29.1
1968		301	+31.4
1969		302	+ 0.3
1970		264	-12.6
1971		246	- 6.8
1972	Drinking Age Lowered (1/1/72)	288	+29.3
1973		261	- 9.4

SOURCE: Quarterly Journal of Studies on Alcohol, Vol. 36, 1975.

Thus, reduction in the legal drinking age will cause increased alcohol consumption, and in turn, intensify alcohol-related problems.[25] Moreover, proponents of this school emphasize the "trickle-down" effect, which posits that when the legal minimum drinking age is lowered, drinking by young people begins at an earlier age.[26] Thus, if the minimum age is lowered from 21 to 18 years, 16 and 17 year olds are more likely to drink. Availability of alcohol to 16 and 17 year olds may, in turn, generate a "trickle-down" effect to younger age groups. While having a minimum drinking age of 21 will not prevent the "trickle-down" effect, the proponents of this school argue that the age groups involved will be older since the effect moves with respect to the minimum drinking age. The ramifications of this effect, often cited by those supporting higher drinking ages, are of great importance to the entire drinking age issue. As cited previously, both drinking and driving inexperience are considered major factors in youth-related traffic accidents. Consequently, the younger the drinking driver, the greater are the risks of having an accident.

Forbidden Fruit Hypothesis - Alexander[27] suggests that to statutorily forbid alcohol use may in fact increase usage as a symbolic protest against authority. Furthermore, Wilkinson[28] contends that the very illegality of the drug may increase its attractiveness. According to this view, higher age limits may encourage unlawful drinking by the young while reducing the likelihood of learning healthy attitudes toward alcohol. It is expected, therefore, that once it becomes legal for young people to drink, the possibility of developing acceptable drinking behavior is enhanced. The "forbidden fruit" hypothesis anticipates favorable effects to follow from lowering the minimum drinking age and thus removing the "thrill" associated with engaging in a disallowed activity. This hypothesis suggests fewer drinking-and-driving mishaps among the affected population.

Systematic research and support for any of the three hypotheses has been lacking until recently. One of the very first impact assessments of lowering the minimum drinking age was conducted in Canada.[29] This study found that in the year the drinking age was lowered, the number of accidents increased by 52 percent. Although the study was marked by methodological problems, it did provide a catalyst for further research.

The impact of a lowered drinking age has been most thoroughly examined in Michigan. Hammond[30] in the first published research, reported increased involvement by 18, 19, and 20-year-old drivers in total and alcohol-related fatal crashes subsequent to the State's 1972 statute change. The research documented a 141 percent rise in driving while intoxicated (DWI) arrests among the law-affected 18-to-20-year-old age group,[31] and also reported results from roadside surveys which indicated that the proportion of 16-to-20-year-old drivers with BACs over .05 percent increased from 1.3 percent to 4.9 percent.

Zylman[32] challenged these findings and argued that the increases could be explained not only by changes in the drinking behavior of young drivers but also by differences in police reporting practices[33] or by the inadequate assessment of normal year-to-year fluctuations of the data (see Table 5).

Ferrence and Whitehead,[34] meanwhile, found that a 69 percent increase in alcohol-related fatal crashes occurring in the first year of Michigan's lowered drinking age was subsequently followed by a further increase of 9 percent in the next. The authors concluded that the data clearly indicated a real increase in drinking-involved fatal collisions and, therefore, were not a function of altered official reporting practices.

Zylman[35] continued the debate. He challenged the supposed causal linkage between the lowering of the minimum legal drinking age and the overall level of accidents. For such a relationship to exist he claimed it was necessary to demonstrate: 1) an increase in all collisions; 2) that this increase was greater than in previous periods; and 3) that this increase could not be attributed to other causes. Since the contemporary research did not

meet these three requirements, Zylman concluded that the change in drinking age did not have an important impact on traffic accidents in Michigan.

View's supporting Zylman's hypothesis were put forth by Naor and Nashold[36] who studied the effect of new drinking-age legislation in Wisconsin. This statutory change was different than that in Canada and Michigan because it made only wine and liquor newly available to 18, 19, and 20 year olds. Beer had been previously available at many establishments in Wisconsin to those 18 and older since 1933. Thus whether or not beer drinking was significantly involved in Wisconsin traffic accidents, a questionable impact from this law should have been expected.

This research described an analysis of BAC levels made on approximately 75 percent of the State's fatally injured drivers from 1968 to 1973. The results showed that about 60 percent of all tested driver fatalities 18 to 20 years of age had BAC's high enough to constitute relevant evidence of intoxication (.05 percent or more). In 1973--the year after the Wisconsin law change--youthful drivers aged 18 to 20 had a higher rate of tested fatalities per 100,000 licensed drivers than did any other age group. The rate of alcohol-involved fatalities was therefore highest for this group as well, although the proportion of alcohol involvement was similar for all groups between 18 and 44. Naor and Nashold concluded that that the increased rate of 18-to-20-year-old driver fatalities was within the range of chance fluctuation. Further, the authors found that the proportion of young driver fatalities with appreciable levels of alcohol in their blood was not significantly higher than that of drivers aged 21 to 24 or 25 to 44. Nevertheless, the previous availability of beer, albeit limited to certain establishments, could not be discarded as a possible source for the lack of impact found in this research.

A comprehensive study of collisions in London, Ontario before and after a reduction in the minimum legal drinking age produced results in conflict with the Wisconsin study.[37] Researchers reviewed the police records of all collisions involving young male drivers for the

two years before and after the change in drinking age.[38] Using an interrupted time-series design the investigators discovered an abrupt change in the rate of traffic accidents which could not be explained by factors other than the change in law (see Table 6). The largest increase of crash involvement was found in the 19-and-20-year age groups which accounted for nearly 77 percent of all collisions by the examined drivers.[39] The authors concluded that from 1971 to 1973, approximately 116 crashes would not have taken place in the city if the legal drinking age had not been lowered.

Williams et al.[40] provided an analysis of four-year fatal crash trends in three states which reduced the legal drinking age.[41] The "changed-law" states were compared with three adjacent states where the drinking age had not been changed. Fatal crash involvement of 18-to-20-year-old drivers was assessed in both the experimental and control states. Crashes involving a 15-to-17-year-old driver cohort were also examined for evidence of a "trickle-down" effect.

Based on studies of BACs of fatally-injured drivers, alcohol has been shown to be more frequently involved in fatal crashes occurring at night (6 p.m. - 6 a.m.), and in single-vehicle fatal crashes.[42] Williams et al. hypothesized that if lowering the minimum drinking age had an effect on overall fatal crash involvement, an impact should be more pronounced in nighttime and single-vehicle crashes. In tests for significant changes in single-vehicle crashes, four of the six experimental age groups showed sharp increases after the respective law changes. However, the lack of a substantial overall increase resulted in the absence of statistically significant differences when all six groups were included. When the 18-to-20-year-old drivers were tested separately, the differences pre and post-law change were statistically significant. Thus, the proportion of single-vehicle fatal crashes involving 18-20 year olds in "changed-law" states increased significantly, concurrent with the reduction in the legal drinking age.

Examination of drivers 15-17 and 18-20 involved in nighttime fatal crashes produced

TABLE 6

TRAFFIC ACCIDENTS IN LONDON, ONTARIO BY AGE

	AGE				
	16-17	18	19	20	24
A. Increase in total collisions	153	256	252	117	61
B. Increase in alcohol-related collisions	26	61	83	61	9
C. % of increase in total collisions contributed by alcohol-related collisions (B/A)	17.0%	23.8%	32.9%	52.1%	14.8%
D. % of collisions due to "other" factors (100-C)	83.0%	76.2%	67.1%	47.9%	85.2%
E. % of collisions due to more drinking generally (C for 24 year olds)	14.8%	14.8%	14.8%	14.8%	14.8%
F. % of collisions due to change in law (C-E)	2.2%	9.0%	18.1%	37.3%	0.0%
G. Number of collisions due to change in law	3.4	23.0	45.6	43.6	0.0
H. Total number of collisions due to change in law			115.6		

* Line C - represents a percentage of the total increased collisions that were alcohol-related;

* Line E - represents an effort to compensate for the number of collisions due to more drinking generally; and,

* Line F - represents the percentage of collisions in all age groups due to the change in the law.

SOURCE: Journal of Studies on Alcohol, Vol. 36, No. 9, 1975.

further evidence of an impact. Nighttime crashes increased consistently after the law change, increasing rather sharply in five of the six groups. The authors maintained that the increase in the proportion of drivers under 21 in nighttime crashes very likely resulted from the reduction in the legal minimum drinking age.

Williams et al. concluded that a significant increase in fatal crash involvement occurred among drivers under 21 in the changed-law states. This trend was particularly evident in nighttime and single-vehicle crashes where alcohol is most often involved. This increase in fatal traffic accidents occurred not only among 18-to-20-year-old drivers, but also in the 15-to-17-year-old group. Furthermore, the estimated number of 15 to 20 year olds that would not have been involved in fatal crashes, had the law not been changed, was approximately 29 in Michigan, 28 in Ontario, and 13 in Wisconsin.

Zylman[43] again presented conflicting evidence. He contended that actual involvement in fatal crashes, whether the driver was reported to have been drinking or not, was a better measurement of the effects of a lowered drinking age.[44] The author analyzed fatal accident data for Maine and Massachusetts both before and after the change in legal drinking age. Fatal crash involvement rates were calculated for the number of 18-to-19-year-old drivers involved in fatal crashes and the estimated number of licensed drivers in the same age group. Nominal increases were found in the fatal crash rate of 18 to 20 year olds after the law change, but Zylman argued that these increases only represented normal yearly fluctuations. In addition, he noted a positive correlation between the number of licensed drivers and increases in fatal crashes among this age group. Based on these findings, the author concluded that neither of the law changes had a significant effect on the number of fatal crashes in Maine and Massachusetts.

Ferreira and Sicherman[45] also investigated the effects of the reduced drinking age in Massachusetts. Unlike Zylman, however, their results revealed that accident rates increased significantly among 18-to-20-year-old drivers--approximately 40 percent for involvement in

fatal crashes. The research employed interrupted time-series methods to examine multiple time series.[46] Table 7 reports the impact found in each of the series. From these results the authors concluded that not only did fatal accident rates increase among the law-affected drivers, but also that the percentage of 18-to-20-year-old driver fatalities involving alcohol rose considerably from 35 percent before the change in law to almost 60 percent following the change.

Interrupted time-series methods were also used by Douglas and Millar[47] in their evaluation of the lowered drinking age in Michigan. The principal objective of this research was to determine if initial increases in crash involvement due to the 1972 law change persisted, or if the impact was only temporary.[48] The investigators established that between 1972 and 1975, 18 to 20 year olds experienced an increase of an estimated 4600 additional alcohol-related traffic crashes. At least 89 of these accidents involved one or more fatalities. Associated with this increase in crash involvement, the authors also discovered a substantial increase in the State's draught beer consumption. In the absence of any convincing explanations to the contrary, Douglass and Millar considered their analysis to be compelling evidence of the impact of alcohol availability on alcohol-related traffic casualties.

In Wisconsin, Birkley and Quirke[49] reexamined effects of the legislation lowering the minimum drinking age. They concluded that youthful drivers were more frequently involved and more frequently killed in Wisconsin crashes. Nevertheless, statistical evidence indicating that the reduced legal drinking age produced any increase of alcohol-involved crashes among 18-to-20-year-old drivers could not be found.[50]

The law change in Michigan was yet again the subject of further examination. Douglass,[51] in the first of two major investigative efforts, conducted impact evaluations of drinking-age reductions in Michigan, Maine, and Vermont. The objectives of this research were: (1) to determine if alcohol-related traffic crashes increased among young drivers;

TABLE 7

MASSACHUSETTS FATAL ACCIDENT RATES BEFORE AND AFTER THE LOWERING OF THE MINIMUM LEGAL DRINKING AGE

	BEFORE LOWERING OF THE MINIMUM DRINKING AGE	AFTER LOWERING OF THE MINIMUM DRINKING AGE	OBSERVED INCREASES
FATAL 18-20	13.7	19.0	5.29* (38.5%)
FATAL 18-20 (control group)	13.7	19.8	6.09* (44.7%)
FATAL 21-23	12.5	12.6	N/S
FATAL 21-23 (control group)	12.5	13.1	N/S
FATAL OVER 23	59.8	56.3	N/S
ALL DEATHS	78.0	80.0	N/S
FATAL WITH OPERATING AFTER DRINKING CITATION	8.0	14.0	6.00* (75%)

( ) The numbers in parenthesis express the differences as a percentage of the base period average

N/S Not statistically significant

* Judged statistically significant

and, (2) if increases were found, to determine whether a causal relationship existed between crash increases and changes in the legal drinking age. Douglass developed a "three-factor surrogate" to overcome reporting inconsistencies of alcohol-related crashes. The surrogate measure was based on prior research establishing the relationship of time of day, driver sex, and number of vehicles involved to accidents caused by drinking drivers. Douglass determined that male drivers involved in single-vehicle crashes between 9 p.m. to 6 a.m. interactively predict driver-crash involvements most likely to be drinking related.

On the basis of the three-factor surrogate, Douglass found that the involvement of 18-to-20-year-old drivers in alcohol-related accidents increased significantly in Michigan. In Maine, the frequency of involvement of law-affected drivers also increased, but this finding did not attain statistical significance. No important changes were found in Vermont. However, it should be noted that Vermont is a small state sharing a long, contiguous border with New York, a state which had a legal drinking age of 18 since the 1930's. Douglass concluded that since the crash involvement of 21-to-45-year-old drivers in Michigan and Maine did not reveal similar increases, the increased involvement in accidents among 18 to 20 year olds was likely the result of the lowered legal drinking age.

Douglass' second study focused exclusively on Michigan and was intended to determine if the initial impacts reported were permanent or transitory.[52] This research was also initiated to determine if urban and rural populations were equally affected and if a "trickle-down" effect could be measured among drivers below the newly mandated age. The results of this study have previously been summarized in the present review (see Douglass and Millar, above).

Recent research provides some indication of what may be expected when the drinking age is raised in a state. In a study sponsored by the Insurance Institute for Highway Safety,[53] nine states which raised their minimum drinking age were matched, for comparative purposes, with states in which the legal drinking age remained unchanged during

the study period.[54] Fatal crash involvement of disenfranchised drivers (including a younger cohort to examine possible "trickle-down" effects) was evaluated against the records of a control group of older drivers. The analysis was based on the assumption that if raising the drinking age reduced drinking-driver involvement in fatal crashes, then nighttime fatal crashes and single-vehicle, nighttime fatal crashes (i.e., crashes more likely involving alcohol) should exhibit greater reductions than daytime fatal crashes and multiple-vehicle, daytime fatal crashes respectively.

The results of the research showed that the law-affected age groups experienced a greater reduction (-30 percent) of driver involvement in nighttime than in daytime fatal crashes in states which raised their drinking age than in comparison no-change states (see Table 8). In addition, crash involvement of these drivers in single-vehicle nighttime fatal accidents dropped by 41 percent in contrast with multiple-vehicle daytime fatal crash involvement. Table 9 reports, for each of the law-change states, the estimated post-law changes in nighttime fatal crash involvement of law-affected and older drivers. Eight of the nine states experienced net reductions in nighttime fatal crashes ranging from 6 to 75 percent.

In concluding this study, the authors maintained that when states raise their drinking age, a corresponding decrease in fatal crash involvement among law-affected drivers should result. Furthermore, any single state that raises its drinking age can expect nighttime fatal crash involvement among these drivers to drop by about 28 percent. As a final point, the authors proposed that in the 14 states having raised their minimum legal drinking age as of January, 1981, an estimated 380 fewer young drivers would be involved in fatal crashes each year.

Subsequent support of these findings was provided by Alexander Wagenaar of the University of Michigan's Highway Safety Research Institute.[55] After years of research describing the detrimental effects of its lowered legal drinking age, the State of Michigan

TABLE 8

STATISTICAL TESTS COMPARING CHANGES IN DRIVER INVOLVEMENT IN FATAL CRASHES BEFORE AND AFTER CHANGES IN LEGAL MINIMUM DRINKING AGE

FATAL CRASH RATIOS COMPARED	DRIVER CATEGORIES					
	Drivers the Law Change Applied to		Younger Drivers		Older Drivers	
	$\mathcal{Z}$ Value[1]	Est. Change (%)	$\mathcal{Z}$ Value	Est. Change (%)	$\mathcal{Z}$ Value	Est. Change (%)
Nighttime : Daytime	-3.29**	-30	-0.29	-6	-0.53	-15
Single-Vehicle Nighttime: Multiple-Vehicle Daytime	-2.85*	-41	-0.32	-12	-0.20	-9
All Types	-1.20	-11	-0.91	-7	+1.03	+11

[1] $\mathcal{Z}$ is standard normal under the null hypothesis

** p=0.001, two-tailed

* p=0.01, two-tailed

TABLE 9

CHANGES IN NIGHTTIME FATAL CRASH INVOLVEMENT IN NINE STATES

Law-Change State	Drivers The Law Change Applied To	Older Drivers	Net Reduction Among Drivers The Law Change Applied To
Illinois	-30%	- 9%	-23%
Iowa	-60%	-29%	-45%
Maine	-14%	- 3%	-11%
Massachusetts	-10%	- 5%	- 6%
Michigan	-17%	+40%	-41%
Minnesota	-56%	-32%	-34%
Montana	+17%	+ 3%	+14%
New Hampshire	-55%	+80%	-75%
Tennessee	-43%	-14%	-33%
Average Reduction			-28%*

* $\pm$ 17% for a 95% confidence interval

reinstated the age to 21 in 1978, through public referendum. Michigan data were once more subjected to interrupted time-series analysis in order to determine the impact of the new law. Wagenaar analyzed monthly frequencies of alcohol and non-alcohol-related crashes involving drivers aged 18 to 20, 21 to 24, and 25 to 45. Table 10 reports both the actual and the expected number of crash-involved drivers for each of these age groups based on the aggregated time-series projections. Since the new law was enacted in December of 1978, the 1979 figure represents the first year affected by the change in law.

The author found a significant decrease in drinking-related crashes among 18-to-20-year-old drivers in 1979. The same year also showed minor reductions in non-alcohol-related motor vehicle crashes for each of the evaluated age groups. Nevertheless, these unexpected reductions were both statistically insignificant and attributable to the effects of the economic recession, increased fuel prices, and mild winter weather which reduced hazardous driving conditions in Michigan. Table 11 presents the statistical findings of the research (the three-factor surrogate is defined as above).

Wagenaar concluded from this study that Michigan's raised drinking age significantly reduced the number of 18-to-20-year-old drivers involved in drinking-related traffic crashes. The findings were claimed to support the thesis that the ease with which alcohol can be obtained--and its visibility in the social environment--affect the amount and pattern of alcohol consumption and, in turn, the incidence of alcohol-related problems.

Expanding on this research, Wagenaar sought to compare the effects of the law change across categories of crash severity.[56] A non-equivalent multiple time-series design was used to examine the following comparisons: 1) states that raised their drinking age were compared with states having unchanged drinking ages; 2) with each of these states, crash involvement of young drivers was compared with that of older drivers; 3) within each state age group combination, the frequency of drinking-related accidents was analyzed--the first based on police-reported drinking drivers and the second using the three-factor surrogate;

TABLE 10

MICHIGAN ALCOHOL AND NON-ALCOHOL RELATED CRASHES, BY AGE

	Time-Series Model Estimate	Standard Error	Significance Level	Percentage* Change
Drivers 18-20				
Had Been Drinking	-.376	.063	.01	-30.7
Had Not Been Drinking	-92.0	65.6	N/S	-6.8
Three-Factor Surrogate	-27.5	8.1	.01	-17.7
Drivers 21-24				
Had Been Drinking	.09	.05	.05	9.4
Had Not Been Drinking	-42.3	69.2	.05	-3.3
Three-Factor Surrogate	3.0	6.7	N/S	2.3
Drivers 25-45				
Had Been Drinking	21.1	16.9	N/S	5.4
Had Not Been Drinking	-147.3	179.5	N/S	-4.5
Three-Factor Surrogate	3.0	12.2	N/S	1.3

N/S Not statistically significant

* The percentages in this colum indicate the difference between the actual totals for 1979 (after the raise in drinking age) and the totals expected (had the age not changed) based on analysis of the 1972-1978 data.

TABLE 11

DRIVERS INVOLVED IN MOTOR VEHICLE CRASHES IN MICHIGAN, 1972-1979

		HAD BEEN DRINKING	HAD NOT BEEN DRINKING	TOTAL	PERCENT HAD BEEN DRINKING
			AGE 18-20		
	1972	8140	75630	83770	9.7
	1973	8170	74990	83160	9.8
	1974	8270	68370	76640	10.8
	1975	10310	67855	78165	13.2
	1976	11625	75755	87380	13.3
	1977	11680	77800	89480	13.0
	1978	12165	82775	94940	12.8
	1979	9010	75290	84300	10.7
Projected	1979	13000	80810	93810	13.8
			AGE 21-24		
	1972	8260	72490	80750	10.2
	1973	8315	69790	78105	10.6
	1974	8320	62785	71105	11.7
	1975	9355	62930	72285	12.9
	1976	10160	70515	80675	12.6
	1977	10750	74795	85545	12.6
	1978	11435	79345	90780	12.6
	1979	12845	73850	86695	14.8
Projected	1979	11740	76390	88130	13.3
			AGE 25-45		
	1972	23075	174315	197390	11.7
	1973	20985	166250	187235	11.2
	1974	20365	150945	171310	11.9
	1975	20895	152560	173455	12.0
	1976	21595	173265	194860	11.1
	1977	21915	182050	203965	10.7
	1978	23880	195670	219550	10.9
	1979	24855	186185	211040	11.8
Projected	1979	23590	195025	218615	10.8

and 4) all crash-involvement measures were compared on the basis of two categories of accident severity (i.e., alcohol-related property damage and injury/fatality-producing crashes).

Results of this research indicated that the raised legal drinking age clearly reduced alcohol-related crash involvement among young drivers in Maine and Michigan. In the latter, a net reduction of 11 to 22 percent in drinking-related, property damage crash involvement was attributed to the implementation of the higher drinking age. Even more important, an 11 to 28 percent reduction was calculated in alcohol-related, injury/fatality-producing crash involvement of 18-to-20-year-old drivers.

In Maine, young drivers experienced a 17 to 22 percent reduction of involvement in alcohol-related property damage accidents. Analyses of more serious crashes revealed no significant shifts in alcohol-related crash involvement among drivers aged 18 and 19. Wagenaar surmised, however, that since there was a significant increase in serious daytime crashes among 18-and-19-year-old drivers, the non-significant change in serious single-vehicle, nighttime crash involvement might indicate that the higher drinking age prevented an increase in single-vehicle nighttime crashes that would have occurred if the law had not been changed.

SECTION II

RESEARCH METHODOLOGY: DATA CONSIDERATIONS AND RESULTS OF THE ANALYSIS

A. Methodology

The statistical technique employed in our research is known as interrupted time-series analysis. A time series may be described as the observation of a variable over time. Interrupted time-series analysis attempts to measure change in the variable due to an event which "interrupts" the normal process of the time series. The time series quasi-experiment is usually credited to Campbell,[57] who described it as a means of assessing the impact of a well-defined intervention on a social process. The design can be diagramed as such:

$$O_1 \quad O_2 \quad O_3 \quad O_4 \quad O_5 \quad X \quad O_6 \quad O_7 \quad O_8 \quad O_9 \quad O_{10}$$

$O_1 \quad O_2 \ldots\ldots O_{10}$ denote the observations of a time series and X denotes a discrete intervention. If X has an impact on the variable, the postintervention observations ($O_6 \ldots O_{10}$) will change in relation to the preintervention observations ($O_1 \ldots O_5$). In the present research, X may be defined as the effective date of legislation lowering the minimum drinking age in Arizona from 21 to 19. Hence, $O_1 \quad O_2 \ldots\ldots O_{10}$ represent the time-series data examined for impact due to the change in law.

The use of the times-series quasi-experiment is most evident in the area of legal impact assessment.[58] This method has been used to test and measure the impact of a speeding crackdown;[59] the impact of decriminalization;[60] the impact of gun control laws;[61] and the impact of air pollution control laws.[62] More relevant, the technique has been used to

assess the impacts of new drunk-driving laws.[63] Consequently, studies in Massachusetts and Michigan have incorporated this methodology in order to determine the effects of a lowered drinking age on traffic accidents.[64]

Our use of interrupted time-series methods employs analytic procedures developed by McCain and McCleary.[65] Previous interrupted time-series evaluations were restricted to assessment of an abrupt (immediate) and permanent impact pattern. Use of the McCain and McCleary procedures permit analysis of four possible impact patterns. Figure II-1 presents the four hypothetical patterns of impact.

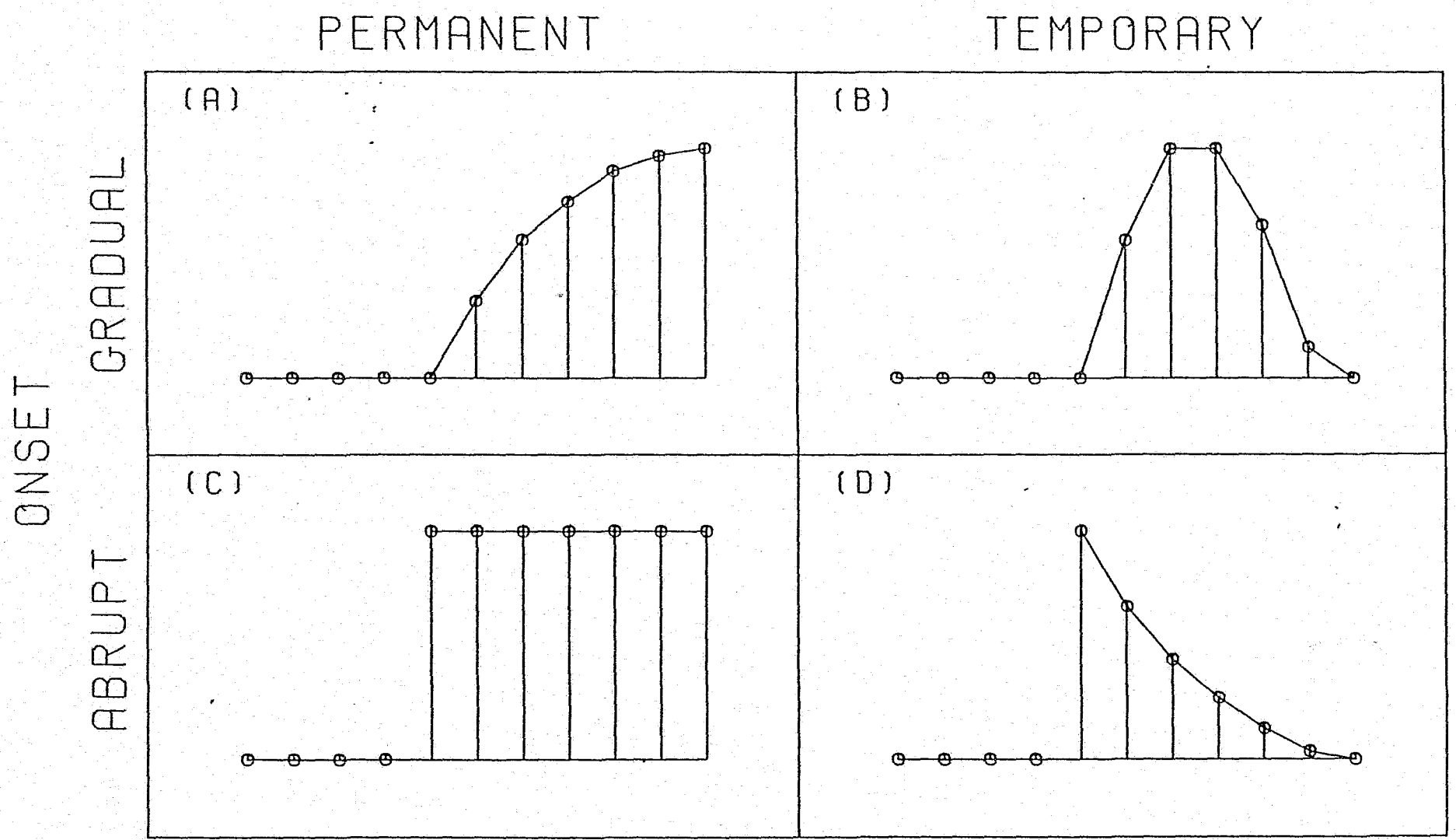
The present study's original hypothesis determined that the data be tested through time-series applications with the expectation of an abrupt and permanent impact. This type of impact pattern is graphically displayed in cell C of Figure II-1. To explore possible alternatives, however, each data series was tested for all the impact patterns displayed in Figure II-1.

In this research, the implementation date of the 19-year-old minimum drinking age (August, 1972) was designated as the intervention point to be analyzed. Each time series was statistically examined for change between preintervention and postintervention values. After analysis, a time series that changed significantly with respect to the intervention, was impacted by the change in drinking age.

Once the intervention point was determined to be discrete, then selection of the appropriate time series became very important. Different time-series data were collected, and on the basis of previous research or theoretical considerations, were designated either experimental or control. A significant change is usually hypothesized for the experimental series only. In the present study there were five experimental series: fatal crashes, crash-related deaths, and beer, wine, and liquor sales.

Figure II-1

GENERAL MODELS OF IMPACT



B. Data Considerations

Many studies encounter problems with data availability and format.[66] This section briefly describes some general data constraints on research of changed drinking ages and the methods used in the present study to overcome them.

Original age and alcohol-specific traffic data were not available in the format required for the particular type of analysis used in this research. Thus, the data relevant to the study may at first glance seem incapable of measuring the effects of the lowered drinking age.[67] However, the exclusive use of age and alcohol-specific traffic data presents inherent problems, and can produce invalid results due to the following:

1) Initiation of most traffic statistics involving alcohol-impaired drivers, are dependent upon the subjective judgements of law enforcement officers.[68] Virtually any effort to examine the relationship between alcohol consumption and traffic accidents must confront this problem. In addition, the reporting of alcohol-related traffic data in Arizona may have been further complicated by the 1972 revision of BAC requirements (from .15 to .10) for presumptive evidence of driver impairment and the Phoenix Alcohol Safety Action Project.[69]

2) The probability of statistical error increases as the size of data values decrease. Thus, what might have been a minor error in larger numbers may appear to be a significant impact in smaller numbers. Using age-specific data in a state with a small population can lead to inconclusive or invalid results. This problem necessitates the use of data large enough for a rigorous examination and yet related enough to the relevant age group to provide substantive findings. The data used in this study afforded the necessary numbers to satisfy these requirements.

As noted previously, original age and alcohol-specific traffic data were not available in the required formats. The methodology of the time-series analysis as developed by McCain

and McCleary, can compensate for this problem through the use of analytical controls. Two of the more important controls used in this study were the determination of a discrete intervention point, and evaluation and elimination of other outside impacting influences.

Selection of an appropriate intervention point is crucial to the time-series methodology.[70] As stated earlier, the implementation date of the lowered legal drinking age (August, 1972) was designated as the intervention point. Consequently, the drinking behavior of 19 and 20 year olds is the only variable directly affected by the change in law. Therefore, if other "rival" influences to the traffic series are ruled out or held constant, a significant increase in accidents, with respect to the intervention point, may be generally attributed to an increase in drinking and driving by 19 and 20 year olds.

Two additional problems were encountered with the Arizona data. These involved growth trends and major disruptions in the series. An upward secular trend was evident in each of the examined data series. This trend is normal and is highly related to Arizona's population growth. Mechanisms within the McCain and McCleary technique were used to control for this trending process. A major disruption between late 1973 and early 1977 was also apparent in each of the traffic-related series. This disruption is primarily due to the 1973 O.P.E.C. oil embargo with its resultant gas shortage, which tended to reduce driving. In addition, part of the disruption may be attributed to the establishment of the 55 m.p.h. speed limit (April, 1974). For the same reasons, similar disruptive effects are evident in traffic data throughout the United States. Our analysis again incorporated procedures to control for these events.

C. Results of the Analysis

Previous indications of the impact of Arizona's lowered drinking age were based on information similar to that shown in Figures II-2 and II-3. Although it appeared that a serious change in teenage driving occurred around the period of the 1972 change in law, the

Figure II–2. Teenage Fatal Crash Involvement and Teenage Driving Population in Arizona

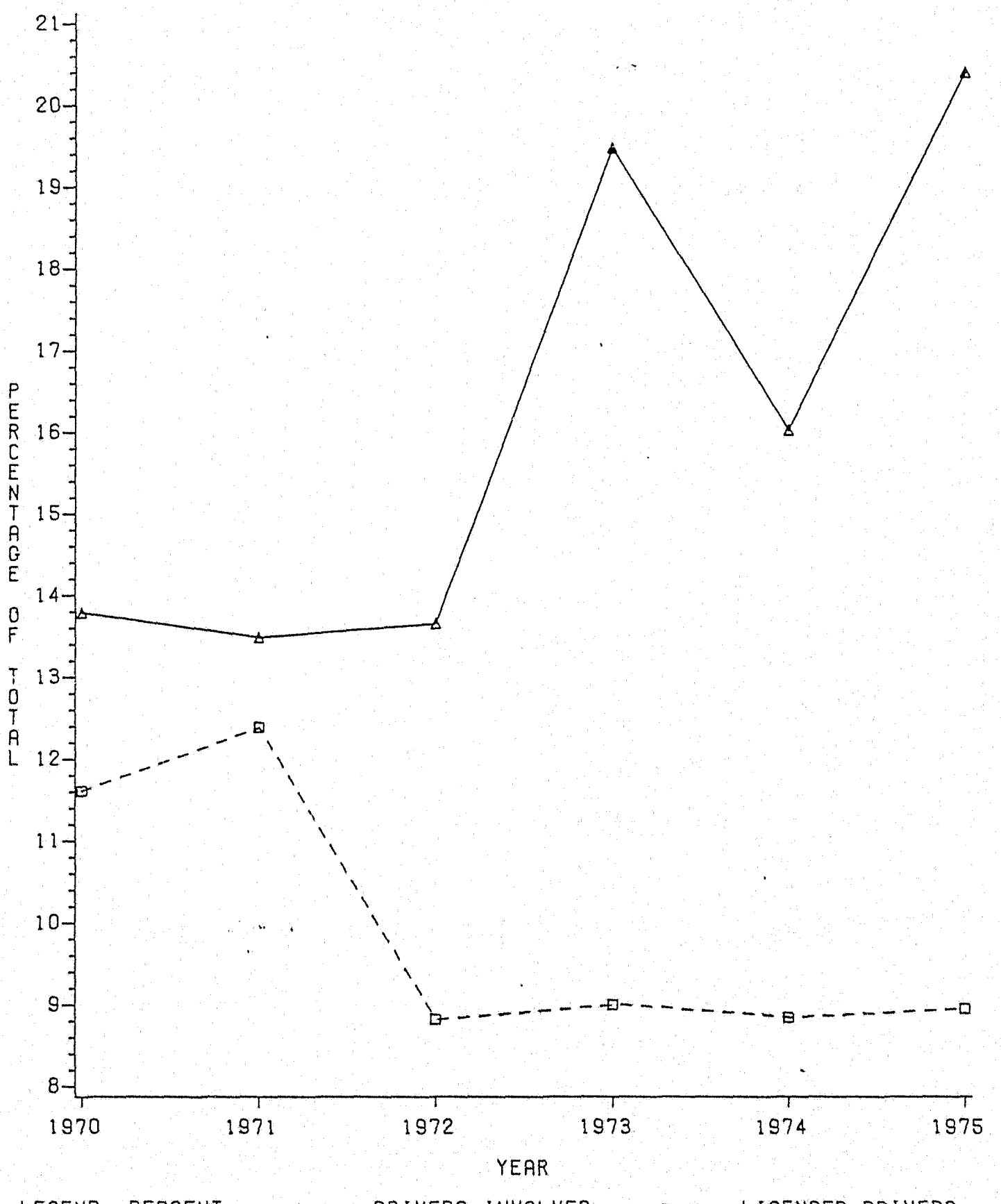
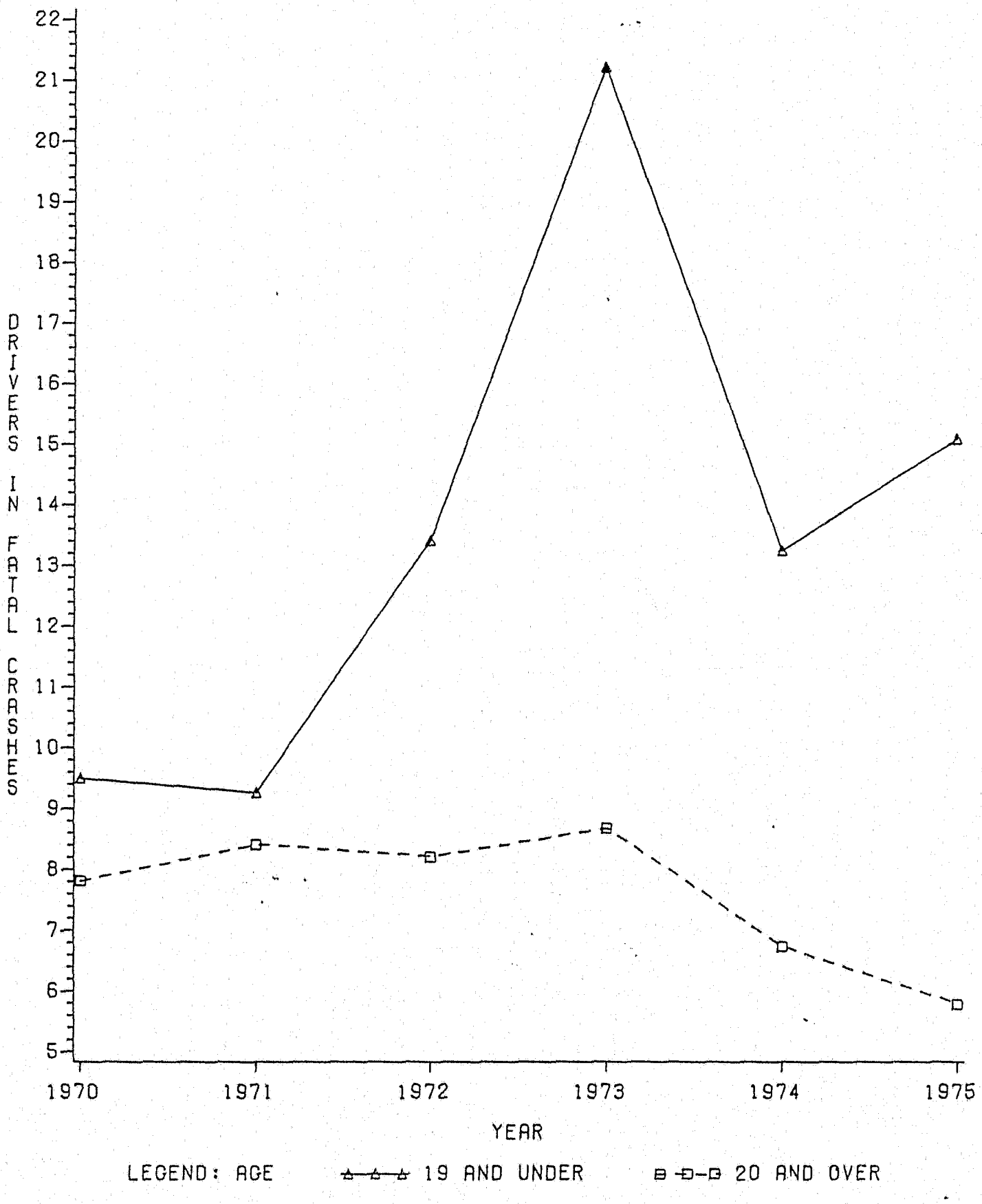


Figure II–3. Relative Fatal Crash Involvement of Teenage and Older Drivers in Arizona, Per 10,000 Licensed Drivers



information provided insufficient evidence to link this change to the lowered drinking age.

Summary statistics of the impacts found in the current research are reported in Table 12. The estimated magnitude of each impact is reported in Table 12 as the simple change in the level of the time series, and the numeric shift for the first month after the change in law. Only results from the univariate analysis of data directly examined for impact by the 1972 law change are listed in Table 12. Other findings are incorporated into the following series summaries.

1) Motor Vehicle Fuel Sales - Figure II-4 (NOTE: The broken-vertical line on the graph of each time series denotes the August, 1972 intervention)

Since an increase in traffic volume would also increase the exposure risk of crash involvement, this series was used to control for this possibility as a rough measure of driving in Arizona. The analysis of this series revealed that no significant increase in driving occurred relative to the lowering of the legal drinking age.

2) Total Traffic Crashes - Figure II-5

This series represents all types of motor vehicle accidents occurring monthly in the state, from January, 1960 to December, 1980. Injury-producing crashes, fatal crashes, and accidents which involve property damage only are included.

The impact derived from analysis, was not statistically significant since even a dramatic increase in accidents attributed to 19 and 20 year olds would not significantly alter the number of crashes for all ages. This series was subsequently used for control purposes.

3) Injury-producing Crashes - Figure II-6

This series included all traffic accidents resulting in an injury regardless of

TABLE 12

ESTIMATED IMPACTS OF THE LOWERED LEGAL DRINKING AGE IN ARIZONA

MEASURE	SERIES MEAN* (Per Month)	CHANGE IN SERIES LEVEL		NET IMPACT
		Percent Change	Raw Impact	
1) Motor Vehicle Fuel Sales (Gallons)**	60,643,604	+4.3%	2,625,322	262,532,226
2) Total Traffic Crashes**	3,209	+3.1%	100	10,000
3) Injury-producing Crashes**	1,212	+1.7%	21	2,112
4) Crash-related Injuries**	1,979	+1.3%	25	2,530
5) Fatal Crashes	43	+26.1%	11	1,128
6) Crash-related Deaths	52	+36.5%	19	1,884
7) Liquor Sales (Gallons)**	180,331	+4.8%	8,727	872,712
8) Wine Sales (Gallons)	162,710	+16.1%	26,219	2,621,860
9) Beer Sales (Gallons)	2,442,862	+7.7%	188,838	18,883,811

* Preintervention series

** The impact of the intervention on this series is not statistically significant at the $P < .05$ level.

Raw Impact = Numeric rise in the time series following the intervention.

NET IMPACT = Additional crashes, deaths, sales, etc., through the duration of the impact on the series.

SOURCE: Traffic data were obtained from the Safety Projects Section of the Arizona Department of Transportation; alcoholic beverage sales data were obtained from the Arizona Department of Revenue, Luxury Tax Division.

Figure II–4. Motor Vehicle Fuel Sales in Arizona, Adjusted to Approximate Month of Consumption

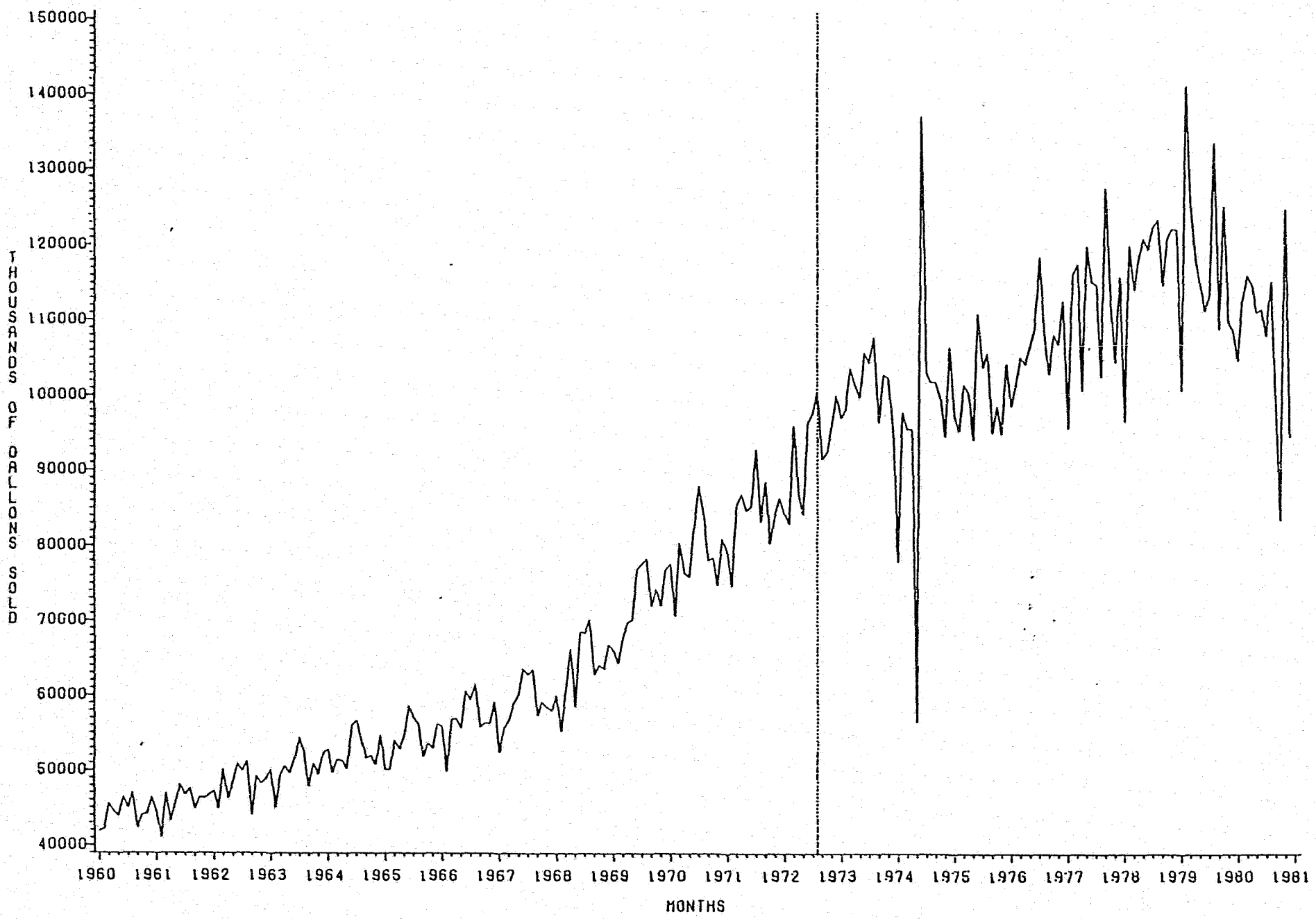


Figure II–5. Total Traffic Crashes
In Arizona

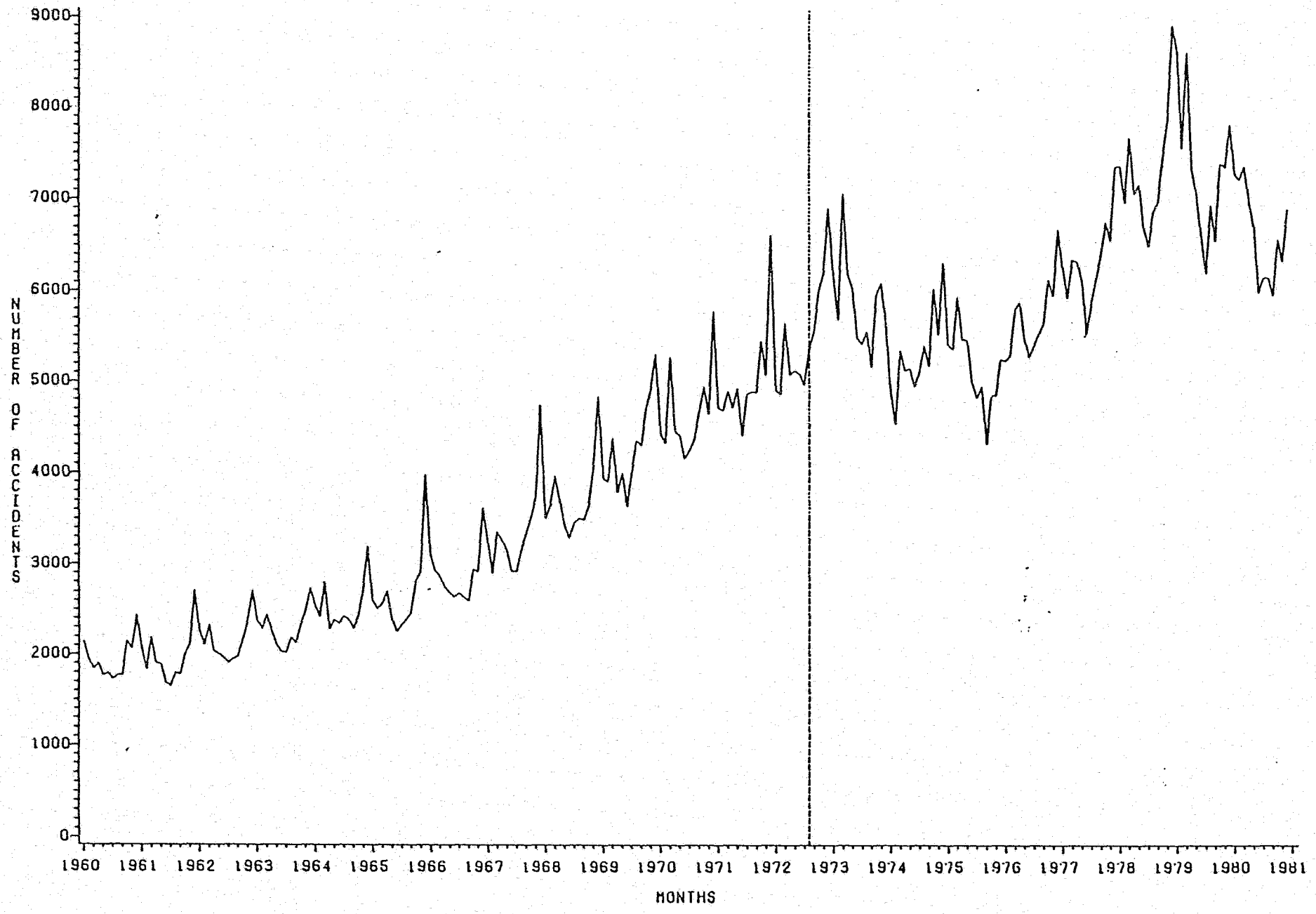
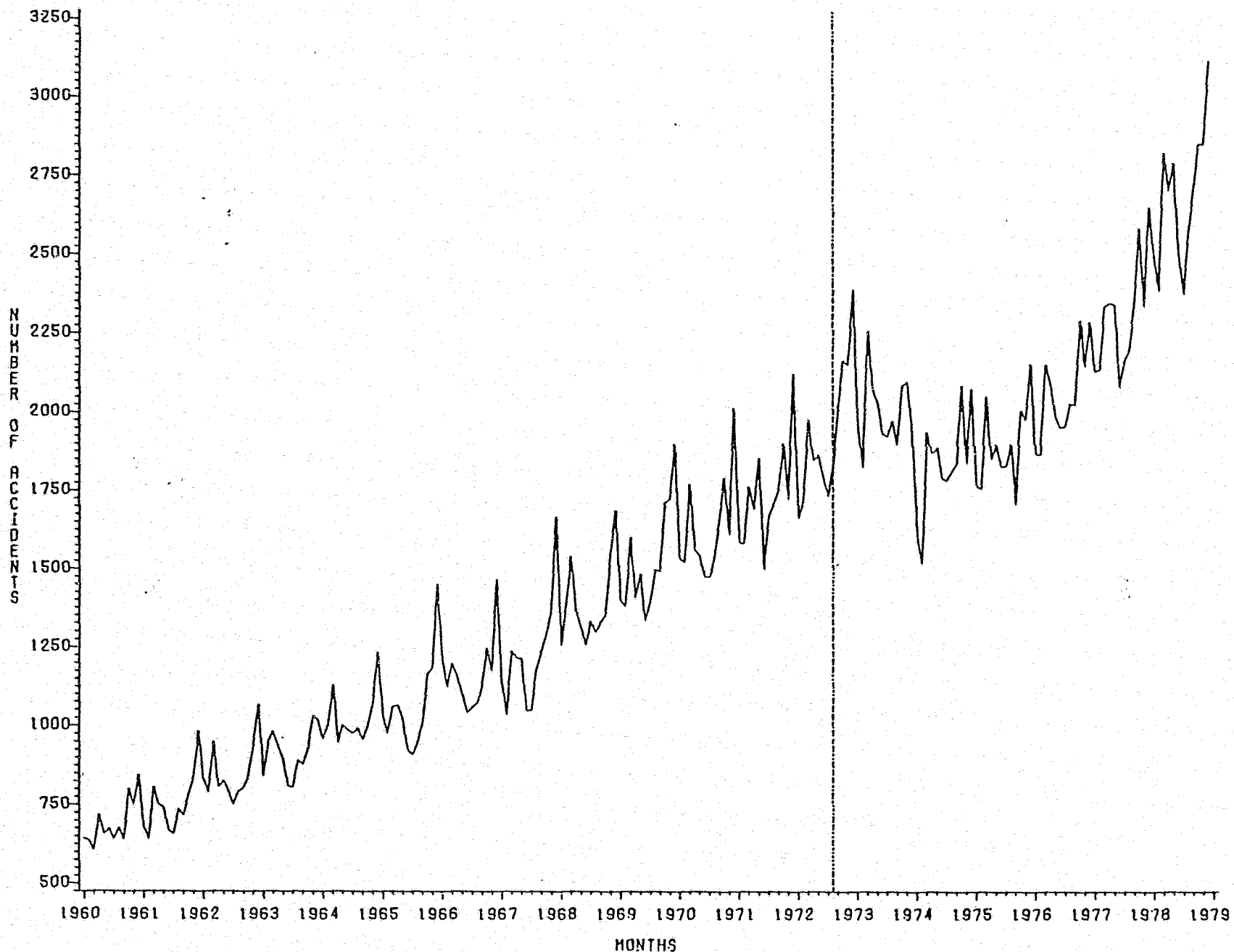


Figure II-6. Injury-Producing Crashes In Arizona



severity. As expected, the monthly aggregate of these crashes was too large to be significantly affected by the changed statute.

4) Crash-related Injuries - Figure II-7

These data are an extension of the previous series, and analysis again produced a non-significant finding.

5) Fatal Crashes - Figure II-8

Fatal crashes are those traffic accidents which result in at least one death. Since fatal crashes are relatively infrequent, the numbers in this series were small enough to reflect an impact by the statutory change. These data were also large enough to negate the problems associated with analysis of small numbers.

Prior research has shown fatal crashes to be highly correlated to both the young driver and drinking and driving in general.[71] This was supported by our analysis which indicated a very significant increase--26 percent--in the series level as a result of the lowered drinking age. This finding was measured at the $P < .001$ significance level, which means that only once out of 1000 times could this finding be due to chance. The impact was found to be abrupt and lasted throughout the postintervention series. More importantly, the analysis further revealed that approximately 1,128 fatal crashes beyond what would have been expected since August, 1972, have occurred as a result of the lowered legal drinking age.

The impact was so pronounced that neither the 1973-75 gas shortage nor the implementation of the 55 m.p.h. speed limit (April, 1974) substantially reduced its strength.

6) Crash-related Deaths - Figure II-9

Research has demonstrated that alcohol-related fatal crashes are more severe

Figure II-7. Crash-Related Injuries in Arizona

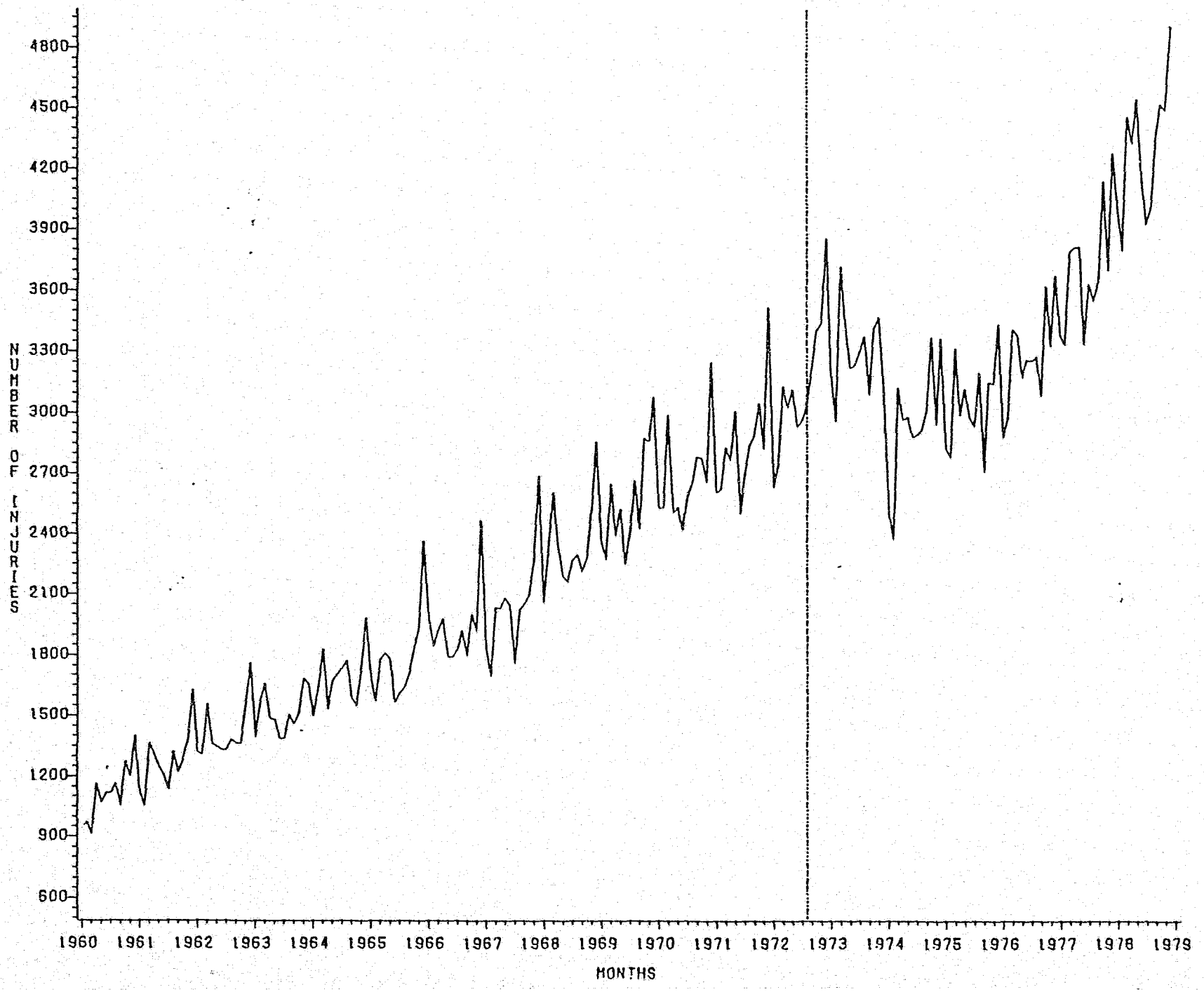


Figure II-8. Fatal Crashes
In Arizona

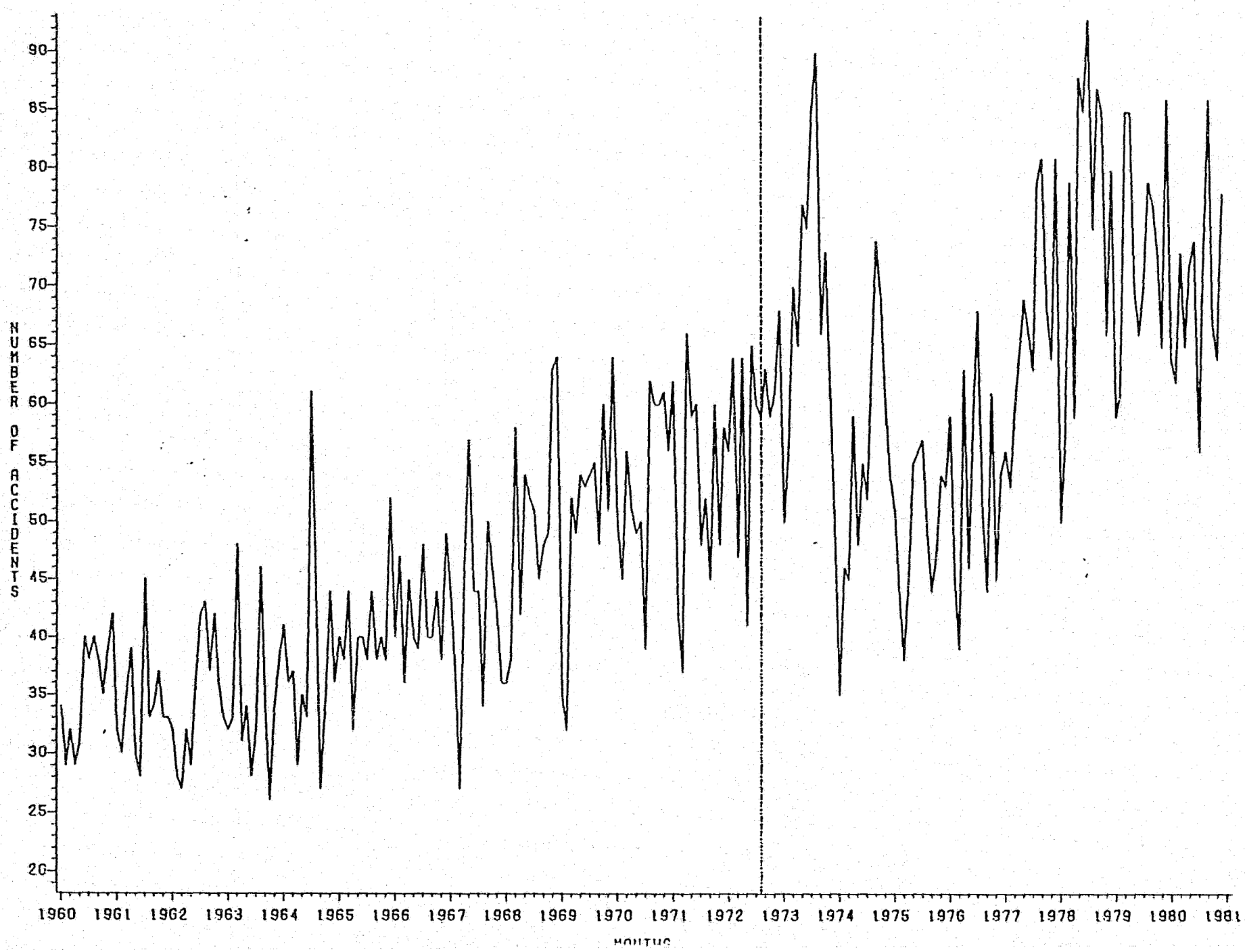
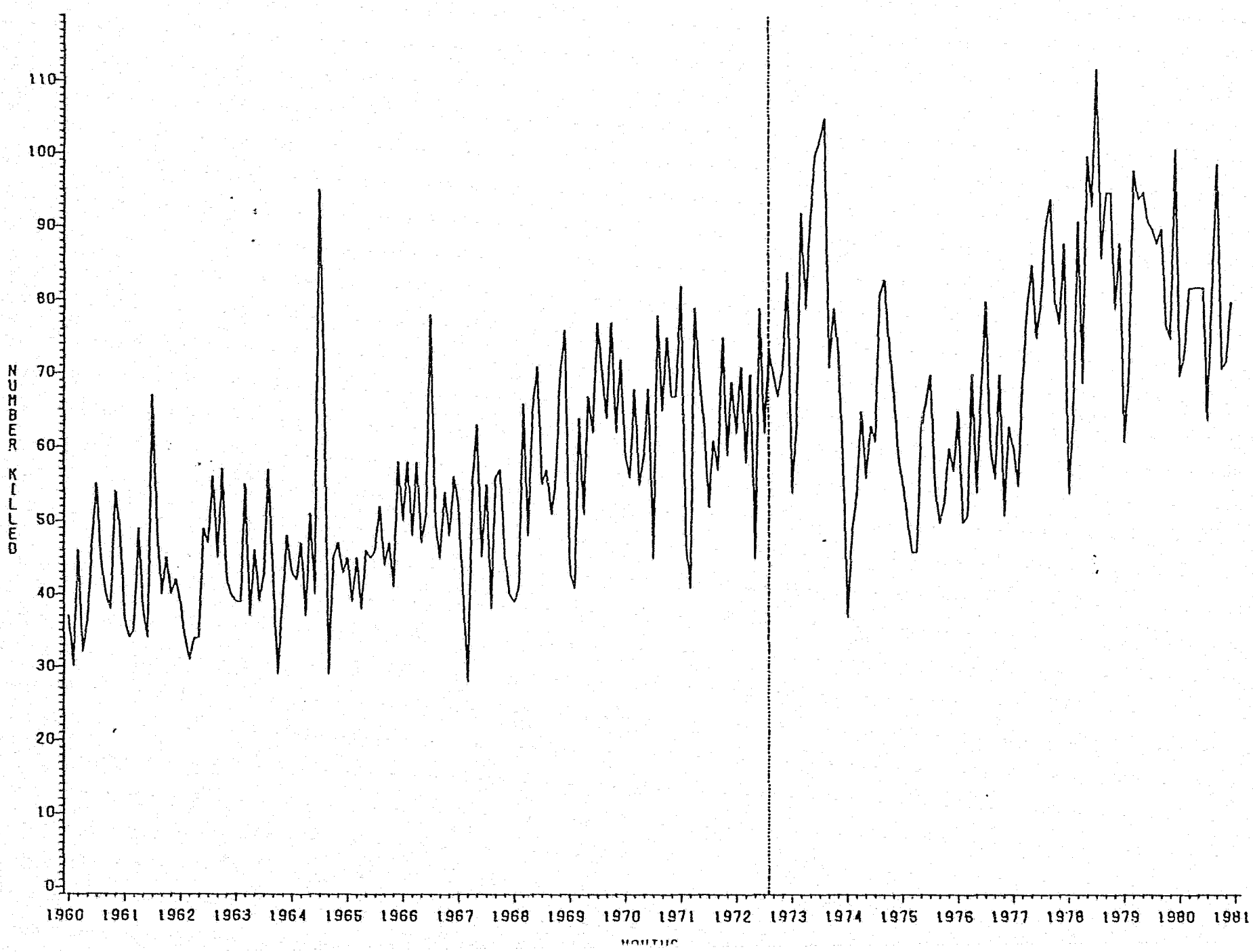


Figure II-9. Crash-Related Deaths
In Arizona



than "normal" fatal crashes.[72] This is supported by the Arizona data reported in Table 13. A simultaneous increase in severity, or, fatalities (deaths) per fatal crash, may be related to an increase in drinking-related fatal crashes.

Traffic fatalities are interdependent with fatal accidents in that these deaths are the product of fatal crashes. To justify the previous findings of this research, it was necessary for this particular series to evidence an equal or greater degree of impact due to the changed law.

The data substantiate the results of the fatal crash series. At the point of intervention, a statistically significant ($P < .01$) 36 percent increase in crash-related deaths was observed. This increase coincides with a rise from 1.19 fatalities per accident to 1.29 deaths per incident. Furthermore, the impact matches the pattern produced in the fatal crash analysis as expected. Based on these findings, an estimated 1,884 lives have been lost on Arizona's streets and highways as a result of the lowered drinking age. Of equal importance is the fact that many of these fatalities were innocent victims.

7) Liquor Sales - Figure II-10

The sale of alcoholic beverages was expected to increase with the addition of new 19-and-20-year-old consumers through the lowering of the minimum drinking age. This expectation assumes the "Restriction Hypothesis" argument described in Section I-D. However, the counter argument (the "Null Hypothesis") suggests that consumption of alcoholic beverages would not increase significantly because 19 and 20 year olds were drinking prior to change in law. Alcoholic beverage sales are examined in this research to help determine the relationships between increased alcohol availability (i.e., the lowered drinking age), alcohol consumption, and crash involvement of law-affected drivers in Arizona.

TABLE 13

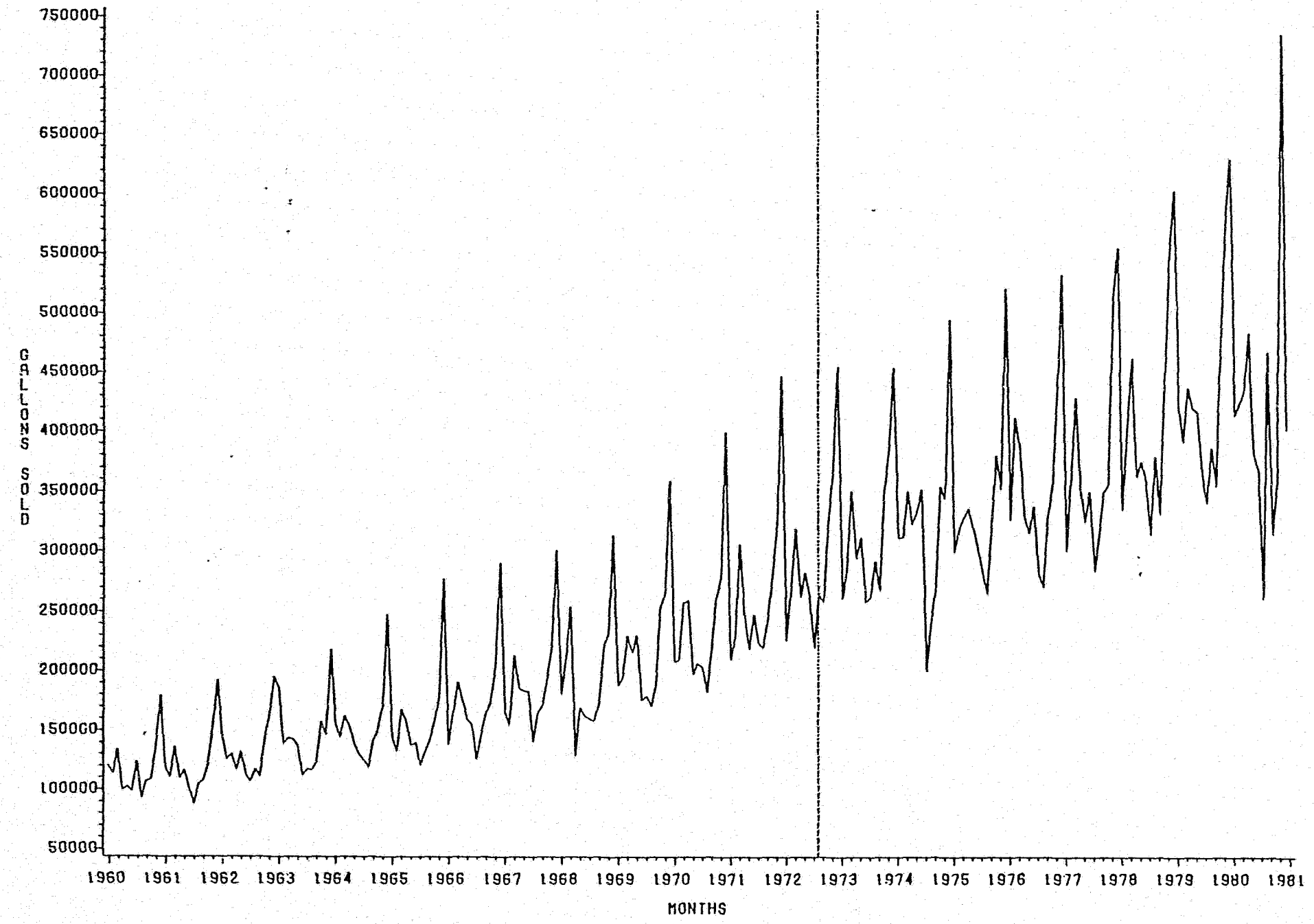
TOTAL TRAFFIC CRASHES IN ARIZONA, 1980

	Alcohol-Related	Non Alcohol-Related
Total Crashes	12,570	62,747
Property Damage Only Crashes	5,826	41,891
Property Damage Only Per Crash	.463	.668
Injuries	11,123	38,574
Injuries Per Crash	.885	.615
Deaths	347	600
Deaths Per Crash	.028	.010
Economic Loss Per Crash*	$10,307	$5,922

* Death = $160,000
Injury = $6,200
Property Damage Only = $870
(Estimates from the National Safety Council)

SOURCE: 1980 Accident Summary, Arizona Department of Transportation.

Figure II-10. Liquor Sales in Arizona, Adjusted to Approximate Month of Consumption



Nevertheless, the sale of hard liquor did not increase significantly as a result of the liberalized drinking law.

8) Wine Sales - Figure II-11

The increased availability of alcohol beverages through the lowered drinking age resulted in a significant increase in the consumption of wine. Analysis of wine sales indicated an immediate and permanent 16 percent rise in the postintervention series level. The importance of this impact can be better addressed in relation to beer sales (below).

9) Beer Sales - Figure II-12

To infer that the impact found in the fatal crash data series was related to increased drinking and driving among law-affected young people, the analysis of the beer sales data should reveal a substantial increase with the reduction in legal drinking age. An examination of relevant research material reveals that: 1) beer is the preferred alcoholic beverage of young people; 2) beer has a much higher proportion of involvement in traffic accidents than any other alcoholic beverage;[73] and, 3) in previous evaluations of lowered drinking ages, beer has been the only alcoholic beverage to increase significantly in sales as a result of the change in law.[74]

The lowering of the legal drinking age in Arizona produced a statistically significant ($P < .01$) eight percent increase in beer consumption. In addition, the impact model for this series displayed the same type of pattern found in the other experimental data series.

Similar research in Michigan and Ontario, Canada had found that only beer sales was importantly affected by the change in drinking age. While the significant rise

Figure II-11. Wine Sales in Arizona, Adjusted to Approximate Month of Consumption

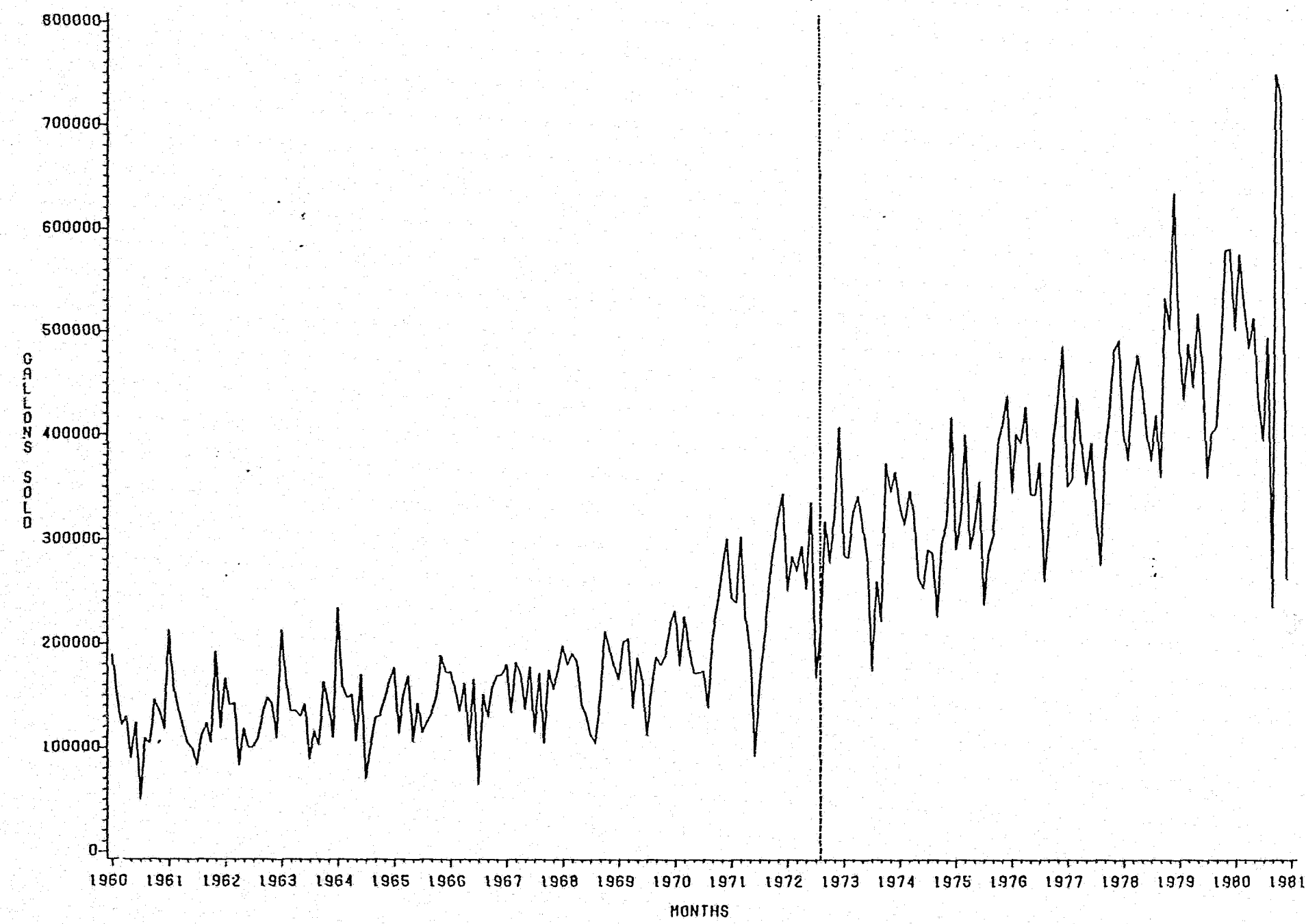
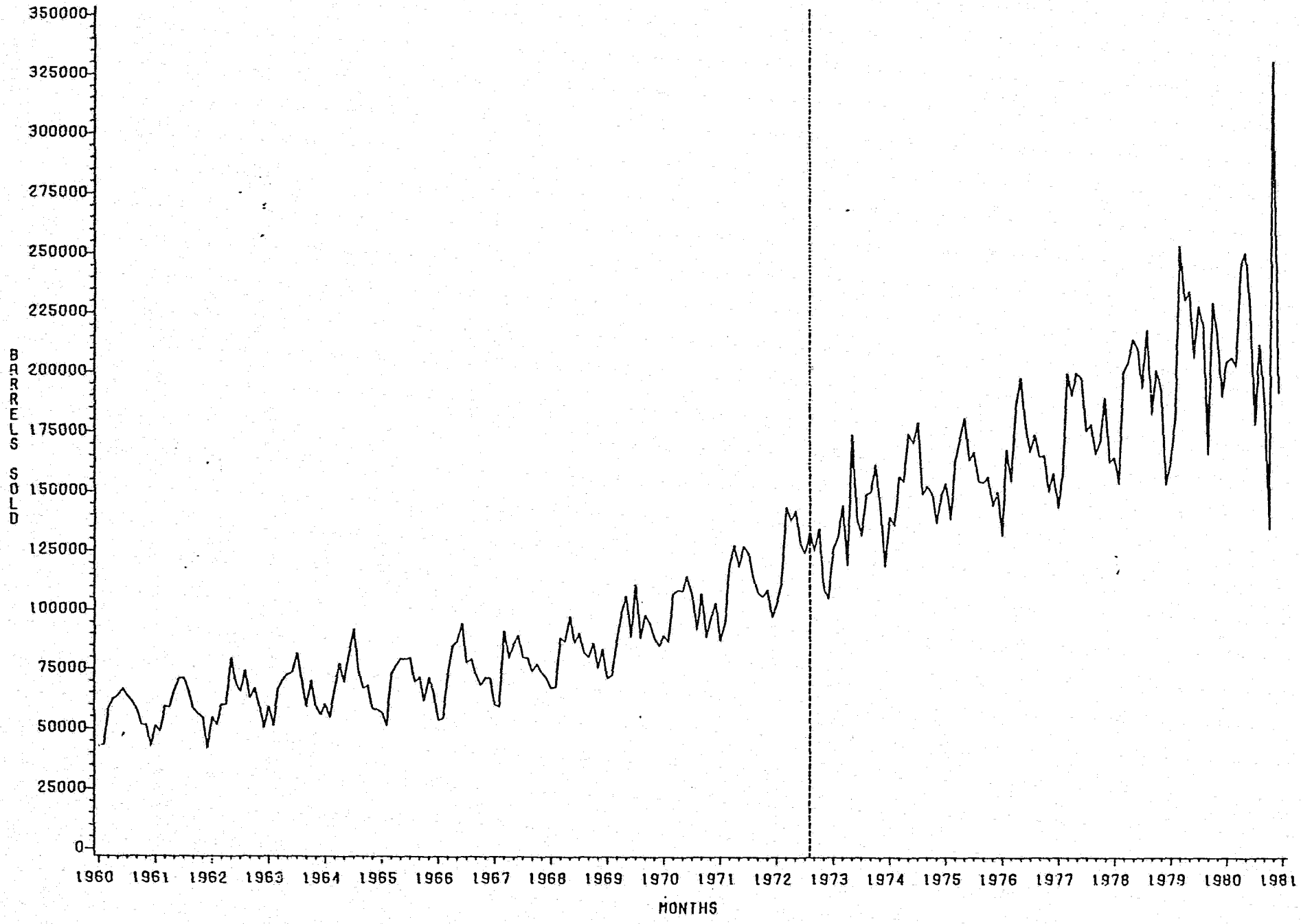


Figure II-12. Beer Sales in Arizona, Adjusted to Approximate Month of Consumption



in both beer and wine sales in Arizona was not unanticipated, it is likely explained by the regional differences. The impacts in Michigan and Canada were shown in the consumption of draught beer rather than packaged beer (i.e., bottles, cans, etc.). One reason why beer is preferred by young people is because it is less expensive than other alcoholic beverages. Draught beer is normally less expensive than packaged beer in the northeastern United States and in Canada. Thus, the increase of draught beer sales over sales of packaged beer and other alcoholic beverages would be expected as a result of its lower cost.

In the present study, both draught and packaged beers sales were analyzed but no substantial impact was measured in either series. Only when the two series were combined as total beer sales was a significant impact observed. This finding was expected because there has been little if any difference between the costs of draught and packaged beer in Arizona since 1972. For this reason, the price of all beer in Arizona was nearer to the price of wine than the price of draught beer was to wine in Michigan and Canada. Hence, the relative cost of wine to beer may explain the differences in wine sales found among the studies. The effect of cost was also demonstrated by the far greater increase, in terms of raw impact, of beer sales over the more expensive wine sales. Overall, the examination of alcoholic beverage sales in this study falls remarkably in line with previous findings.

SECTION III

SUMMARY AND CONCLUSIONS

The scope of this study was narrowly defined as an assessment of Arizona's 1972 minimum drinking age change. It became clear quite early in our efforts that the topic, though limited, was one of considerable magnitude and depth. The issue is a sensitive one in Arizona and indeed nationwide.

Our review of the literature revealed a vast amount of corroborative evidence for our initial hypothesis:

* Young people are more likely impaired at lower blood alcohol concentrations than others;
* The likelihood of a more serious accident occurring sharply increases in relation to increasing blood alcohol concentration;
* Studies investigating the relationship between age and blood alcohol concentration consistently demonstrate that the probability of accident involvement increases at a greater rate, and is significantly higher for younger drivers;
* Young inexperienced drivers are disproportionately involved in both non-alcohol and alcohol-related accidents;
* Eighteen to twenty-year olds are generally: inexperienced drivers; inexperienced drinkers; and within the most active drinking group;
* Drivers in their teens and twenties are greatly over-represented on week-end nights from 8:00 p.m. to 4:00 a.m.; and,
* A large body of prior research provides overwhelming testimony to the detrimental effects of reducing the minimum legal drinking age.

Our hypothesis of an abrupt and permanent impact was supported by all data examined in the study. Use of interrupted time-series methods produced substantive, as well as dramatic, results. Arizona's lowered drinking age resulted in a 26 percent increase in fatal crashes leading to approximately 1,128 additional fatal crashes since 1972. Given the increased severity of these accidents, an estimated 1,884 additional lives were lost as a result this law.

The research literature makes it quite clear that a major problem exists in young drinking drivers. Moreover, the research shows that the problem increases substantially when legal drinking ages are lowered. Our study confirms these findings. Furthermore, the present research maintains that when alcohol is made available to young people there is a corresponding increase in both the consumption of alcohol and in the drinking-related driving behavior of this population. This thesis strongly suggests that the traffic-related problems produced by the State's 19-year-old drinking age can be reduced by restoring this age to 21.

As a result of the analytical investigation and the interpretation of the research findings, it is the conclusion of this report that a significant immediate, and permanent increase in fatal traffic crashes and deaths occurred as a direct result of the 1972 drinking age change. This conclusion is further verified by the significant increase determined in the level of alcoholic beverage sales correlated to the lowered drinking age.

Based on the above, the authors submit that the reinstatement of the 21-year-old drinking age will effect a significant savings of lives on Arizona's streets and highways.

NOTES

1. Arizona Legislature, House of Representatives, A Bill to Raise The Minimum Drinking Age to Twenty-One, H.B. 2078, 35th Legislature, 1st Session, 1981.

2. N. Rosenberg, R.H. Laessig and R.R. Rawlings, "Alcohol, Age and Fatal Traffic Accidents," Quarterly Journal of Studies on Alcohol, 35 (1974): 473-489.

3. F.F. Preusser, J.F. Oates and M.S. Orban, "Identification of Countermeasures for the Youth Crash Problem Related to Alcohol: Review of Existing Literature and Preliminary Hypotheses, "United States Department of Transportation, DOT-HS-099-30747, Dunlop and Associates, Inc., (Oct. 1973).

4. Organization for Economic Cooperation and Development, New Research on the Role of Alcohol and Drugs in Road Accidents, (Paris: O.E.C.D., 1978)

5. B.F. Landstreet, The Drinking Driver: The Alcohol Safety Action Programs, (Springfield, Ill.: Charles C. Thomas, 1977).

6. P.M. Hurst, "Estimating the Effectiveness of Blood Alcohol Limits," Behavioral Research on Highway Safety 1, 1970, and P.M. Hurst, "Epidemological Aspects of Alcohol in Driver Crashes and Citations," in M.W. Perrine, ed., Alcohol, Drugs and Driving, NHTSA Technical Report, DOT-HS-255-2-489, United States Department of Public Safety, (1973).

7. Organization for Economic Cooperation and Development, Young Driver Accidents, (Paris: O.E.C.D., 1975).

8. R.E. Allsop, "Alcohol and Road Accidents," Ministry of Transport, Road Research Laboratory Report No. 6, Harmondsworth (1966).

9. Organization for Economic Cooperation and Development, Young Driver Accidents, H. Wechsler, Minimum Drinking Age Laws, (D.C. Heath and Co., 1980), Paul C. Whitehead et al., "Collision Behavior of Young Drivers," Journal of Studies on Alcohol, 36, 1975.

10. Organization for Economic Cooperation and Development, New Research on the Role of Alcohol and Drugs in Road Accidents.

11. J.A. Waller, E.M. King, G. Nielson and H.W. Turkel, "Alcohol and Other Factors in California Highway Fatalities," Journal of Forensic Science, 14, (1969): 429-44.

12. P.M. Hurst, S.K. Bagley, "Acute Adaptation to the Effects of Alcohol," Quarterly Journal of Alcohol Studies, 33 (1972): 358-378., D.W. Goodwin, B.J. Powell, J.A. Stern, "Behavioral Tolerance to Alcohol in Moderate Drinkers," American Journal of Psychiatry 127, (1971): 87-89.

13. P.M. Hurst, S.K. Bagley, "Acute Adaptation to the Effects of Alcohol."

14. D.W. Goodwin, B.J. Powell, J.A. Stern, "Behavioral Tolerance to Alcohol in Moderate Drinkers."

15. M. Burns and H. Moskowitz, Psychophysical Tests for DWI Arrest: Report to the National Highway Traffic Safety Administration, (Los Angeles: Southern California Research Institute, 1977).

16. P.M. Fishburne, H.I. Abelson and I. Cisin, National Survey on Drug Abuse: Main Findings 1979, (Rockville, Maryland: National Institute on Drug Abuse, 1979).

17. Lazar and Lazar reviewed external factors attributed to the evolving social structure and listed the following as important variables contributing to alcohol-related problems:

-availability of automobiles to teens age 16 and over,
-unstructured time without adult supervision,
-access to money,
-ability to purchase or obtain alcohol,
-adult drinking examples,
-social toleration of intoxication, and
-relaxation of general social norms.

"Youthful Drunk Drivers: A Mushrooming Crisis," In F. Huelke, ed., Proceedings of the 20th Conference of the American Association for Automotive Medicine, American Association for Automotive Medicine, Morton Grove, Illinois, 1976.

18. R.K. Jones, K.B. Joscelyn, Alcohol and Highway Safety 1978: A Review of the State of Knowledge, United States, Department of Transportation, NHTSA, DOT-HS-5-01217, 1978.

19. National Highway Traffic Safety Administration, Results of National Alcohol Safety Action Projects, United States, Department of Transportation. DOT-HS-804-033, 1979.

20. J.F. Rooney, S.M. Schwartz, "The Effect of Minimum Drinking Age Laws Upon Adolescent Alcohol Use and Problems," Contemporary Drug Problems, 6 (1977): 569-583.

21. H. Wechsler, Minimum Drinking Age Laws.

22. Rooney and Schwartz, "The Effect of Minimum Drinking Age Laws Upon Adolescent Alcohol Use and Problems."

23. R.G. Smart, M.S. Goodstadt, "Effects of Reducing the Legal Alcohol Purchasing Age on Drinking and Drinking Problems," Journal of Alcohol Studies, v. 38, 7 (1977): 1313-1323.

24. Ibid.

25. R.E. Popham, W. Schmidt and J. De Lint, "The Effects of Legal Restraint on Drinking," in B. Kissin and H. Begleiter, eds., The Biology of Alcoholism, v. 4, (New York: Social Aspects of Alcoholism, 1976).

26. J.F. Mosher, "The Prohibition of Youthful Drinking: A Need for Reform," Contemporary Drug Problems 6 (1977): 397-436.

27. C.N. Alexander, "Alcohol and Adolescent Rebellion," Social Forces, 45, (1967): 542-550.

28. R.L. Wilkinson, The Prevention of Drinking Problems: Alcohol Control and Cultural Influences, (New York: Oxford University Press, 1970).

29. W. Schmidt and A. Kornaczewski, A Note on the Effect of Lowering the Legal Drinking Age on Alcohol Related Motor Vehicle Accidents, Addiction Research Foundation, Substudy No. 552, Toronto, 1972.

30. R.L. Hammond, "Legal Drinking at 18 or 21--Does It Make Any Difference?" Journal of Alcohol and Drug Education, v. 18, 3, (1973): 9-13.

31. In comparison, a 26 percent increase for the same offense was noted for those over 21 years of age. The large discrepancy could have been due to increased awareness on the part of law enforcement officers.

32. Richard Zylman, "Fatal Crashes Among Michigan Youth Following Reduction of Legal Drinking Age," Quarterly Journal of Studies on Alcohol, 35 (1974): 283-286.

33. Since official reports on alcohol related accidents are sometimes based on the subjective opinions of police officers the data should be treated very carefully. Zylman, "Fatal Crashes Among Michigan Youth Following Reduction of Legal Drinking Age."

34. Roberta G. Ferrence and Paul C. Whitehead, "Fatal Crashes Among Michigan Youth Following Reduction of the Legal Drinking Age," Journal of Studies on Alcohol, 36 (1975): 171-172.

35. Richard Zylman, "Fatal Crashes Among Michigan Youth Following Reduction of the Legal Drinking Age (A Response)," Journal of Studies on Alcohol, 36 (1975): 173-177.

36. Ellen M. Naor and Raymond D. Nashold, "Teenage Driver Fatalities Following Reduction in the Legal Drinking Age," Journal of Safety Research, 7 (1975): 74-79.

37. Paul C. Whitehead et al., "Collision Behavior of Young Drivers," Journal of Studies on Alcohol, 36 (1975): 1208-1223.

38. In all age groups examined, men were engaged in five times as many collisions as women and their rate of alcohol involved collisions was 20 times higher. Due to this, and the small number of alcohol related collisions for women in the study area, the analysis was limited to males.

39. An excess of at least 58 collisions per year in a community the size of London (population 200,000) constitutes a major effect of this change in alcohol-control measures, which, if extrapolated to Canada as a whole, would be on the order of 6000 collisions per year and for the United States would extrapolate to approximately 60,000 collisions per year.

40. Allan F. Williams et al., "The Legal Minimum Drinking Age and Fatal Motor Vehicle Crashes," The Journal of Legal Studies, 4 (1975): 219-239.

41. Michigan, Ontario, Canada and Wisconsin were the "changed law" states; Indiana, Minnesota and Illinois represented the controls.

42. Williams et al., "The Legal Minimum Drinking Age and Fatal Motor Vehicle Crashes."

43. Richard Zylman, "When It Became Legal to Drink at 18 in Massachusetts and Maine: What Happended?" Journal of Traffic Safety Education (1976): 34-46.

44. Williams et al., "The Legal Minimum Drinking Age and Fatal Motor Vehicle Crashes."

45. Joseph Ferreira and Alan Sicherman, "The Impact of Massachusetts Reduced Drinking Age on Auto Accidents," Accident Analysis and Prevention, 8, (1976): 229-239.

46. All data series were adjusted for seasonality and mileage. Control groups were added for fatal accidents involving 18 to 20 year olds and 21 to 23 year olds.

47. Richard L. Douglass and Charles W. Millar, "Alcohol Availability and Alcohol-Related Casualties in Michigan 1968-1976," in Mark Gulanter, ed., Currents in Alcoholism: Treatment and Rehabilitation, New York, Greune and Striton, Inc., 1979.

48. The analysis of traffic crash data involved controlling for long-term linear trends associated with population and economic growth and for seasonal cycles.

49. Michael M. Birkley and Michael A. Quirke, "The Effect of Lowering the Legal Drinking Age on 18 Through 20 Year Old Wisconsin Drivers," Grassroots, (1979): 19-22.

50. It should be noted, however, that prior to the change in law, persons aged 18 through 20 were legally entitled to purchase beer in 5,416 establishments licensed to sell beer only.

51. Richard L. Douglass, "The Legal Drinking Age and Traffic Casualties: A Special Case of Changing Alcohol Availability in a Public Health Context," Alcohol Health and Research World, (Winter 1979/1980): 18-25.

52. Douglass and Millar, "Alcohol Availability and Alcohol-Related Casualties in Michigan 1968-1976."

53. Allan F. Williams et al., "The Effect of Raising the Legal Minimum Drinking Age on Fatal Crash Involvement," Prepared for the Insurance Institute for Highway Safety (June 1981).

54. Data on driver involvement in fatal crashes from January 1975 through September 1980 were obtained from the Fatal Accident Reporting System (FARS) of the National Highway Traffic Safety Administration.

55. Alexander C. Wagenaar, "Effects of the Raised Legal Drinking Age on Motor Vehicle Accidents in Michigan," The Highway Safety Research Institute Research Review, 11 (1981): 1-8.

56. Alexander C. Wagenaar, "Effects of Raising the Legal Drinking Age on Traffic Accident Involvement of Young Drivers," Presentation at the 109th Annual Meeting of the American Public Health Association, University of Michigan Highway Safety Research Institute, November 1981.

57. D.T. Campbell, "From Description to Experimentation: Interpreting Trends as Quasi-Experiments," in C.W. Harris, ed., Problems of Measuring Change, (Madison: University of Wisconsin Press, 1963)., D.T. Campbell and J.C. Stanley, Experimental and Quasi-Experimental Designs for Research, Chicago: Rand-McNally, 1966.

58. R. McCleary and R.A. Hay, Applied Time Series Analysis for the Social Sciences, Beverly Hills: Sage Publications, 1980.

59. D.T. Campbell and H.L. Ross, "The Connecticut Crackdown on Speeding: Time Series Data in a Quasi-Experimental Analysis," Law and Society Review, 3 (1968): 33-53., G.V. Glass, "Analysis of Data on the Connecticut Speeding Crackdown as a Time Series Quasi-Experiment," Law and Society Review, 3 (1968): 55-76.

60. D. Aaronson, C.T. Dienes and M.C. Musheno, "Changing the Public Drunkenness: The Impact of Decriminalization," Law and Society Review, 12 (1978): 405-436., R. McCleary and M.C. Musheno, "Floor Effects in the Time Series Quasi-Experiment," Political Methodology, Vol. 7, No. 2 (1980).

61. S.J. Deutsch and F.B. Alt, "The Effect of Massachusetts' Gun Control Law on Gun-Related Crimes in the City of Boston," Evaluation Quarterly, 3 (1977): 315-328., R.A. Hay, Jr. and R. McCleary, "Box-Tiao Time Series Models for Impact Assessment: A Comment on the Recent Work of Deutsch and Alt," Evaluation Quarterly, 3 (1979): 277-314., F.E. Zimring, "Firearms and Federal Law: The Gun Control Act of 1968," Journal of Legal Studies, 4 (1975): 133-198.

62. G.E.P. Box and G.C. Tiao, "Intervention Analysis with Applications to Economic and Environmental Problems," Journal of the American Statistical Association, (1975): 70-92.

63. H.L. Ross, D.T. Campbell and G.V. Glass, "Determining the Effects of a Legal Reform: The British 'Breathalyzer' Crackdown of 1967," American Behavioral Scientist, 13 (1970): 493-509., H.L. Ross, R. McCleary and T. Epperlein, "Deterrence of Drinking and Driving in France: An Evaluation of the Law of July 12, 1978," Law and Society Review, 16 (1982): 345-374.

64. J. Ferreira and A. Sicherman, "The Impact of Massachusetts Reduced Drinking Age on Auto Accidents." R.L. Douglass and J.A. Freedman, Alcohol-Related Casualties and Alcohol Beverage Market Response to Beverage Alcohol Availability Policies in Michigan, Vol. 1, Highway Safety Research Institute, University of Michigan, Ann Arbor, Michigan, 1977.

65. L.J. McCain and R. McCleary, "The Statistical Analysis of the Simple Interrupted Time Series Quasi-Experiment," in T.D. Cook, D.T. Campbell, Quasi-Experimentation; Design and Analysis Issues for Field Settings, (Chicago: Rand McNally, 1979).

66. Richard L. Douglass and Charles W. Millar, "Alcohol Availability and Alcohol-Related Casualties in Michigan 1968-1976.", Joseph Ferreira, Jr. and Alan Sicherman, "The Impact of Massachusetts' Reduced Drinking Age on Auto Accidents," Alexander C. Wagenaar, "Effects of the Raised Legal Drinking Age on Motor Vehicle Accidents in Michigan."

67. Ibid.

68. R. Zylman and S.D. Bacon, "Police Records and Accidents Involving Alcohol," Quarterly Journal of Studies on Alcohol, Suppl. No. 4. (1968): 178-211. J.R. Gusfield, The Culture of Public Programs; Drinking-Driving and the Symbolic Order, Chicago and London, The University of Chicago Press, 1981.

69. T.R. Clay and V.S. Ellingstad, An Analysis of Total Project Impact, City of Phoenix Alcohol Safety Action Project, June, 1977.

70. M.C. Musheno, "On the Hazards of Selecting Intervention Points: Time Series Analysis of Crime Policy," Paper Presented at the Special National Workshop on Research Methodology and Criminal Justice Program Evaluation, March 17-19, 1980.

71. R.K. Jones, K.B. Joscelyn, Alcohol and Highway Safety 1978: A Review of the State of Knowledge.

72. Ibid.

73. Ibid.

74. R.G. Smart, "Changes in Alcoholic Beverage Sales After Reductions in the Legal Drinking Age," American Journal of Drug and Alcohol Abuse, 4 (1977): 101-108. R.G. Smart and M.S. Goodstadt, "Effects of Reducing the Legal Alcohol Purchasing Age on Drinking and Drinking Problems," and R.L. Douglas and J.A. Freedman, "Alcohol Related Casualties and Alcohol Beverage Market Response to Beverage Alcohol Availability Policies in Michigan," v. 1, Highway Safety Research Institute , (Ann Arbor: University of Michigan, 1977).