U.S. Department
of Transportation

**National Highway
Traffic Safety
Administration**

Alcohol and Highway Safety 1989: A Review of the State of Knowledge

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CHAPTER 1

INTRODUCTION

This report was prepared under a National Highway Traffic Safety Administration (NHTSA) contract (DTNH2-88-C-07358) to update the state-of-knowledge about alcohol and highway safety. It is the fourth in a series of NHTSA-sponsored reviews of this field, commencing with the landmark 1968 report to Congress (U.S. Department of Transportation, 1968). The first update of the 1968 report was published in 1978 (Jones and Joscelyn, 1978), and this was followed by another update published in 1985 (U.S. Department of Transportation, NHTSA, 1985).

The updates were designed to meet the needs of the field as they were perceived at the time they were prepared. Thus, the first update was a very detailed review emphasizing research conducted since the 1968 report, but incorporating new perspectives drawn from the literature prior to 1968. In some instances, the reviews of the pre-1968 literature were quite extensive, involving analyses and presentations of older data that had not been published before.

The second update was an "interim update" covering "the most clearly important studies and findings during the period from January 1978 to December 1982." (U.S. Department of Transportation, NHTSA, 1985, page 1). It was reorganized to reflect the then-current interest on general deterrence initiatives to drinking and driving, and left large portions of the 1978 update intact. It was not intended to be a broad and comprehensive review of the scientific literature.

The update reported here takes yet another direction. Its organization is similar to the 1978 update, but its focus is on *new developments and trends* in the field. The emphasis on new developments was desirable (as well as a practical necessity) because of the sheer quantity of research in many sectors of the field, much of which confirms previous findings. The examination of trends in the field was possible because of the availability of several years of hard data in computerized databases such as NHTSA's Fatal Accident Reporting System (FARS). Because of the limitations of available databases, prior reviews could not effectively treat time-dependent trends.

Within this context, this update deals with the entire spectrum of alcohol-traffic safety topics, from problem definition to problem solution. It is concerned with documents published since those reviewed in the last update, that is, those published from January, 1983, through November, 1989. As was the case with the 1978 report, it is more than a literature review in that it attempts a more extensive than usual synthesis of current knowledge and, in some instances, develops new data and performs additional analyses to help fill gaps or answer questions about the methods or results of a study.

The material emphasized in this report has been selected from the most scientifically reliable studies. Over 2,000 documents were identified in the course of our literature search, and 756 were retained as references. Citations for these references are provided in two separate bibliographies. First, a bibliography of reference materials *cited in the report* is presented after the last chapter. This is followed by a second bibliography of documents *recommended for further reading.* These latter documents were reviewed in preparing a chapter, but were not cited explicitly in the report for several reasons. First, a few documents were published before 1983 and thus were outside of the time frame of concern here. They were reviewed again for this report primarily to provide continuity from prior updates. Second, some documents reported findings similar to those in the cited documents and would not have added to the discussion in this report. Third, some documents dealt with subjects that were peripheral to the subject of drinking-driving, but still of sufficient interest and relevance to be included as background materials.

This report contains four chapters (Chapters 2 through 5) that deal respectively with the nature of drunk driving problem, the effect of alcohol on the human body and driving performance, the characteristics of persons who drink and drive, and programs designed to reduce the incidence or consequences of drinking-driving. The report's major conclusions and its recommendations for research are given in Chapter 6.

CHAPTER 2

THE ALCOHOL-CRASH PROBLEM

This chapter is concerned with trends in the general magnitude of the alcohol-crash problem as estimated from data taken from studies of highway crashes and driver and pedestrian populations. The detailed characteristics of the persons who have been involved in drinking-driving mishaps are treated in later chapters. As in prior reviews, our objective here is two-fold:

- To determine approximately how many crashes of various levels of severity involve drinking drivers; and
- To determine the extent of over-involvement of drinking-driving in crashes of the various severities.

The second objective is related to the *riskiness* of drinking-driving. Past research has established that the risk of crash involvement increases with the increase in amount of alcohol in the body. In this chapter, our concern is new knowledge about the extent of this alcohol-crash risk.

PRIOR FINDINGS

The 1978 report (Jones and Joscelyn, 1978) noted the lack of any national study methodically investigating the many variables that describe highway crashes, and that, for the most part, research had proceeded in directions of greatest interest to individual investigators. As a result, it was necessary to piece together bits of information from separate studies never intended for global application. Despite this, the report found a "remarkably consistent" picture. Some 40% to 55% of all fatally injured drivers in the studies had a blood alcohol concentration (BAC) of .10% or more. Of the drivers killed in single-vehicle crashes, 55% to 65% had a BAC of at least .10%. Nine to 13% of drivers in injury crashes and about 5% of drivers in property damage crashes had a BAC of .10% or more. The report estimated that, in 1975, 15,200 fatal crashes involved drivers with a BAC above the legal BAC limit (.10%), and that there were 120,000 personal injury crashes and 765,000 property damage crashes with drivers over the legal limit. The annual societal cost of all these crashes was estimated to be in the order of $4 billion.

The 1978 update also found that crash risk increases as driver BAC increases. The relative probability of a crash was found to begin to increase "precipitously" as the driver's BAC approached .08%. At a BAC of .10%, the probability of a fatal or serious-injury crash was estimated to be 6 to 12 times that of a driver with

no alcohol. The relative probability of a fatal crash was said to be much higher at higher BACs, over 20 at a BAC of .15%.

The 1978 report found a paucity of studies on the magnitude of the alcohol-pedestrian safety problem, but nevertheless ventured an estimate that about one-third of all fatally injured pedestrians had a BAC of .10% or more at the time of their death.

The 1984 update (U.S. Department of Transportation, NHTSA, 1985) was able to use some initial data from NHTSA's Fatal Accident Reporting System (FARS). These data came from 14 to 17 states that had the "most complete" BAC data on fatally injured drivers in the years 1980, 1981, and 1982. They showed that about 50% of drivers in fatal crashes had a BAC of at least .10%; this result was "essentially in accord" with that from the 1978 update whose midpoint for this group of drivers was 47%. The 1984 update also reported the results of a study using a different criterion for alcohol involvement, *viz.*, that the driver, pedestrian, or cyclist had a BAC of .01% or more; *or* the driver was charged with drunk driving by the police; *or* the investigating officer had indicated in the accident report that a driver or pedestrian had been drinking prior to the accident. Using this criterion, 56% of fatal crashes in 15 states with good BAC reporting in 1980-1982 were found to involve alcohol. Forty-eight percent of fatal pedestrian accidents in these states involved pedestrians by this criterion.

The 1984 report presented additional analyses of the crash risk factors associated with drinking-driving. One interesting finding (from a study in New Orleans by Blomberg, *et al.*) was that the relative risk of involvement in a fatal pedestrian accident did not begin to rise until a BAC of .15% to .20% was reached. This is consistent with the hypothesis that safe walking is generally easier than safe driving, since the relative risk curve for fatal motor vehicle accidents starts to rise at a much lower BAC.

The 1984 report's estimates of the percentage of different types of crashes involving drivers with a BAC of .10% or more *circa* 1980 were: fatal crashes, 47-50%; injury crashes, 18%; and property damage crashes, 5%. The report estimated that, in 1980: 24,000 to 27,500 persons were killed in alcohol-related crashes; 708,000 were injured; and there were 1,224,000 property damage crashes involving alcohol. The total economic cost to society of all of these losses was estimated at over $10 billion in 1980 dollars.

CRASH INVOLVEMENT OF DRINKING DRIVERS

A fundamental requirement for quantifying the alcohol-crash problem is an objective measure of immediate drinking behavior. As in the past, the most objective measure of immediate drinking behavior is blood alcohol concentration

(BAC)[1]. Because BAC describes a chemical state of the body, its measurement is not dependent upon the subjective judgement of the driver or an observer (such as a police officer or accident investigator). As long as certain methodological pitfalls[2] are avoided in selecting drivers and reasonable care is taken in the measurement process itself, BAC is the preferred measure of immediate drinking behavior. Only studies based on BAC measurements are included in this chapter.

Fatal Crashes

In prior updates of the state-of-knowledge of alcohol and highway safety, determination of alcohol involvement in a fatal crash was based on a BAC test of fatally injured drivers in jurisdictions that tested a large percentage of such drivers. A major research development in the epidemiology of fatal traffic crashes since the last state-of-knowledge update is the availability of more useful data in the Fatal Accident Reporting System (FARS) database maintained by NHTSA. The utility of this resource in prior updates was limited by the relatively small fraction of cases for which blood alcohol concentration (BAC) measurements had been taken and were known. In 1987, more than half of the states tested the BACs of a high percentage of fatally injured drivers and had the results of those tests for inclusion in FARS (U.S. Department of Transportation, 1988b). Virtually all national studies of fatal crashes in this country in recent years have used the FARS database.

There are a number of studies in which fatal alcohol-crash data have been presented for a more limited geographical area, usually an entire state (see, for example, Jones *et al.*, 1988; Hatfield, Pendleton, and Gonzales, 1988; Stanek, *et al.*, 1984; Owens, McBay, and Cook, 1983). However, these studies have invariably used FARS (or data contained in FARS) also, so their results would not provide any significant additional insights on the alcohol-crash problem nationwide. Thus, they are not discussed here.

Figure 2-1 summarizes FARS data on fatally injured drivers from 15 states with "good" reporting of BAC in 1980, 1983, and 1987 (Fell and Nash, 1989)[3]. (Note

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[1] BAC is a measure of the amount of alcohol in a person's blood, stated in terms of the *weight* of a quantity of alcohol in a given volume of blood. In this report, the units of BAC will be grams of alcohol per *100* milliliters of blood. For example, if a given measure showed .01 grams of alcohol in a 100 milliliter sample of blood, we would state the result as a BAC of .01 %.

[2] The major problem is the introduction of bias due to non-random selection of samples of drivers for BAC testing. Another problem is ensuring that the BAC taken is the BAC at or near to the time of the crash. These and other problems are discussed by Jones and Joscelyn (1978) in the first update of the state of knowledge of alcohol and highway safety.

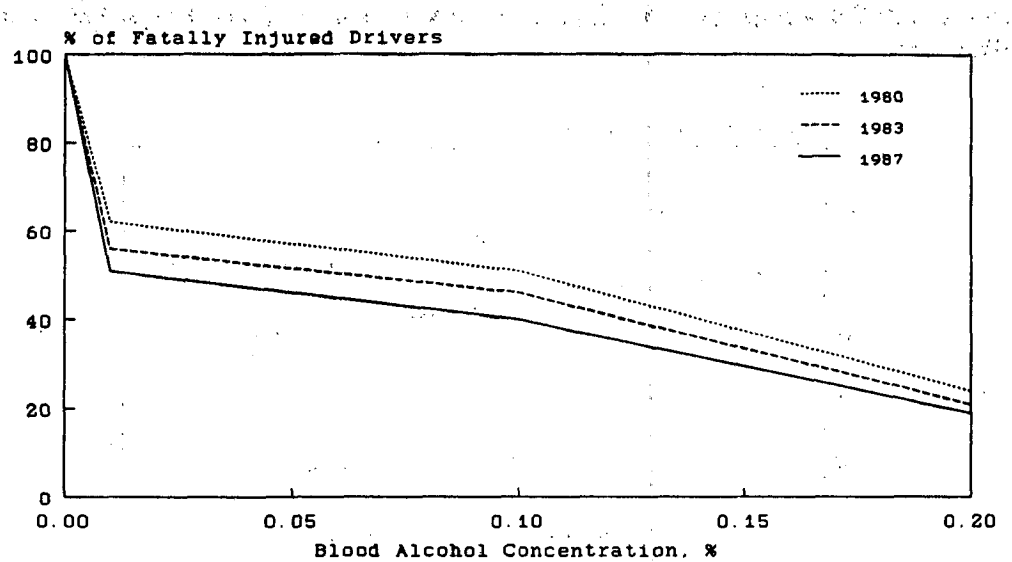
[3] Good reporting states are defined by National Highway Traffic Safety Administration as those testing and reporting the BAC of at least 80% of fatally injured drivers in 1980, and continuing with that level of testing and reporting through 1987.

that the labeling for the ordinate of this and all other figures in this report appears at the top of the ordinate rather than at the left.) Forty to 51% of these drivers had a BAC of .10% or higher, and 30 to 38% had a BAC of .15% or more. These data are consistent with those presented in the prior updates.

However, a plot of FARS data versus time reveals a steady decline in the percentage of drivers with BACs exceeding .10% since 1980 (Figure 2-2). *The decline amounts to about 11 percentage points in absolute terms, or a relative percentage of 22%.* A similar decline is reflected in NHTSA's expansion of these data from 15 states to all states. Further, there is also a decline in the percentage of fatally injured drivers at the higher BACs (Figure 2-3).

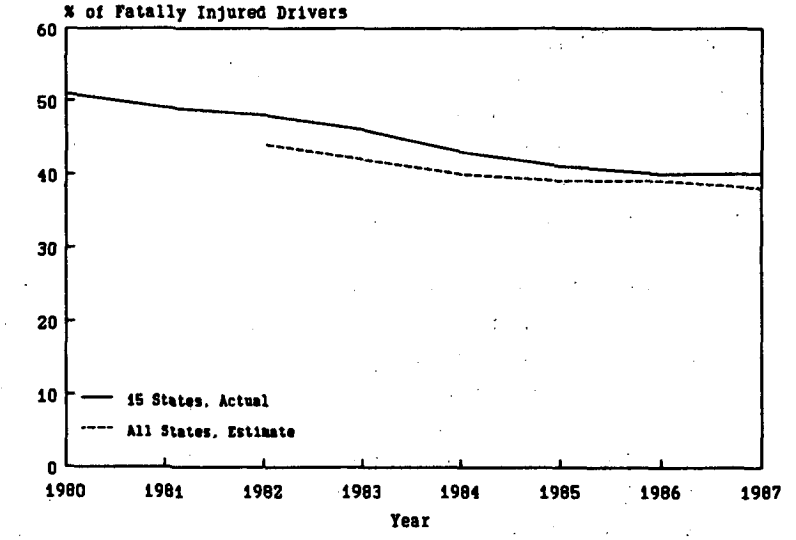
Zobeck (1986) used the FARS database to calculate the percentage of so-called *alcohol-related* fatal crashes over a period starting in 1977 and extending through 1984. The criterion for being alcohol-related was that either (1) the investigating officer judged there was alcohol involvement, or (2) there was a positive BAC reported, or (3) there was a citation reported for DUI. Criteria 1 and 3 are based upon the subjective judgement of the investigating officer and the latter also on the legal requirements for a charge of DUI. The results of the Zobeck study are shown in Figure 2-4 in comparison with the BAC test results from the 15 good-reporting states and do not show the same trend for comparable years as the data based on BAC.

Figure 2-1: Percentage of fatally injured drivers with BACs greater than or equal to given values - 15 good reporting states



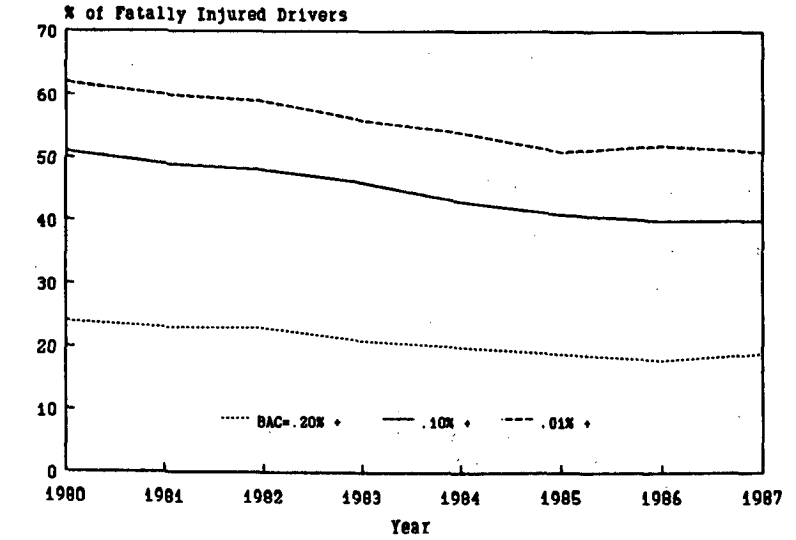
Source: Fell and Nash, 1989

Figure 2-2: Percentage of fatally injured drivers with BACs = .10%+ in 15 good reporting states and in all states, 1980-1987



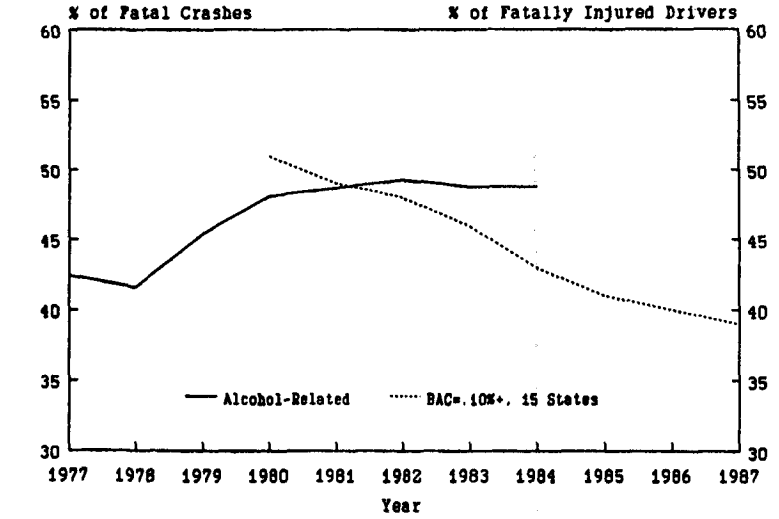
Source: U.S. DOT, 1988b

Figure 2-3: Percentage of fatally injured drivers by year in 15 good reporting states, 1980-1987



Source: Fell and Nash, 1989

Figure 2-4: Comparison of two definitions of alcohol-crashes.



Source: Zobeck, 1986; Fell and Nash, 1989

Percentage of crashes that are "alcohol-related" increase and flatten out during the 1977-1984, while the percentage of fatally injured drivers with a BAC of .10% or more steadily decreases during 1980-1987. A very likely reason for this difference is that the alcohol-related measure includes trends other than alcohol-crash involvement, specifically a general increase in police officer awareness and likely increased assessment of a crash as alcohol-involved, a general increase in DUI arrest rate, and changes in the legal environment concerning what justified a DUI charge. Also, the number of fatally injured drivers who were tested for BAC has increased steadily over time. Unless corrected for, this would also tend to increase the percentage of fatal crashes involving alcohol using the alcohol-related criteria. The FARS data based on the BAC criterion are affected very little, if at all, by such biases, provided that such data are taken only from states that test a high percentage of fatally injured drivers.

It is interesting that a downward trend similar to that shown by the FARS data also occurred in Canada and Victoria, Australia, where the BACs of a large percentage of fatally injured drivers were also measured[4] (Figure 2-5). The Victorian trend appears to be displaced to the left of the U.S. trend by about three

[4] Note that legal limits were different in these three countries. In the U.S., the term "legal limit" is usually taken to mean a BAC of .10%, even though a few states have a higher or lower limit, or even two or more legal limits indicating different levels of alcohol-impaired driving. In the referenced figure, a BAC of .10% is used as the "legal limit" for the U.S. In Victoria, Australia, and Canada, the legal limits have consistently been .05% and .08%, respectively, over the period indicated in the figure.

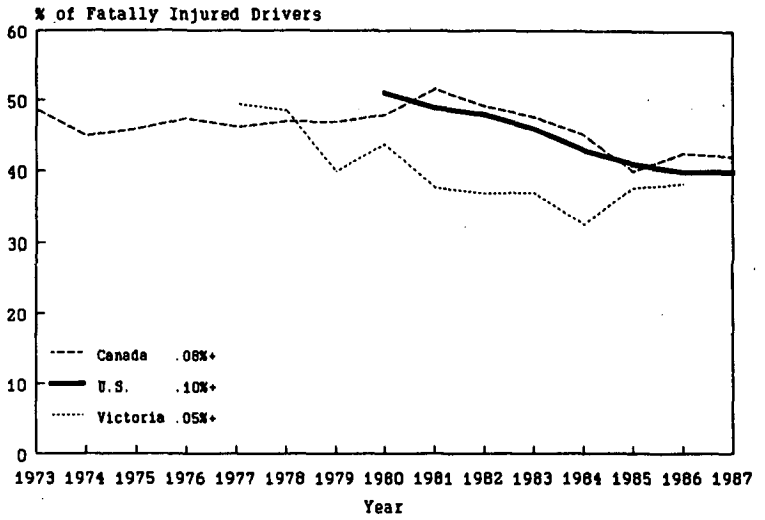
years. The Canadian trend is nearly coincident with the U.S. trend. All three studies show a flattening out of the trend in recent years, and there is a suggestion of an increase in the trend in the Victorian and Canadian data. Note that Victorian data are from a single state in Australia, while the data from Canada and the U.S. are for entire countries.

Nonfatal Crashes

There were no new studies that provide trend data based on BAC alone for non-fatal crashes. Earlier, studies involving BAC measurements showed that about 10% of injury crashes and 5% property damage crashes involved alcohol at .10%+ level (Figure 2-6) (Jones and Joscelyn, 1978; U.S. Department of Transportation, NHTSA, 1985).

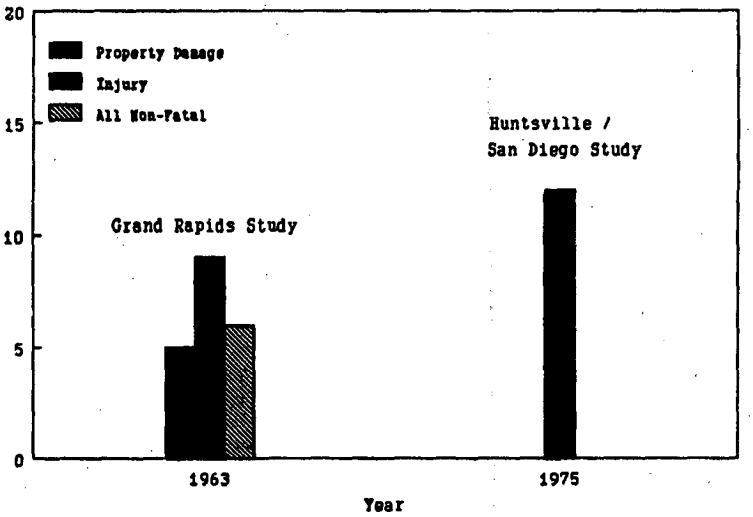
Data are available from the state of Victoria in Australia and indicate a downward trend in the percentage of injury crashes involving a driver whose BAC was .05% or more (Figure 2-7). This trend has almost exactly the same slope as the Victorian trend in percentage of fatally injured drivers involving alcohol at this BAC level. This suggests that a similar relationship might exist in the U.S., and this possibility should be studied.

Figure 2-5: Percentage of fatally injured drivers with illegally high BACs in the United States; Canada; and Victoria, Australia



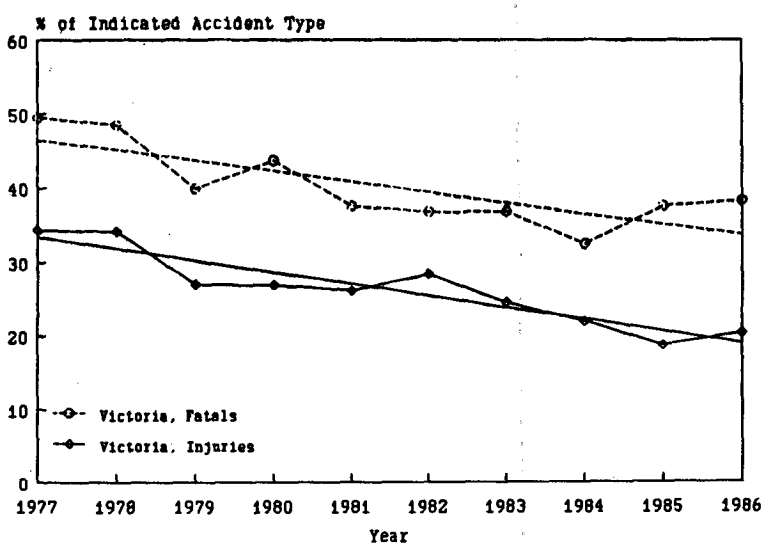
Source: Donelson, 1989; U.S. DOT, 1988b; South, 1988

Figure 2-6: Percentage of non-fatal crashes involving a driver with a BAC of .10%+, 1963 and 1975



Source: U.S. DOT, 1985; Jones and Joscelyn, 1978

Figure 2-7: Percentage of fatal and non-fatal crashes in Victoria, Australia, involving drivers with a BAC of .05%+, 1977-1986



Source: South, 1988

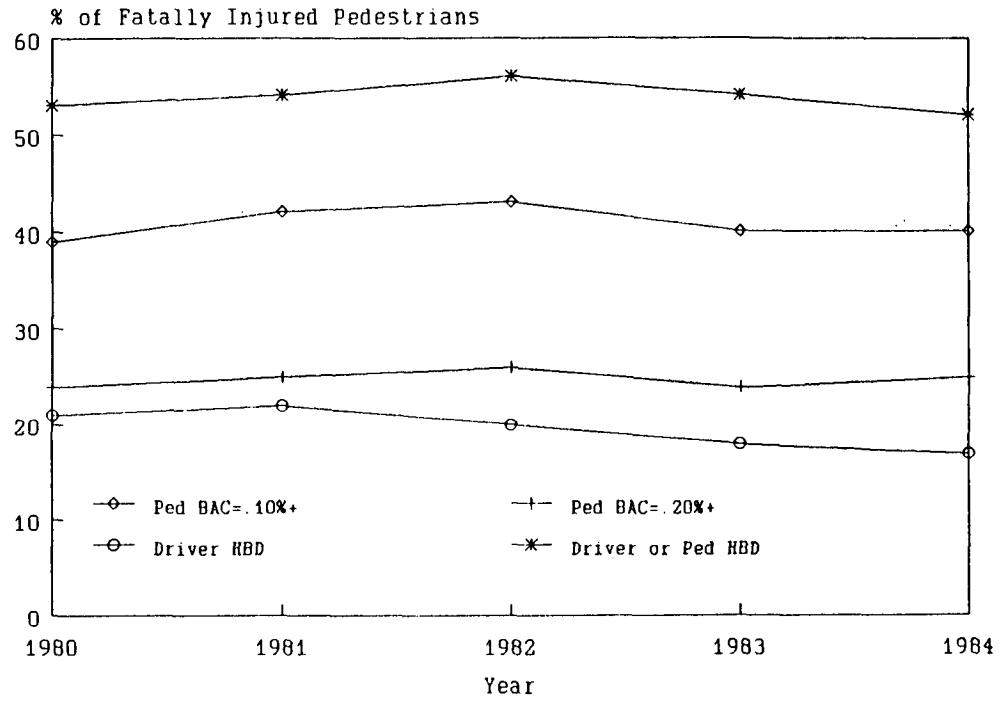
Pedestrians

Again, FARS provides the best trend data for fatal pedestrian accidents involving alcohol. Fell and Hazzard (1985) compiled FARS data from 15 good reporting states during the 1980-1984 period. Their data show that:

- 40% of fatally injured pedestrians had a BAC of .10% or more;
- 25% of fatally injured pedestrians had a BAC of .20% or more;
- The driver had been drinking in about 20% of fatal pedestrian accidents; and
- Either the driver or the pedestrian had been drinking in about 55% of fatal pedestrian accidents (Figure 2-8).

These data were quite stable over the time period studied with no apparent trend either upward or downward.

Figure 2-8: Percentage of fatally injured pedestrians in alcohol-related crashes in 15 good reporting states, 1980-1984



Source: Fell and Hazzard, 1985

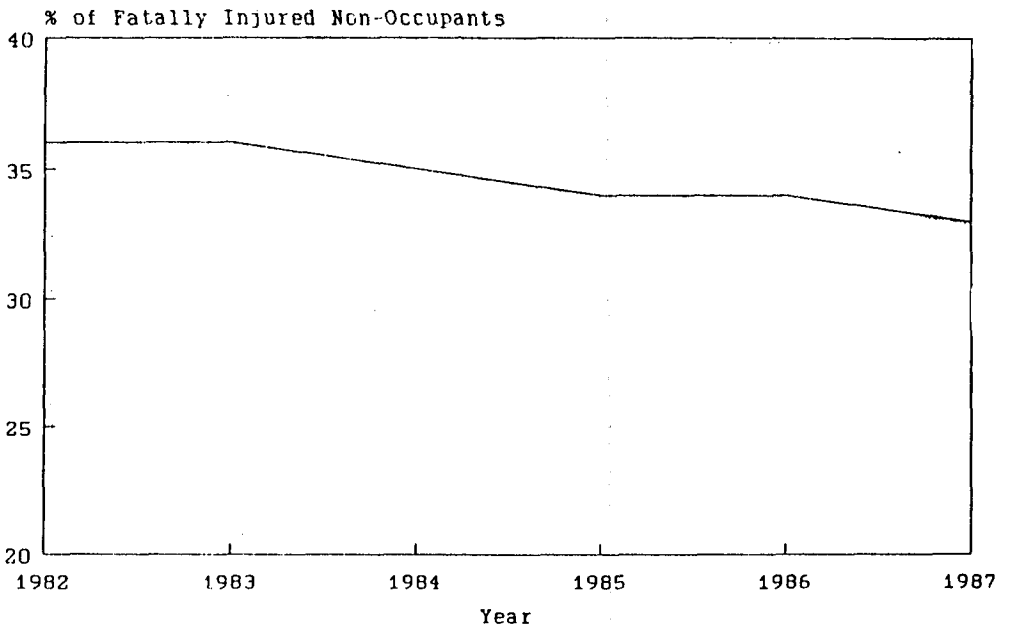
The latest FARS report (U.S. Department of Transportation, 1988b) presents six years of data on all adult non-occupant fatalities (i.e., pedestrians and pedal-cyclists). They show that 35% of these non-occupants had a BAC of .10% or more (Figure 2-9). There is a hint of a downward trend in these data, but the statistical significance of such a "trend" is not known. No foreign trend data on non-occupants were found in our literature search.

DRINKING BEHAVIOR OF DRIVERS USING THE ROADS

The major new development in this area is the finding of a reduction in the percentage of drinking drivers using the roads during the time when alcohol-crash risk is the highest, that is, nighttime hours on weekends. This finding flows from a replication of the national roadside survey conducted by The University of Michigan researchers in 1973 (Wolfe, 1974). The findings of the 1973 survey were discussed in the 1978 update.

The new survey (Lund and Wolfe, 1989) was conducted by Mid-America Research Institute under the sponsorship of the Insurance Institute for Highway Safety. It was conducted in locations designed to match the 1973 locations as closely as possible. Where possible, the same jurisdictions and locations used in

Figure 2-9: Percentage of fatally injured non-occupants with BAC = .10%+, 1982-1987



Source: U.S. DOT, 1988b

1973 were used in 1986. It turned out that 15 of the 24 jurisdictions surveyed in 1973 were also surveyed in 1986. The procedures used in selecting replacement jurisdictions (dictated usually by the original jurisdictions choosing not to participate) are described by Lund and Wolfe in their report. In the 1986 survey, 3,100 drivers at 182 sites were stopped during the hours of 10:00 pm to 3:00 am on Friday and Saturday nights from early May, 1986, through mid-June. It found a reduction of 52% in the percentage of drivers with a BAC of .10% or more (Figure 2-10). The reduction in the percentage of drivers with a BAC of .05% or more was nearly 60%. These reductions were statistically significant at the .01 level. Note that 92% of the drivers stopped by the survey team in 1986 agreed to permit a BAC test, compared to 86% in 1973. The effect of this difference in refusals is not known, but correcting for refusal rate could amplify the true difference in percentage of .10%+ in the two surveys if the refusers had a higher BAC than the non-refusers.

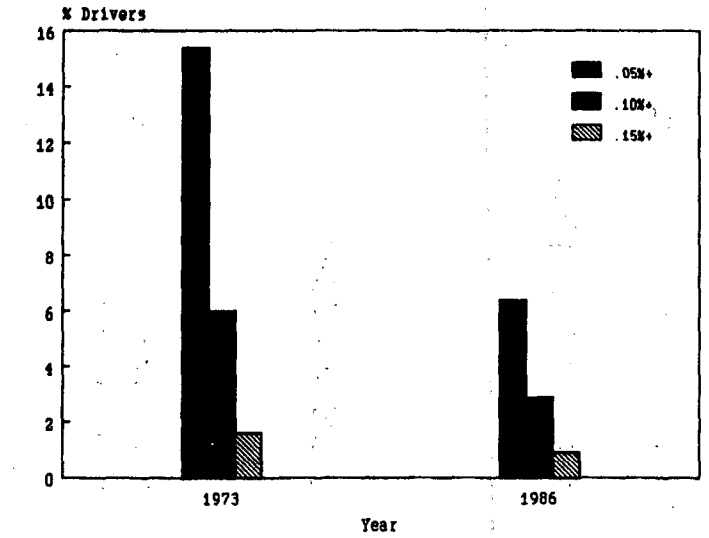
Although the latest roadside survey took considerable care to make it as comparable as possible to the earlier survey, it was clearly impossible to match it in every respect. For example, the 1973 survey was conducted during the Fall, while the 1986 survey was conducted in the Spring and early Summer. Fifteen out of 24 jurisdictions surveyed were the same, but 15 matching jurisdictions may not have been representative of the larger set. Some sites were "piggy-backed" on to existing police checkpoints, although Lund and Wolfe found the results from the sites using checkpoints "similar" to those not using checkpoints and combined the two data sets. These and other possible differences between the two surveys indicate that some caution should be used in comparing their results.

There has been very little roadside survey activity in this country in recent years, primarily because of the changed legal environment which makes it much more difficult to obtain government participation and funding. The only other large-scale survey was conducted statewide in Minnesota in 1985 during nighttime hours. It also found a reduction in the percentage of drivers with a BAC of .10% or more (Palmer and Tix, 1985). This reduction was of the same magnitude as that reported in the national studies, 45% compared to 52%. However, the survey obtained a relatively low BAC response rate (75%).

No other U.S. studies were found that could be used for estimating changes in drinking-driving behavior over time. In particular, there have been no new studies of drinking-driving behavior during daytime or weekdays that would be comparable to the Grand Rapids study[5].

[5] The Grand Rapid study was conducted by Borkenstein and his associates in 1962 and 1963. It is discussed at length in the 1978 update.

Figure 2-10: Non-accident involved drivers, 1973 and 1986, common locations, nighttime, weekend



Source: Lund and Wolfe, 1989

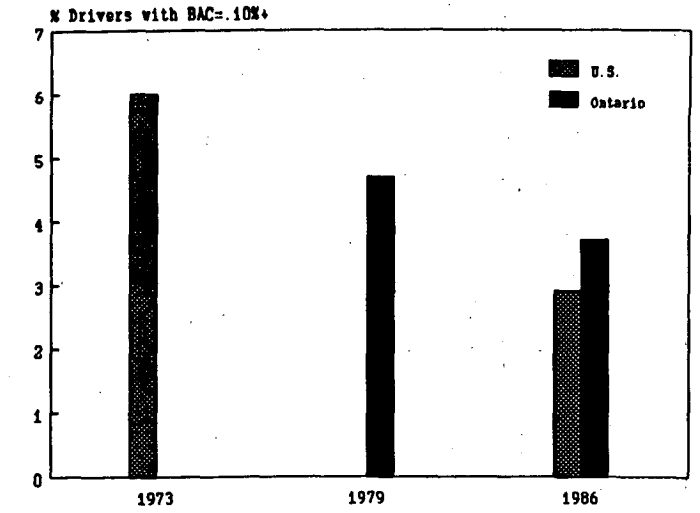
In 1986 the province of Ontario, Canada, conducted a roadside survey that closely matched its 1979 survey (Ontario Ministry of Transportation, 1988). This survey was similar in design to the U.S. survey, but was conducted on *Wednesday* night through Saturday night during the hours of 9:00 pm through 3:00 am between May 18 and July 18, 1986. A total of 12,125 drivers participated in the survey. Over 96% of the drivers stopped provided a breath sample. This survey also found a reduction in the percentage of drinking drivers (BAC > .10%) using the roads, from 4.7% in 1979 to 3.7% in 1986. This "trend" is similar to that suggested by the U.S. data (Figure 2-11). Note that the U.S. survey and the Canadian survey are not strictly comparable because of the differences in the days of the week of the two surveys.

CRASH RISK OF DRINKING DRIVERS

There is evidence that the *average crash risk per driver year* of a fatal alcohol-related crash has also declined in the past several years. Data from FARS show that the probability that a licensed driver in the U.S. will be killed and have a BAC of .10% or more in a one-year period has declined from 100 per 100,000 in 1980 to about 65 per 100,000 in 1987, a reduction of 35% (Figure 2-12).

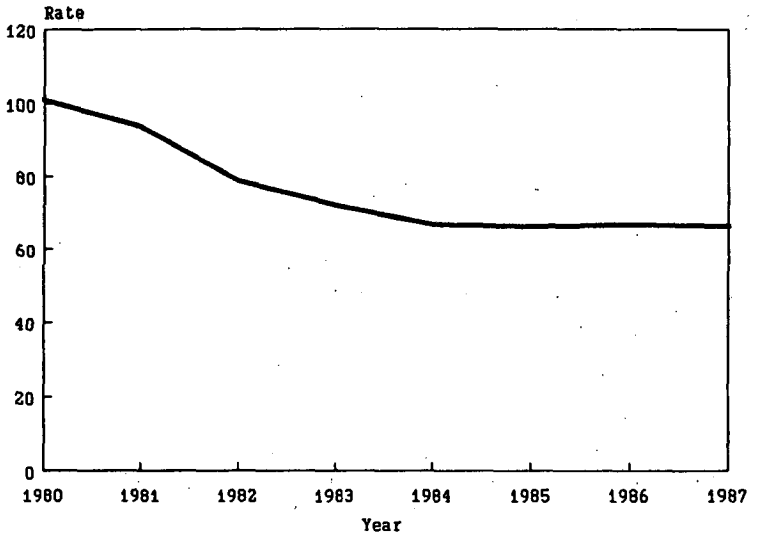
It is not possible to estimate any trends in the *conditional probability* of an alcohol related crash (i.e., the probability of a crash per exposure unit given a

Figure 2-11: Non-accident involved drinking drivers, U.S. and Ontario, Canada various years



Source: Lund and Wolfe, 1989; Ontario Ministry of Transportation, 1988

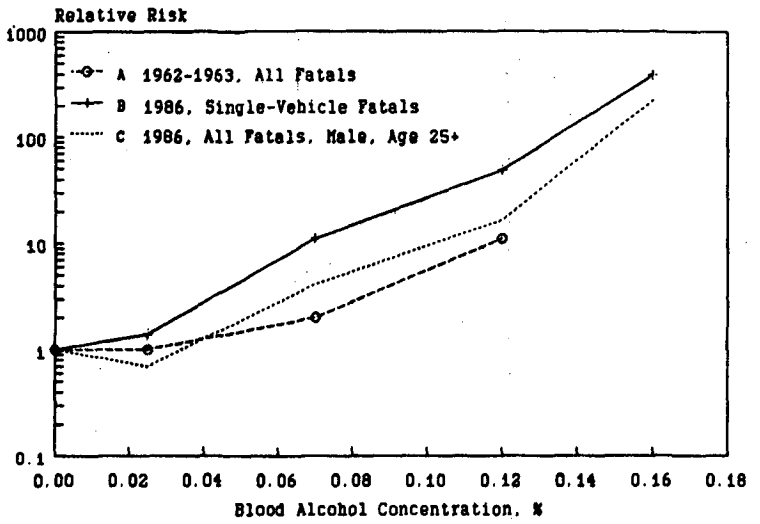
Figure 2-12: Fatal-crash rate per 100,000 licensed drivers of drivers with BAC = .10%+, 1980-1987



Source: U.S. DOT, 1988b

certain BAC) because no controled studies of crash risk have been conducted that would permit this. The last rigorous case-control study[6] in this country was the Huntsville / San Diego study of injury crashes summarized in the 1978 and 1984 updates of the state-of-knowledge of alcohol and highway safety (Jones and Joscelyn, 1978; U.S. Department of Transportation, NHTSA, 1985). However, data from the 1986 national roadside survey combined with FARS data suggest that the relative risk of a fatal alcohol-related crash is still very high, even at the lower BACs (Zador, 1989). For example, at a BAC of .07%, the driver's relative risk of being killed in a *single-vehicle* crash is about 11 during weekend nighttime hours (Figure 2-13). In comparison, data from the Grand Rapids study conducted more than 20 years earlier over a 24-hour period, seven days a week, indicate a driver's relative risk of being killed in a *single-vehicle or a multi-vehicle* crash is about 2 at the same BAC. We note that the data from these two surveys are not strictly comparable, because the data on the crash-involved drivers and the non-crash involved drivers were not matched in Zador's study. In addition, the Grand Rapids study dealt with a single jurisdiction, while Zador's study covered many jurisdictions and included more environments.

Figure 2-13: Relative risk of a fatal crash for drivers as a function of BAC - A: Grand Rapids Study; B,C: National Roadside Survey / FARS data analyzed by Zador



Source: Jones and Joscelyn, 1978; Zador, 1989

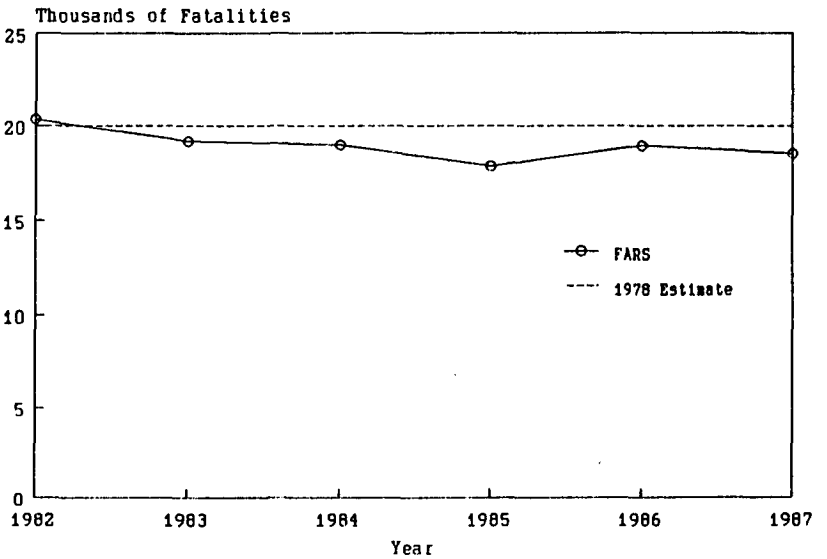
[6] A case-control study compares the characteristics of crash-involved drivers (the"case" group) with those of non-crash involved drivers (the "control" group) using the roads at the same times and places as the crash-involved drivers.

SUMMARY AND CONCLUSIONS

It is quite clear that there has been a substantial reduction in alcohol-related fatalities and in drunk driving in general over the past several years. A rule of thumb (substantiated by research) had been that about 50% of fatally injured drivers had a BAC of .10% or more. Now, this figure is closer to 40%. FARS data indicate that the number of fatalities involving a driver with a BAC of .10% or more has also decreased, from an estimated 20,400 in 1982 to an estimated 18,500 in 1987 (Figure 2-14). This amounts to a reduction in fatality rate for .10%+ drivers from 8.8 per 100,000 population in 1982 to 7.6 in 1987. This is a reduction of about 14%. However, research suggests that the reduction in the alcohol-crash risk has stabilized and has reached a plateau.

This decrease in alcohol involvement in fatal crashes has been accompanied by a very large decrease in drinking-driving in general. Roadside surveys suggest that there has been a reduction of some 50% in the percentage of drivers with a BAC of .10% or more. Note that the reduction in percentage of .10%+ non-crash involved drivers is much greater than the reduction in percentage of .10%+ fatally injured drivers. The reason for this is not known, but could be due to inherent

Figure 2-14: Estimated number of alcohol-related fatalities with driver BAC = .10%+, 1982-1987



Source: U.S. DOT, 1988b; Jones and Joscelyn, 1978

differences between alcohol-impaired drivers who are involved in fatal crashes and alcohol-impaired drivers who are not involved in such crashes. It could also be due to other factors present in different degrees in the two groups, for example, a different mix of vehicle types and a different mix of roadway types.

Non-fatal crashes have a lower percentage of alcohol involvement than fatal crashes. However, it could be expected that a reduction in alcohol-impaired driving would also reduce the percentage of non-fatal crashes involving alcohol, although scientific evidence of this is very limited.

CHAPTER 3

ALCOHOL EFFECTS ON PEOPLE

Epidemiologic studies such as those discussed in the previous chapter are most useful for estimating the crash risk associated with different levels of drinking and for determining how many crashes involve those levels of drinking. They are less useful for assessing the causal role of alcohol in crashes and for understanding how and to what degree alcohol impairs performance of tasks critical to safe driving. This chapter discusses recent knowledge flowing from the scientific study of alcohol's effects on the human body in general and on behaviors related to driving in particular. As in prior updates, the organization of the discussion proceeds along three lines:

- biochemistry of alcohol;
- physiological effects of alcohol; and
- behavioral effects of alcohol.

The first two categories are concerned with how alcohol is absorbed and metabolized in the body, and with measuring the amount of alcohol present in the body. The last category deals with the mechanisms of alcoholic intoxication and the effects of alcohol on behaviors related to driving.

The scientific literature in this area is highly technical and involves many disciplines in the medical and behavioral sciences. Thus, the discussion here is necessarily limited to the major issues pertinent to alcohol and highway safety. The reader is referred to the materials cited and to the materials recommended for further reading for a trail to more in-depth treatments of these topics.

PRIOR FINDINGS

The 1978 update found that blood alcohol concentration (BAC) could be measured with high precision by a number of means, including breath-testing devices. It concluded that BAC was the most useful parameter known for relating alcohol consumption to human behavior.

The report found that neuromuscular responses could be impaired at a BAC as low as .04%, but that some motivated experienced drinkers could overcome the impairing tendencies at a BAC as high as .20%. It was found vision *per se* was not greatly affected at a BAC of less than .10%, but that it became impaired in most persons at higher BACs. Research indicated that one's ability to distinguish closely separated moving objects became impaired at a very low BAC, perhaps as low as .03%. Laboratory tests of simple tracking performance and concentration showed that these were not significantly impaired even at a BAC as high as .10%.

However, performance of more complex tracking tasks was diminished in many individuals at BACs in the .05% to .10% range. A person's ability to divide attention between tasks was reported to be impaired at a BAC as low as .02% and to often be impaired at BACs above .08%. There was some evidence that risk taking may be increased for some persons at moderate BACs.

The 1978 report's review of literature reporting actual driving experiments found that the ability of many drivers to perform parking maneuvers became impaired at BACs as low as .04% to .06%. Vehicle maneuvering at low speeds was degraded at a BAC of .08% to .10% for average drinkers but less so for heavy drinkers. Driving performance at higher speeds became impaired at slightly lower BACs. The report concluded that behavior that had been studied was consistently and significantly impaired in virtually all individuals as BACs approach .10%. Only a few of even the heaviest drinkers were found to suffer little impairment at BACs much greater than .10%.

The 1985 review concurred with the earlier findings and reported some new research involving driving experiments. This research indicated that drivers with BACs in the .08% to .10% range tended to drive faster and to stop less smoothly than other drivers. Two studies were found that suggested that the driving performance of some individuals with low BACs was degraded.

BIOCHEMISTRY AND PHYSIOLOGICAL EFFECTS OF ALCOHOL

Alcohol Absorption, Metabolism, and Measurement

Work in this area has resulted in a better understanding and empirical definition of the process of alcohol *absorption and elimination*. Variability in absorption has been found to be quite high, with absorption time varying by an order of magnitude and peak BAC by a factor of 2 to 3. Affirmation that the Widmark curve of elimination is "an inappropriate description for the elimination of alcohol... for a significant portion of the population" was reported. A variability in mean hourly decrease in BAC of up to an order of magnitude has been reported in careful experiments. These variabilities are affected by a wide range of factors, including subject sex, age, and type of beverage consumed, among others (Dubowski, 1986; U.S. Department of Transportation, no date; Donelson, Beirness, and Simpson, 1988).

These findings illustrate the pitfalls in developing nomograms and charts of the type that are often distributed in drunk driving programs. Such materials can be misleading unless care is taken to account for factors of the type indicated above that affect variability in the absorption and elimination of alcohol (see Dubowski, 1985; O'Neill, Williams, and Dubowski, 1983; Donelson, Beirness, and Simpson, 1988; and Jones, 1988).

There have been no fundamentally new discoveries in *breath-alcohol measurement and analysis*, but much there has been improvement in the field (Dubowski, 1986)[1]. Many of these improvements relate to court cases which hinge on the use of blood alcohol concentration (BAC) as determined from breath-alcohol measurement, as indicated above. Dubowski states that no such case has ever been overturned on the basis of wrong scientific principles. He also states unequivocally that the influence of acetone (produced naturally by some bodily processes) in inflating BAC measurements is a myth. Flores and Frank (1985) also concluded that acetone interferents "have no practical significance in traffic law enforcement" (page 1). The same holds for other interferents. With proper safeguards of the type recommended by NHTSA (National Bureau of Standards, 1983), breath testers currently in use are unaffected by radio frequency interference. Oral alcohol contamination disappears after about 10 minutes. Research since prior state-of-knowledge updates affirms the inherent scientific and technological validity of breath alcohol testing.

While breath alcohol measurement is now the clear standard in many areas of highway safety (especially in the enforcement of drunk-driving laws), *blood alcohol measurement* is still widely used (for example, in measuring alcohol presence in the bodies of persons killed in traffic crashes). Dubowski (1986) recently updated the state-of-the-art of blood alcohol analysis. He concluded that for blood, (1) contamination during withdrawal is rare and easily avoidable, (2) no changes in original alcohol content occur in untreated specimens for up to 14 days, (3) treatment with sodium fluoride and sodium oxide inhibits neoformation and alcohol loss for much longer periods, (4) microbial production of alcohol does not occur when proper precautions are taken (e.g., refrigerating a body within 4 hours after death), (5) use of plasma and serum instead of whole blood can inflate BAC by 10% to 18% ("not an uncommon practice"), and (6) endogenous production of alcohol is insignificant.

In the past, drunk driving laws have stated their limits on alcohol presence in the body in terms of blood alcohol concentration rather than breath alcohol concentration. However, law enforcement agencies have come to use breath alcohol measurements almost exclusively in enforcing these laws. This means that the breath alcohol measurements must be converted to blood alcohol measurements for use in legal proceedings in most states. There is a large body of research dating back into the 1950s that shows that properly conducted breath alcohol measurements can be converted to blood alcohol measurements with sufficient precision for use in legal proceedings. (See the 1978 update for a discussion of earlier studies

[1] Many of these improvements are in instruments used in forensic applications. These include better preliminary breath testers for determining whether to arrest a driver suspected of being impaired, breath testers for use in alcohol interlock systems on cars, and evidentiary testers for measurements used in court. These applications are discussed in the section entitled TECHNOLOGICAL APPROACHES in Chapter 5.

which indicated that breath testers typically *underestimated* BACs determined from blood analysis by up to 10% or so.) In fact, Biasotti (1984) states that "there is no *practical* significance to arguments being raised by the defense community regarding inaccuracies that may arise from a breath alcohol analysis used to determine an equivalent BAC" (page 1168, emphasis added). Nevertheless, there is some controversy on this issue, much of which is related to the effect of individual differences on the factor used in converting breath alcohol measurements to blood alcohol measurements. For example, Dubowski (1985) asserts that, under current knowledge, it is not possible to convert breath alcohol measurements to blood alcohol measurements with "forensically acceptable certainty." (He also states in the same paper that it is not ordinarily possible to make a forensically valid extrapolation of a blood or breath measurement forward or backward in time on the sole basis of individual analysis results.) The issue of conversion will become moot as more and more states specify their limits for alcohol presence in the body in terms of breath alcohol concentration, as is now specified in the laws of 24 states.

Acute and Chronic Effects of Alcohol

The most significant *acute effect of alcohol* is still its effect on the central nervous system (CNS), and its subsequent effect on neuromuscular functions, sensory functions, cognition, mood, and behavior. Some of these effects are discussed later in this report, but are due primarily to alcohol's action as a CNS depressant.

An important finding of recent research is that *alcohol is a clear potentiating factor in trauma*. There is a popular belief that a drunk person is more relaxed and may therefore be less severely injured in an accident than a sober person. Experimental studies with laboratory animals and epidemiological research with traffic accidents (Waller, Stewart and Hansen, 1986) has shown that this is not so. One model controling for factors indicating physical crash severity showed that drivers judged by officers to have been drinking (whose judgement was very reliable in those cases where a BAC test was performed) were 4.45 times as likely to be killed as sober drivers. Another model found a factor of 2.25. The effect of alcohol appeared to be larger in accidents of low severity than in accidents of high severity. The effect of alcohol depends on BAC, but it does not appear to increase consistently. For the risk of fatal or severe injuries, three models showed increases by factors between 1.73 and 2.09 for drivers who had been drinking.

Chronic effects of alcohol generally occur after long-term heavy use of alcohol. The most common site of alcohol-injury in the body is the liver which plays a primary role in metabolizing alcohol. Recent research has established that alcohol's effect on the liver is a direct one, rather than an indirect one due to alcohol-induced malnutrition. It is now known that many of alcohol's harmful effects are

due to its effects on the endocrine system. Many of alcohol's links to cancer and other diseases are for chronic heavy drinkers and alcoholics. Research generally is lacking on the effects of amount of alcohol consumed on non-crash morbidity and mortality (U.S. Department of Health and Human Services, NIAAA, 1983; Turner, 1989). In a few instances (e.g., ovarian cancer), risk is actually decreased by alcohol consumption. Additional confirmation of so-called fetal alcohol syndrome was obtained.

It is our impression after examining the literature that the variability of alcohol effects on the human body is now much more recognized than it has been. This applies to the full spectrum of alcohol interactions with the human organism, from ingestion through elimination. Researchers and / or reviewers now tend to be more cautious about making blanket statements about alcohol effects than they were at the time of prior updates. No research evidence was found that any chronic physical effect of alcohol had a direct effect on highway safety.

BEHAVIORAL EFFECTS OF ALCOHOL

General Effects on the Nervous System

Two new theories of alcohol's effects have arisen since the last state-of-knowledge update (U.S. Department of Health and Human Services, NIAAA, 1983). The first has to do with the *mechanism behind alcohol's reinforcing property*, that is the physiological and biochemical processes through which the use of alcohol is reinforced or "rewarded." It is now hypothesized that much of alcohol's appeal is directly related to its excitatory effects. There is much research in this area to support this hypothesis, and the experimental evidence implicates several neurotransmitters, including dopamine, as the neurochemicals responsible for the reinforcing properties of alcohol.

The second new theory states that a class of chemicals called tetrahydroisoquinolines (TIQs) may play a role in habitual heavy drinking. These TIQs are formed in the body as alcohol is metabolized and appear to increase preference for alcohol in animals (U.S. Department of Health and Human Services, NIAAA, 1983).

The meaning of these new developments for Highway safety is unclear, but they could offer encouragement for the development someday of so-called "sobering agents" and other "chemical countermeasures."

Specific Effects on Driving-Related Behaviors and Driving Performance

Much of the great volume of research that has been conducted in this area[2] has simply tended to reconfirm what has already been known for many years (see summary of the findings of prior state-of-knowledge updates, above), for example, that:

- Neuromuscular functioning begins to be impaired at a BAC of .04% or lower, but impairment can be "controled" by some subjects at a BAC as high as .20%.
- Purely sensory aspects of vision (e.g., static visual acuity and peripheral vision) show little or no impairment at BACs lower than about .10%. More complex visual performance (e.g, dynamic visual acuity) is impaired at BACs as low as .08%.
- Impairment of complex tracking performance and divided attention tasks begins to occur at BACs as low as .02%.
- Short-term memory is relatively unaffected even at moderate BACs.
- Performance of activities involving simultaneous bodily functions is degraded more and at a lower BAC than is performance of single functions.
- Some modalities of driving performance as measured in closed-course experiments are degraded at BACs as low as .05%.

However, some light has been shed on the specifics of these effects, (Mitchell, 1985; Moskowitz and Robinson, 1988; Transportation Research Board, 1987) and on some other effects as well. For example, studies in Sweden clearly indicate that the impairing effects of alcohol can be present long after drinking has ceased and the BAC has returned to zero (Laurell and Tournos, 1982). A 20% decrement in driver performance of an accident-avoidance maneuver was found eight hours after a group of drivers had participated in a drinking party and whose BAC had returned to normal. Other studies suggest that fatigue and sleep deprivation are more difficult to cope with for drinking drivers than they are for other drivers (Stein, Allen, and Cook, 1985).

Another issue that has received widespread attention is the *effects of low BACs on behavior.* This interest has no doubt been heightened by the knowledge that many countries have much lower legal limits for BAC than exist in the U.S., for example, Australia and the Scandinavian countries. A recent report has synthesized research in this area (Moskowitz and Robinson, 1988). The authors conclude that performance of tracking and divided attention tasks is degraded at BACs consider-

[2] For a detailed review of this literature, see Moskowitz and Robinson, 1988, and Transportation Research Board, 1987).

ably less than .05%. This is consistent with prior research as reported in the 1978 update. Moskowitz and Robinson also conclude that information processing, perception, and psychomotor skills are impaired at BACs of less than .10%, but generally more than .05%.

Moskowitz and Robinson recommended that the legal limit for BAC be set at .05%, without discussing the issue of amount of impairment and the relationship of a given amount of impairment with driving performance and traffic crashes. This issue is important because a very small decrement in a test score on a pursuit tracking task does not necessarily equate to an increased risk of a crash. Mitchell's review of the literature in 1985 (Mitchell, 1985) noted that while impaired driving performance can be observed starting at BACs of .05% to .06%, the performance decrement is small and does not begin to rise rapidly until a BAC of .10% is reached. Also, issues of research design (e.g., number and kinds of subjects tested under what kinds of conditions) are not discussed.

The issue of *alcohol tolerance* has been addressed in a number of studies. Mitchell (1985) discusses some aspects of this effect addressed in the literature prior to 1985. It has been known for 70 years that an *acute tolerance* effect exists in that performance impairment on some tasks is greater when BAC is rising than when falling (the Mellanby effect). One recent study found that of most of the variability in sensitivity and acute behavioral tolerance to ethanol was related to pre-existing individual variability (that is, unknown factors unique to given individuals) rather than to sex, age, height, weight, or drinking history (Wilson and Plomin, 1985).

Studies since 1943 have confirmed that there is, indeed, a *chronic tolerance* effect as well. Epidemiologic studies (Jones and Joscelyn, 1978) and experimental studies as well support this conclusion. Sensorimotor coordination tasks show the greatest degree of tolerance, but closed-course driving experiments also demonstrate that heavy drinkers are less affected at moderate BACs than are light drinkers.

There is some indication that chronic tolerance can be developed over a much shorter period of time than was thought, as short as a few days for loss of muscular coordination. Recent research also suggests that learning may play an important role in acquiring tolerance to alcohol, that is, that exposure to alcohol alone is not sufficient to induce tolerance; the initial environmental cues must also be repeated. Finally, basic research is showing more and more that tolerance is influenced by various neuronal and hormonal systems that influence the transmission of neural impulses, and that physical dependance as well as tolerance may result from an adaptation of neuronal membranes during chronic alcohol exposure (U.S. Department of Health and Human Services, NIAAA, 1983).

SUMMARY AND CONCLUSIONS

Research in this area has proceeded at a respectable level, but with no "breakthroughs." The validity of breath testing for determining BAC has continued to be strengthened to the point where its principles and technology can no longer be seriously questioned. The great *variability* of alcohol effects is now recognized, but is only beginning to be understood. There is more knowledge now than ever about the *biochemistry of alcohol* and its effects, with at least a glimmer of hope that chemical countermeasures may someday become a possibility. The phenomenon of *alcohol tolerance* is also recognized more and understood better than at the time of prior reviews.

We have found no really new knowledge about the *impairing effects of alcohol at low BACs*. Clearly, performance of the more complex tasks is degraded at low BACs, but the issue of how much impairment among which groups under which conditions remains unresolved.

CHAPTER 4

PEOPLE WHO DRINK AND DRIVE

Chapters 2 and 3 have presented data from recent research confirming that consumption of alcohol degrades driving performance and is a major risk factor in traffic crashes. This chapter examines the characteristics of drivers whose drinking and driving behavior increases crash risk. Epidemiologic data of the type presented in Chapter 2 are examined in more detail to identify any changes in the characteristics of drinking drivers in recent years. These data are augmented by data from surveys and other sources which help to further define the characteristics of drinking drivers.

All of this is preceded by a background discussion of trends in drinking and drinking patterns in the United States.

PRIOR FINDINGS

The 1978 update found a lack of sufficiently detailed controled studies to assess accurately the alcohol-crash risk of most subgroups of drivers. Despite this and other shortcomings of past research, much useful data were found. The report observed that drinking as well as driving had increased in the past 30 years. In particular, the per capita consumption of absolute alcohol had risen some 33% since 1947, with a disproportionate amount being consumed by the 12% of the drinking age population who were heavy drinkers.

The report found that many variables had been examined in an attempt to better understand the attributes of persons who drink and drive. Among the biographical variables examined, a person's *sex* was found to be one of the best differentiators of drinking drivers, with males being significantly overrepresented in all kinds of drinking-driver populations. Possible explanations of this were that males simply drink more or that social customs call for males to do most of the driving at night when most drinking-driving occurs. With respect to *age*, both very young drivers and very old drivers were found to drink and drive less frequently, but the very young drivers had a much greater alcohol-crash risk when they did drive. Studies of a driver's *marital status* revealed that divorced and separated persons seemed to engage in drinking-driving more frequently and to have a higher alcohol-crash risk than persons of other marital statuses. Other biographical variables found to be associated with a higher degree of drinking-driving were *a "lower" occupational status* and *low-income*. However, neither of these two attributes was found to be associated with a higher alcohol-crash risk.

The *time of day* during which driving occurs was found to have one of the strongest relationships with drinking-driving patterns of all of the driving variables studied in the literature. Drinking-driving was described as a primarily nighttime phenomenon, with drinking drivers being found some two to four times as often in nighttime crashes as in daytime crashes. *Day of the week* was also found be a strong differentiator of drinking-driving, with more alcohol-related crashes and more drinking drivers found on the weekend than on weekdays. The *origin of the trip* which involved drinking-driving was most frequently bars or taverns and other persons' homes. The literature indicated that drinking drivers (particularly, persons arrested for DWI) had more crashes and substantially more contacts with traffic law enforcement agencies than did other drivers. DWIs were seldom female, very young, or very old, and were usually from "low status" occupations. Their arrests usually occurred at night and during weekends.

Finally, the 1978 report found that beer is the preferred *type of alcoholic beverage* of drinking drivers by a factor of about two-to-one over other beverages. Beer was favored especially by high-BAC drivers and by drivers reporting that they were heavy drinkers. The *place of drinking* was reported to be their own homes by two-thirds of the drivers responding to one survey, but the higher BACs were found most often among persons drinking at public establishments. *Persons with severe drinking problems* were found to be overrepresented among fatally injured drivers with high BACs and among drivers who were judged responsible for the crashes in which they were killed. The report found evidence that some *personality and stress* variables were associated with drinking-driving, including alienation and hostility, belligerence, and negativism. These latter findings were judged not to be conclusive or amenable to generalizing.

The 1984 update generally concurred with findings of the 1978 report on drinking and drinking patterns, but presented some additional interesting information. The 1984 update reported the finding of one study that about 11% of the population over the age of 18 who are the heaviest drinkers consumed over half of all beverage alcohol sold. It reported that Americans consume about as much alcohol from beer as wine and liquor combined, and that the preference for beer and wine is highest among 25-34 year age group, while the preference for liquor peaks in the 50-54 year age group.

The 1984 update presented data from NHTSA's Fatal Accident Reporting System (FARS) providing additional confirmation that the youngest drivers tend to have the highest risk of an alcohol-related fatal crash, on the order of 4.5 per 100 million vehicle miles travelled for teen-age drivers, compared to about 1.5 for drivers aged 25-44. Younger drivers were found to be on the road more often during late nighttime hours and on weekends than were older drivers.

The 1984 update presented a very useful table summarizing the correlates of alcohol-crash involvement *circa* 1985. This table is shown below:

Table 4-1: Correlates of alcohol-crash involvement, *circa* 1985

Driver Characteristics	Low Involvement	Higher Involvement
Sex	Female	Male
Age	Teenagers	20 to 40 years
Prior Arrests	None	One or more
Drinking	Low quantity, frequency	High quantity, frequency
Drinking history	Social drinker	Problem drinker
Type of Beverage	--	Beer
Marital status	Married	Widowed, divorced, separated
Occupational level	High	Low
Race	White	Non-white
Income	High	Low
Education	More	Less
Miles driven	High annual mileage	Low annual mileage
Trip origin	--	Bar, tavern
Place of drinking	Home	Public drinking place
Previous crashes	None	One or more
License status	Valid	Suspended or revoked
Crash Characteristics		
Type of accident	Multiple	Single
Time of accident	Day	Night
Day of week	Weekday	Weekend

Source: U.S. Department of Transportation, NHTSA, 1985

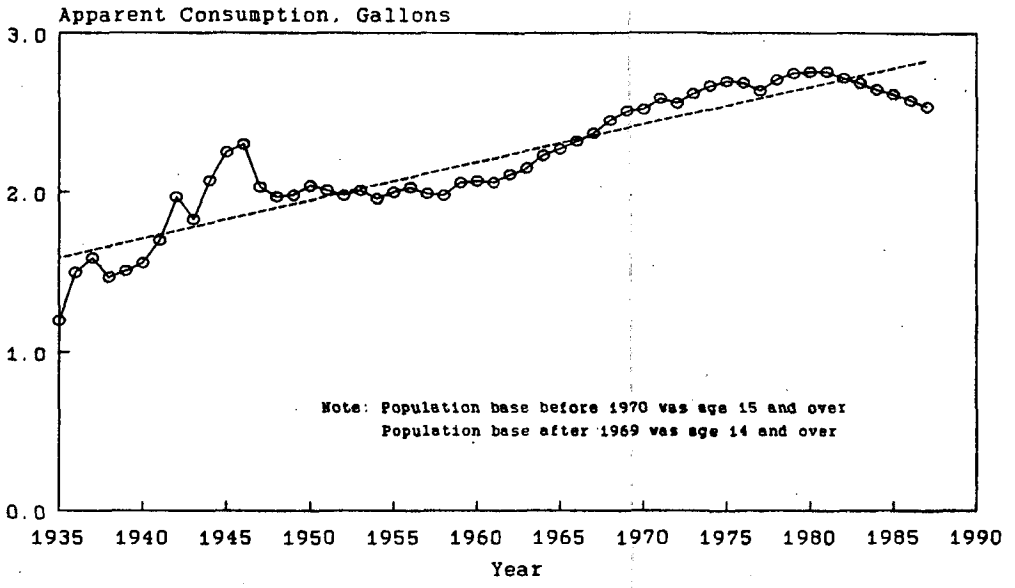
DRINKING AND DRINKING PATTERNS

Apparent Consumption

Brooks *et al.* (1989) have compiled data on the apparent consumption[1] of ethanol in the U.S. since 1850. Their data show a general trend upward since 1935 (Figure 4-1). The data for the past 25 years show some systematic fluctuations with some indications of a period of about five years. The points for the last few years indicate the beginning of a decline. However, this recent decline appears to be due primarily to a decline in the consumption of spirits: the consumption of wine and beer has exhibited little change (Figure 4-2).

Data from Canada also show a long-term trend in overall per capita consumption of ethanol (Figure 4-3). However, the Canadian trend differs from the U.S. trend in that it levels off after 1974. Mann and Anglin (1988) examined the Canadian data in relation to alcohol-related crashes. As indicators of such crashes, they used fatal crashes in which alcohol-involvement was reported, single-vehicle

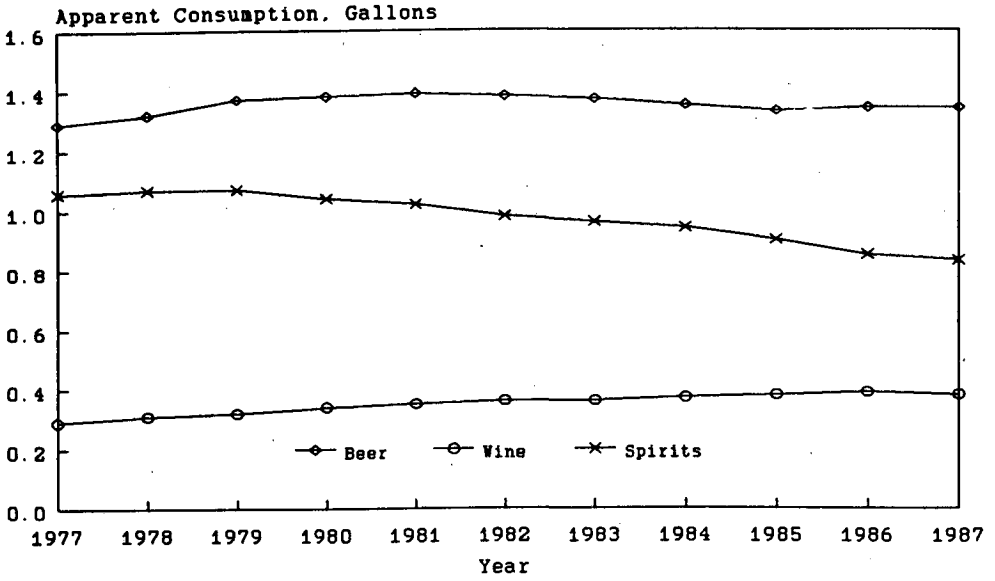
Figure 4-1: Per capita consumption of ethanol in the U.S., 1935-1987



Source: Brooks, et al., 1989

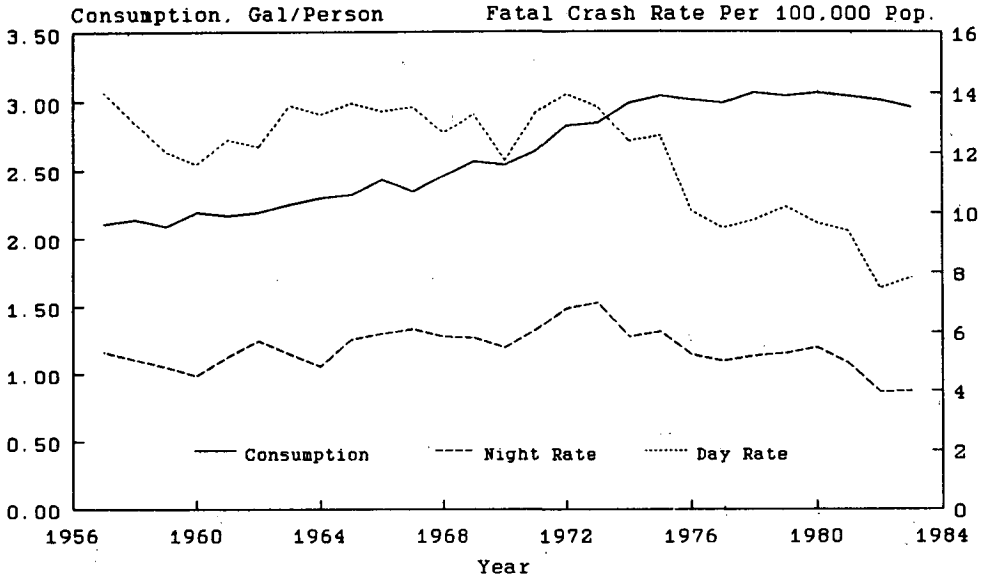
[1] The term "apparent consumption" is used in the literature to indicate gallons of absolute ethanol consumed per person of drinking age. Drinking age is usually assumed by researchers to be less than the minimum legal drinking age. The study by Brooks and associates used a drinking age of 15 for the years prior to 1970, and a drinking age of 14 for 1970 through 1987.

Figure 4-2: Per capita consumption of ethanol in the U.S. by type of beverage, 1977-1987



Source: Brooks, et al., 1989

Figure 4-3: Per capita consumption of ethanol and fatal crash rate, Ontario, Canada, 1957-1983



Source: Mann and Anglin, 1988

fatal crashes, and nighttime fatal crashes, all taken at rates per 100,000 population. Only the crash rate based on reported alcohol involvement showed a direct correlation with per capita consumption: the other two more objective rates showed a significant correlation with per capita alcohol consumption only when rates for complementary crashes (multi-vehicle fatals and daytime fatals) were included in the analysis. These correlations are noteworthy, because such correlations have never consistently been found in past studies.

However, Joksch (1989) showed that the significant coefficients of alcohol consumption were not necessarily due to an effect of alcohol but equally likely to a simple time trend, or to other factors having simple time trends. His analysis indicates that the findings of Mann and Anglin cannot be used to support the otherwise plausible hypothesis that crashes involving alcohol are related to per capita alcohol consumption.

Walsh (1987) presents data on per capita consumption of alcohol in Ireland from 1951 through 1984. The data show an increasing trend from 1952 through 1974, and a decline from 1979 on. He includes this variable with a time trend and certain intervention variables in several regression models with traffic death rates per registered vehicle as the dependent variable. As expected, the models show significant coefficients for per capita consumption. However, despite a very high correlation coefficient ($r^2 = .93$), the models do not fit the data satisfactorily; the residuals exhibit strong non-random patterns (unpublished analysis by Mid-America staff).

We have seen no comparable studies of alcohol consumption and crashes in the U.S., but there has been a reduction in the percentage of alcohol-related driver fatalities during a time when apparent consumption of alcohol was decreasing beginning in 1981. However, it is not clear whether this latest decrease is a long-term effort, or part of a short-term fluctuation, or has occurred before. Thus, the relationship between per capita consumption of alcohol and alcohol-related crashes in the U.S. remains unknown.

Drinking Patterns

Hilton (1988) has examined data from surveys of self-reported drinking practices in the U.S. over the past 20 years to see how the *distribution* in consumption among various subgroups might have changed. The subgroups were defined according to frequency and quantity of drinking, and by age and sex, among other factors. He found that most of the changes among these groups were not statistically significant. Generally, drinking patterns were fairly stable over time, with a few exceptions. The data suggested an increase in heavy and moderate drinking among men in 1984 compared both to 1964 and 1979 and a decline in occasional drinking (Figure 4-4). There was also an increase of heavy drinking among women, for these

periods, but the increase occurred over fewer measures than for men (Figure 4-5). Nevertheless, the *percentage* increase in frequency of heavier drinking from 1979 to 1984 was quite large for both men and women (Figure 4-6). Hilton also found a significant time trend (increasing) in heavy drinking for men and women of age 21-34 years.

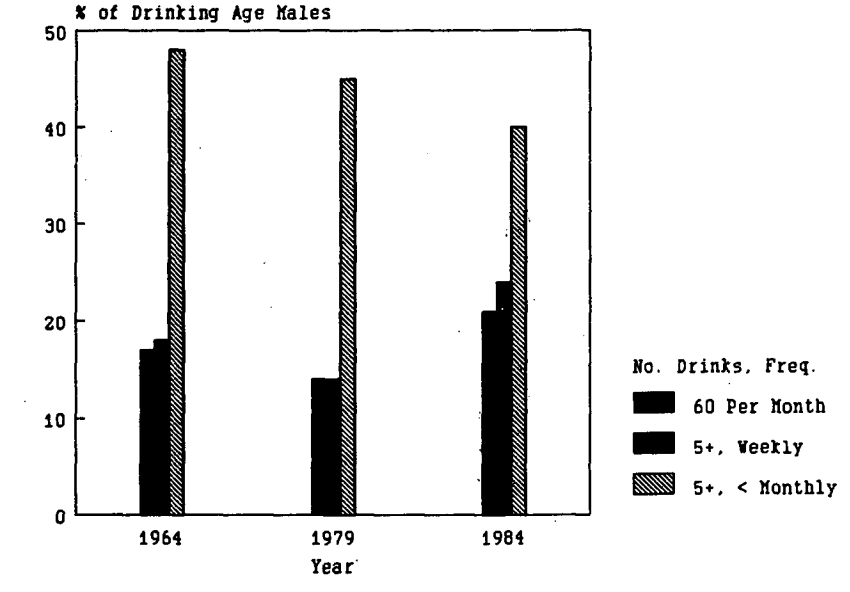
Johnston, *et al.* (1989) have recently published their update of data from The University of Michigan's ongoing *Monitoring the Future* study of the drug usage practices (including alcohol) of graduating high school seniors in the U.S. All measures of drinking for this group increase to a maximum between 1979 and 1981 and decline gradually through 1986. Note that this pattern includes measures of heavy drinking as well as light drinking (for example, see Figure 4-7). The authors do not indicate whether this decline is a significant trend or a random effect.

CHARACTERISTICS OF DRINKING DRIVERS

Biographical Variables

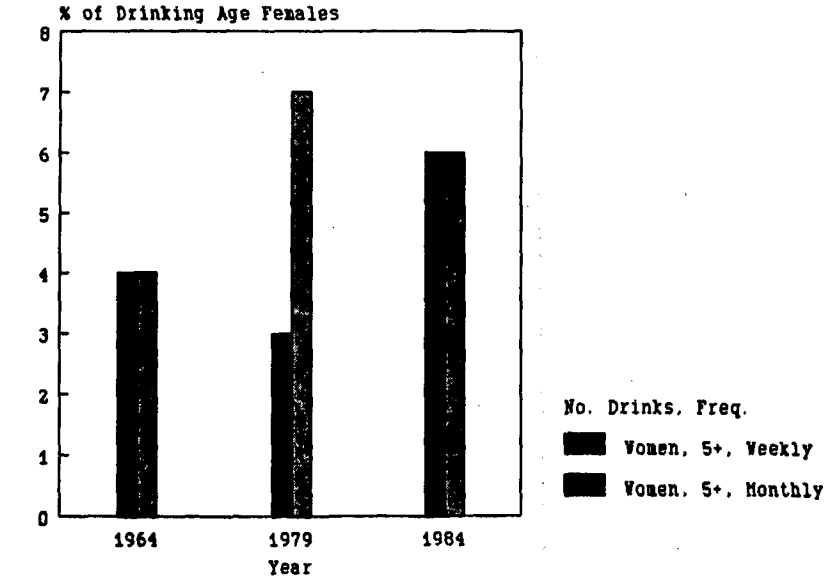
Sex. A first examination of fatal crash data from FARS reveals little or no changes in alcohol-crash involvement of female drivers compared to that of male drivers in the period 1982-1987: only 12% to 13% of all fatally injured drivers with a BAC of .10% or more were female (Figure 4-8). However, a closer look at fatal crash *rates* reveals a slightly lower decrease in the alcohol-crash rates for female

Figure 4-4: Changes in male drinking patterns, 1964-1984



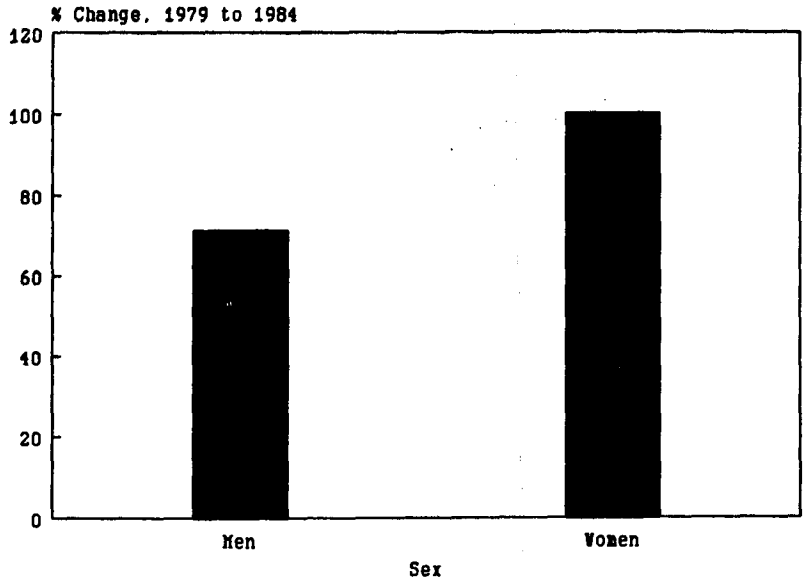
Source: Hilton, 1988

Figure 4-5: Changes in female drinking patterns, 1964-1984



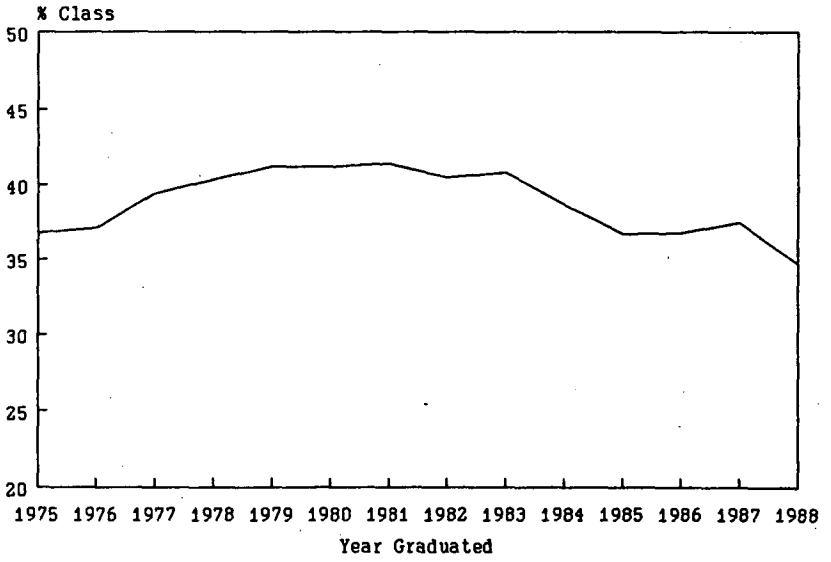
Source: Hilton, 1988

Figure 4-6: Percentage change in percentage of men and women drinking at least five drinks weekly, 1979-1984



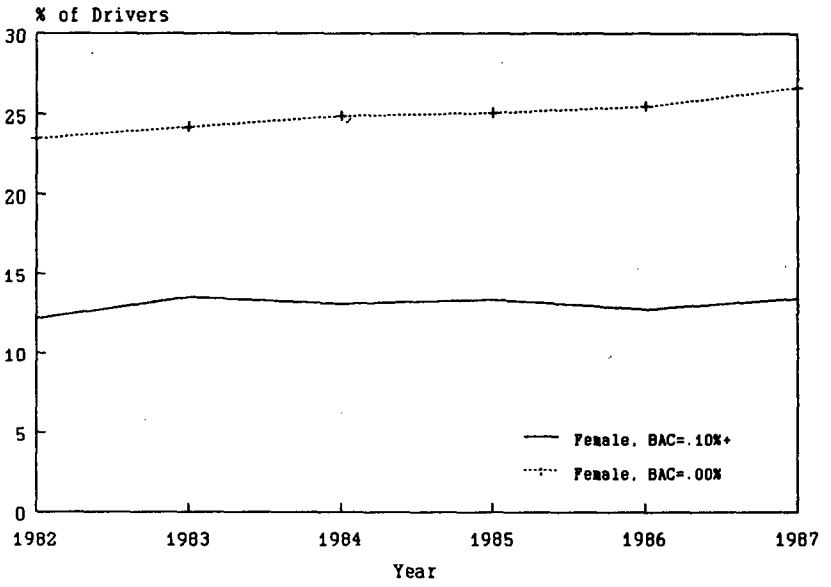
Source: Hilton, 1988

Figure 4-7: Percentage of High School graduating class who drank 5 or more drinks in a row during the past two weeks



Source: Johnston, O'Malley, and Bachman, 1989

Figure 4-8: Percentage of female drivers in fatal crashes, 1982-1987

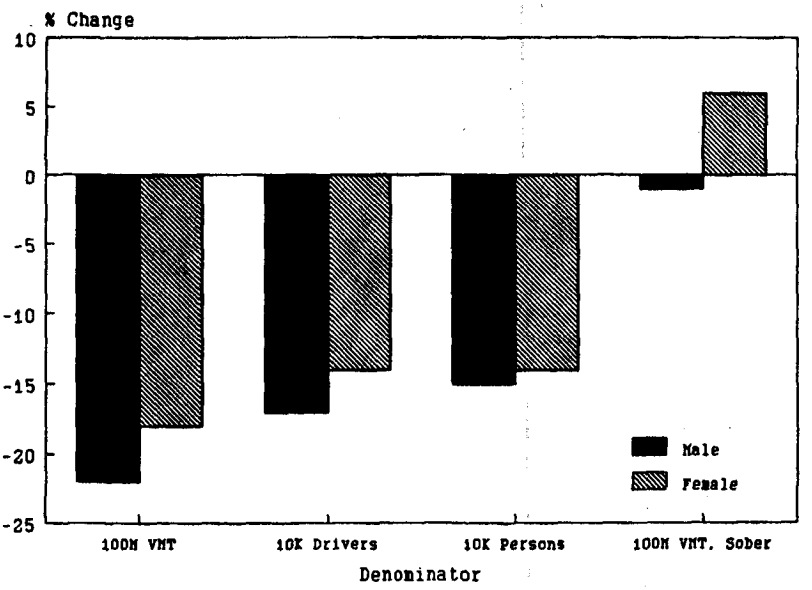


Source: U.S. DOT, 1988b

drivers in the 1982-1985 period (Fell, 1987) (Figure 4-9). (Note that the last category in the figure refers to the crash rate of "sober" drivers, that is, drivers with a BAC of zero.) Moreover, three out of four fatal alcohol-crash rates of age 21-24 female drivers *increased* while the rates of male drivers of the same age decreased (Figure 4-10). Popkin and Associates (1988) reported a decrease in male alcohol-crash rate per 100,000 vehicle miles traveled in North Carolina over the period 1979-1984, and essentially no change in the female alcohol-crash rate over the same period (Figure 4-11).

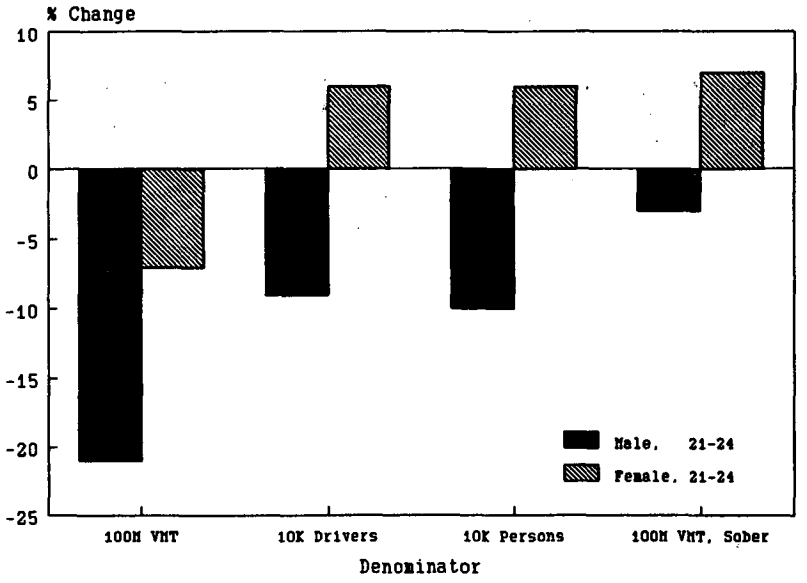
The FARS data cited in the prior paragraph only covered a four-year period (1982-1985), not sufficient for studying longer-term trends. Unfortunately, BAC test data of fatally injured drivers become less useful for years much earlier than 1980, principally because many states did not perform BAC tests on a large enough percentage of such drivers. To overcome this problem, alcohol-crash epidemiologists have often used nighttime single-vehicle fatal crashes as a surrogate for crashes involving drivers with a high BAC. This is because a very large percentage of drivers in nighttime single-vehicle fatal crashes have been found to have a BAC in

Figure 4-9: Percentage change in fatal alcohol-crash involvement rate of male and female drivers, 1982-1985



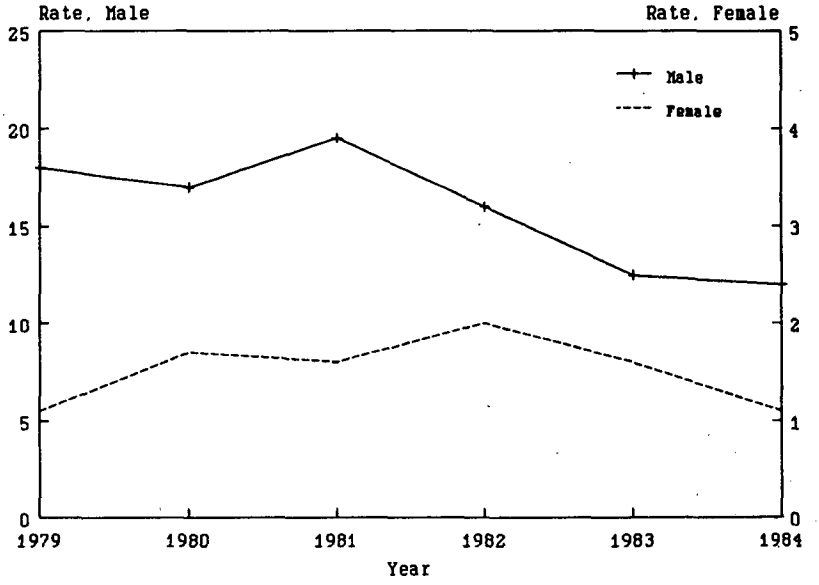
Source: Fell, 1987

Figure 4-10: Percentage change in fatal alcohol-crash involvement rate of age 21-24 male and female drivers, 1985-1987



Source: Fell, 1987

Figure 4-11: Fatality rate per 100,000 miles of male and female drivers with BAC>.09%, North Carolina, 1979-1984

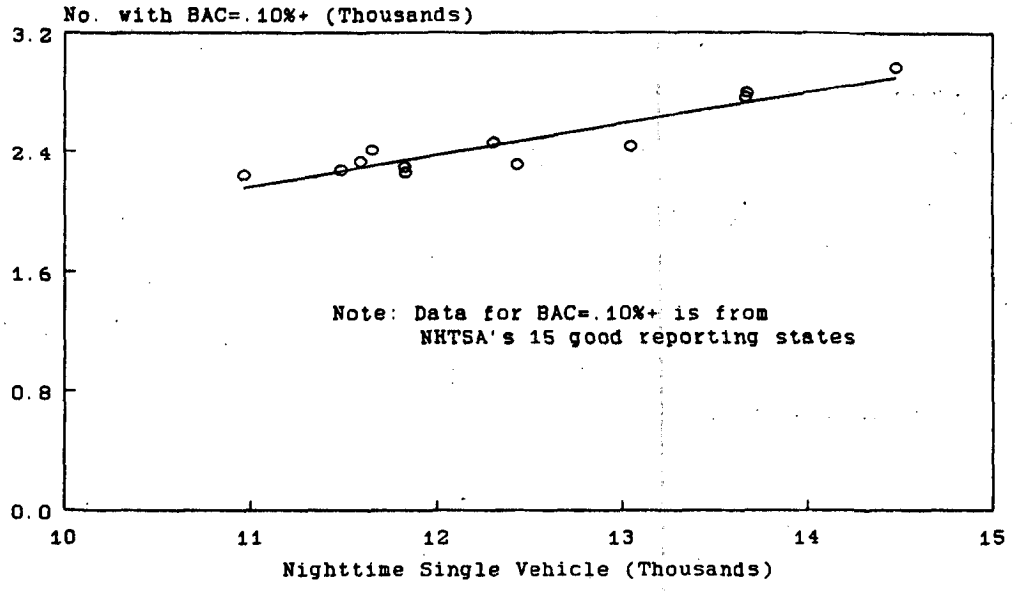


Source: Popkin, et al., 1988

excess of .10%[2]. Indeed, an examination of nighttime single-vehicle fatal crashes nationwide and BAC data from the 15 "good reporting" states (using the University of Michigan's Automated Data Access and Analysis System or ADAAS) shows a high correlation between these two measures, both in absolute and relative terms (Figure 4-12 and Figure 4-13).

Figure 4-14 plots the percentage of female drivers in nighttime single-vehicle fatal crashes from 1977 through 1988. Note that, consistent with data based on BAC, there is little change in this percentage for the *year* 1985 compared with the year 1982. However, there is a clear trend over the entire 1977-1988 period. *The percentage of female drivers in nighttime single-vehicle fatal crashes increases steadily over the period at an average rate of about 0.3 % per year.* In 1988, about 16% of drivers in nighttime single-vehicle fatal crashes were female, compared with 12% in 1977, a relative increase of 33%. However, this increase is not necessarily due to more drinking-driving by females. It could also be due to more nighttime driving by females.

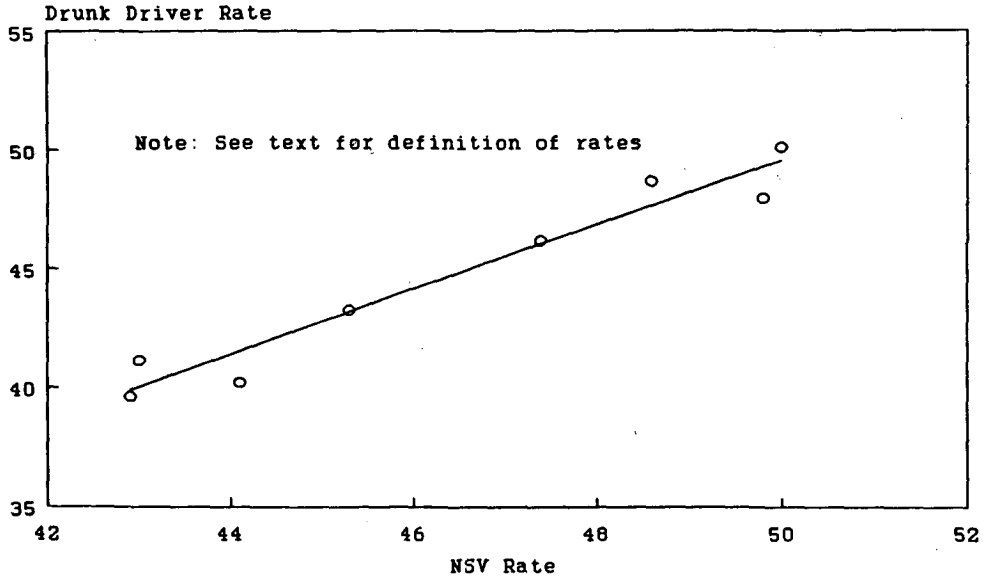
Figure 4-12: Driver fatalities in nighttime single-vehicle crashes vs. driver fatalities with BAC = .10%



Source: FARS (ADAAS)

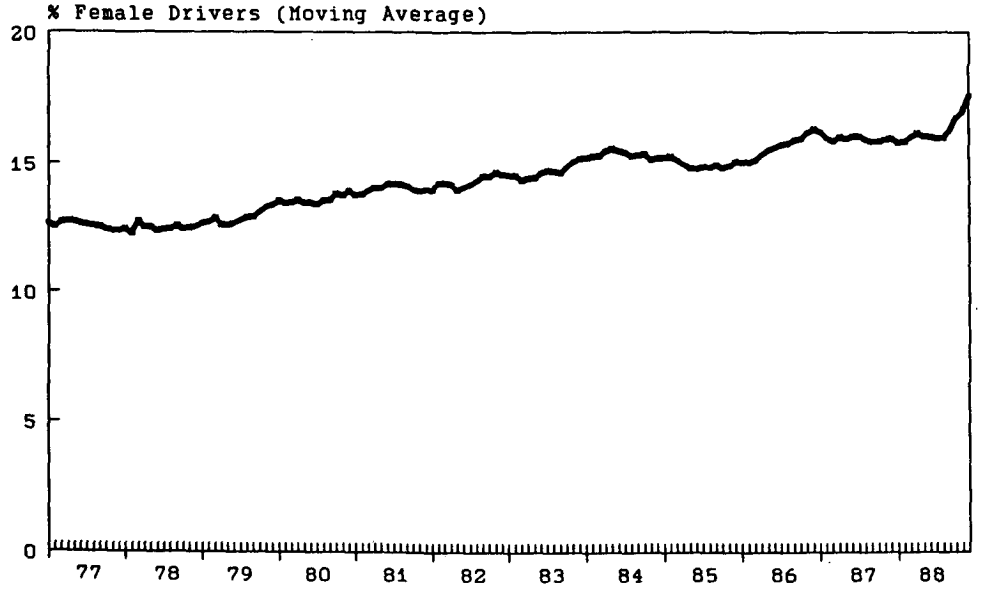
[2] See, for example, the prior state of knowledge updates. Although it is reasonable to use nighttime single-vehicle fatal crashes as a surrogate for fatally injured drivers with a high BAC, its use is not without some risk. We have found no study showing that the number of fatally injured drivers with a given BAC is a constant percentage of the number of nighttime single-vehicle fatal crashes over time.

Figure 4-13: Nighttime single-vehicle driver fatality rate vs. drunk driver fatality rate



Source: FARS (ADAAS)

Figure 4-14: Percentage of female drivers in nighttime single-vehicle fatal crashes 1977-1988



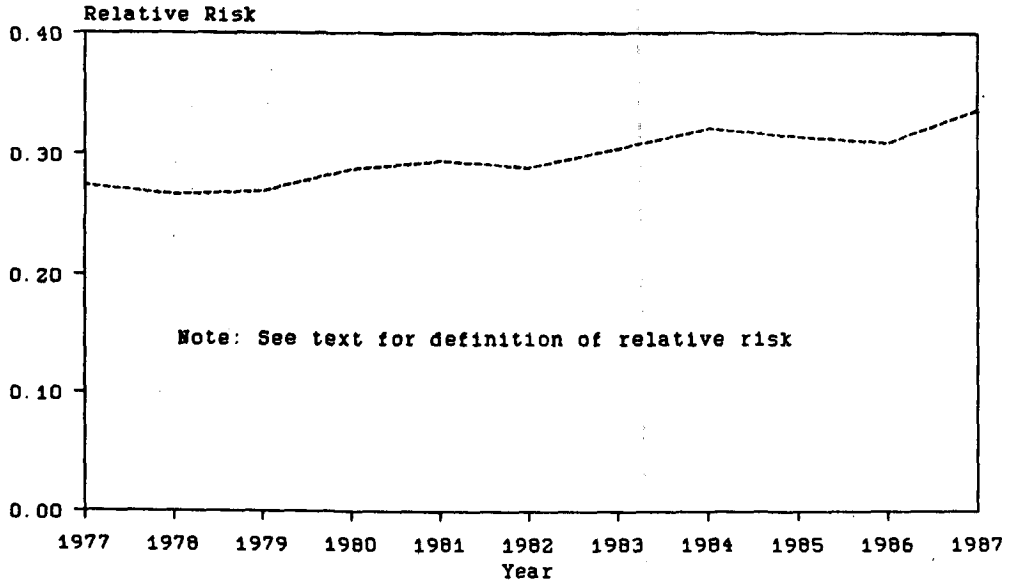
Source: FARS (ADAAS)

The *risk per licensed driver* of female drivers of a nighttime single-vehicle fatal crash relative to that of all drivers is shown in Figure 4-15. Again, an upward trend is apparent, from .274 in 1977 to .337 in 1987, an increase of 23% over the 11-year period.

We have no trend data on the proportion of female alcohol-impaired drivers using the road at all hours of the day and all days of the week. However, the national roadside surveys conducted in 1973 and 1986 (Lund and Wolfe, 1989) found that the percentage of alcohol-impaired female drivers using the roads during nighttime weekend hours decreased 57% (from 3.0% to 1.3%) between 1973 and 1986 (Figure 4-16 and Figure 4-17). By contrast, the percentage of their male counterparts decreased only 29%. Further, Lund and Wolfe report a larger percentage of female drivers using the roads in 1986 than in 1973 and state that "this disproportionate reduction in alcohol-related driving by females coupled with the substantial increase in the proportion of female drivers on the road at these hours was a very large factor in the overall reduction of alcohol-impaired driving" (page 15).

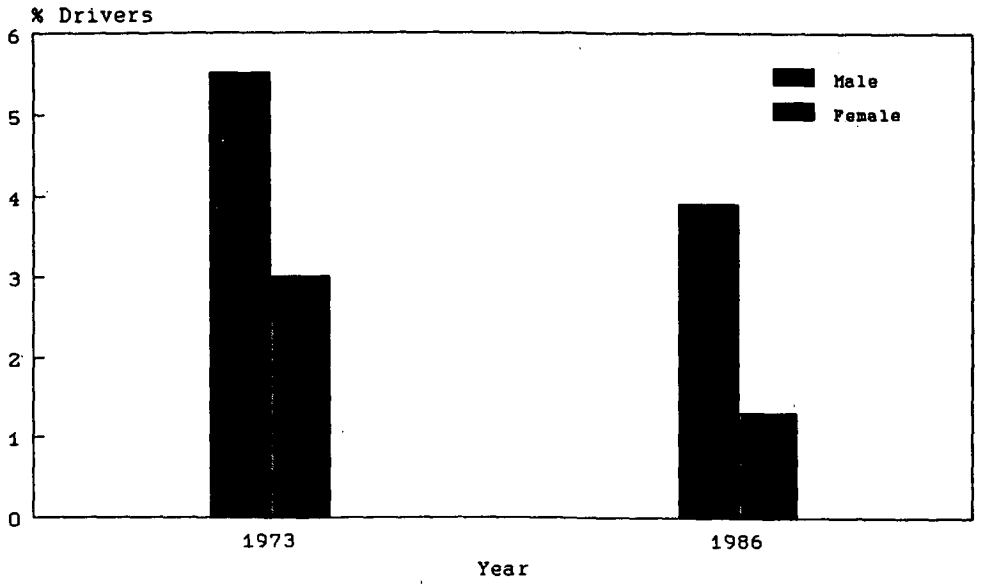
In fact, the roadside survey in the Lund and Wolfe report shows very clearly that the greater number of female drivers on the road during nighttime weekend hours is being counterbalanced by the lessened proclivity of female drivers to drive

Figure 4-15: Relative risk of a nighttime single-vehicle fatal crash, female drivers, 1979-1987



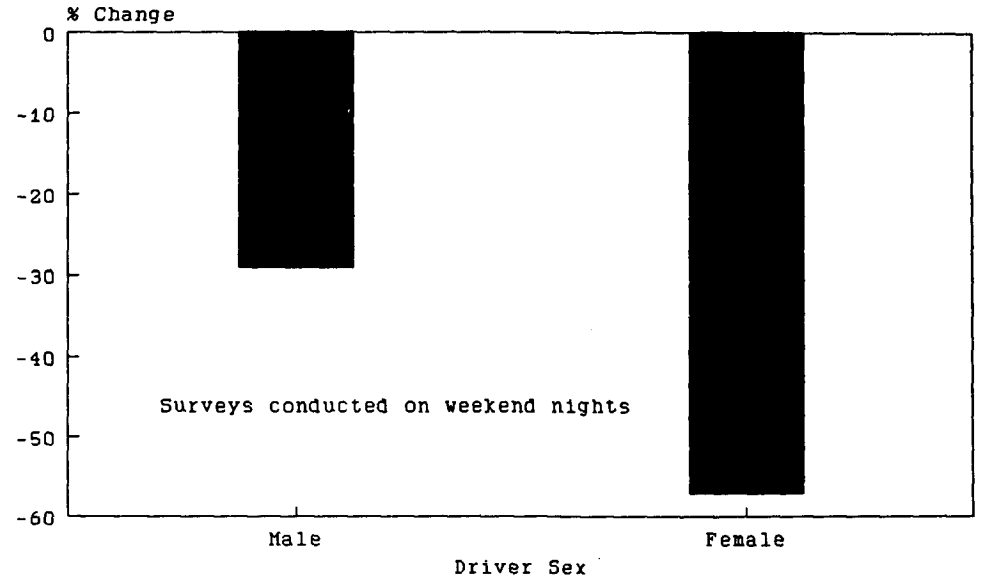
Source: FARS (ADAAS)

Figure 4-16: Non-accident involved male and female drivers with BAC = .10%+, 1973 and 1986, nighttime, weekend



Source: Lund and Wolfe, 1989

Figure 4-17: Percentage change in percentage of non-accident involved drivers with BAC = .10%+ by sex, 1973 to 1986

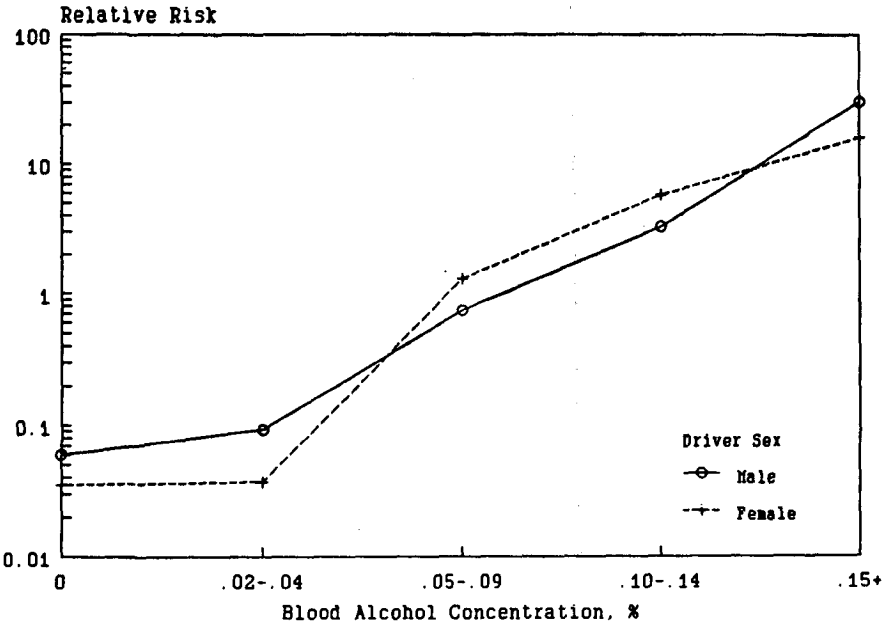


Source: Lund and Wolfe, 1989

with an illegally high BAC. Thus, the percentage of .10%+ drivers who were female was 9.9% both in 1986 and 1973, and females still had the same "share" of the drinking-driving problem by this measure. We also have no data on trends in relative risk of males and females. Earlier studies have shown that the relative crash-risk of female drivers at moderate BACs is several times that of male drivers at the same BACs (Jones and Joscelyn, 1978). Recent work (Zador, 1989) has shown that the relative risk of a *driver fatality in a single-vehicle crash* is about half that for males in both the lowest and the highest range of BACs (BAC < .05% and BAC > .15%). (See Figure 4-18.) In the middle range of BACs (.05% $\leq$ BAC $\leq$ 0.14%), however, female risk was found to be about twice as high as male risk. There is no obvious explanation for this complex pattern, but it indicates that it is not inconsistent to have a greater decrease in the percentage of alcohol-impaired female drivers using the road than in the percentage of alcohol-impaired female drivers in fatal crashes.

Nevertheless, the reasons for the relatively smaller decrease in the alcohol-crash rates of female drivers compared with those of male drivers are not entirely clear. Possible reasons may include different consumption patterns and different

Figure 4-18: Relative risk of a driver fatality in a single-vehicle crash by driver sex and BAC

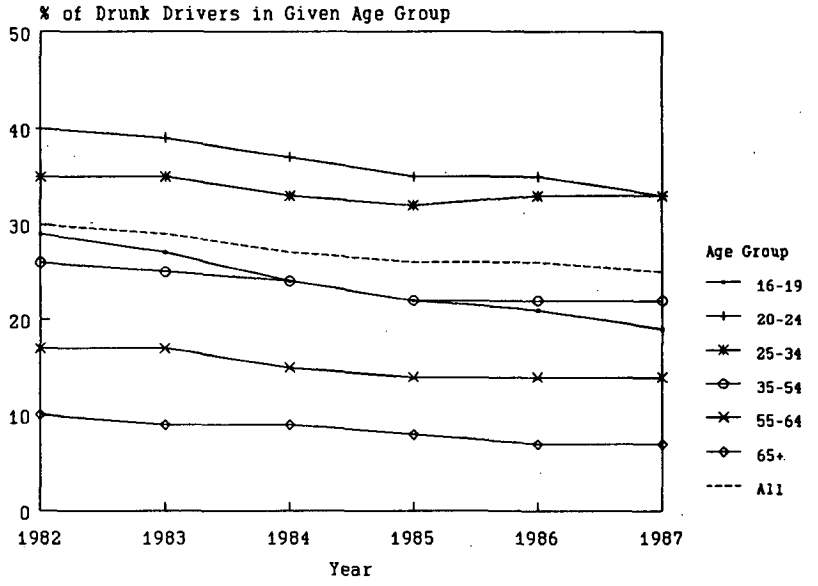


Source: Zador, 1989

driving patterns for the two groups, as well as age effects and lifestyle factors with differential effects on impaired driving. One interesting hypothesis is that the group of female drivers using the roads in the mid-1980s had a different alcohol-crash *risk* relative to males than did the group of female drivers using the road in the mid-1970s.

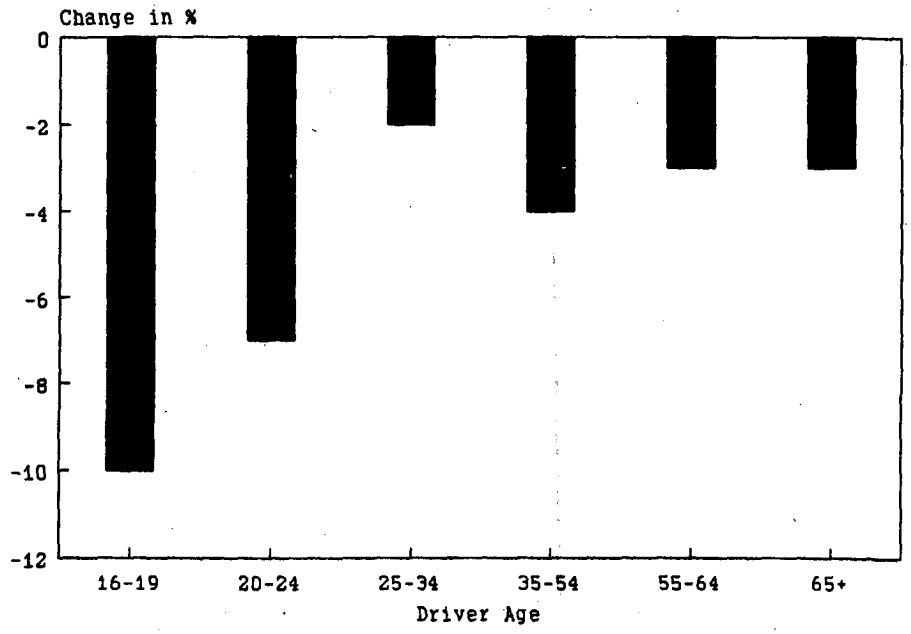
Age. Figure 4-19 shows the percentage of alcohol-impaired drivers in fatal crashes by driver age for the 1982-1987 period. This percentage has declined for all age groups during this period, with the largest decreases in the two youngest age groups (Figure 4-20). However the largest *percentage* declines have been in the youngest age group and the oldest age group (Figure 4-21). (Note that the distribution of percentage decrease by age follows a U-shaped curve.) The decreases have been rather consistent over time (Figure 4-22 and Figure 4-23). Data on nighttime single-vehicle fatal crashes suggest that drivers under 25 years of age still represent a significantly smaller proportion of the alcohol-crash problem than they did 10 years ago (Figure 4-24). By contrast, drivers in the 25-34 age group account for a significantly larger proportion of the problem than they did 10 years ago (Figure 4-25). Finally, drivers in the oldest age group have a larger (but still small compared to the younger age groups) share of the alcohol-crash problem (Figure 4-26). Of course, these conclusions are only applicable to the extent that nighttime single-vehicle fatal crashes are a valid and stable surrogate of alcohol-related crashes, as Figure 4-12 and Figure 4-13 suggest they are.

Figure 4-19: Percentage of drivers in fatal crashes with BAC = .10%+ by age, 1982-1987



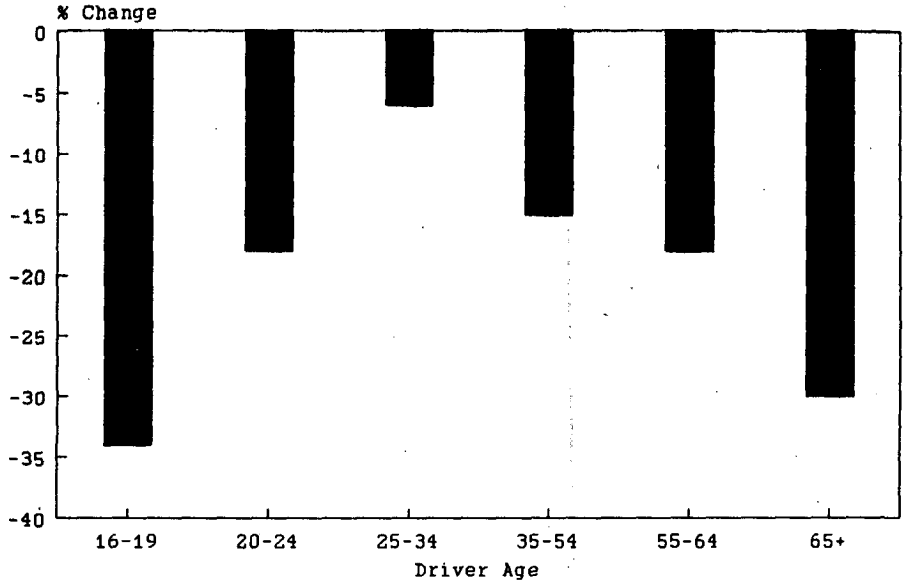
Source: U.S. DOT, 1988b

Figure 4-20: Change in percentage of drivers with BAC = .10%+ in fatal crashes by age 1982-1987



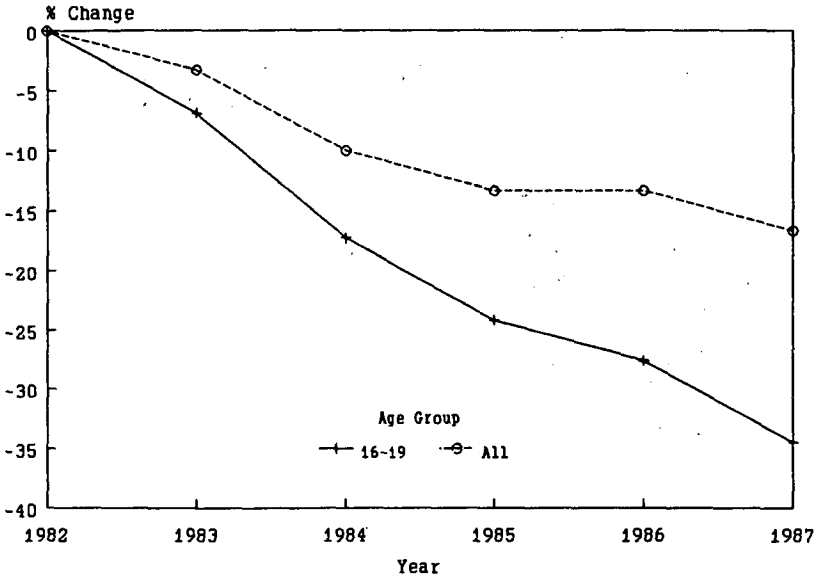
Source: U.S. DOT, 1988b

Figure 4-21: Percentage change in percentage of drivers with BAC = .10%+ in fatal crashes by age, 1982-1987



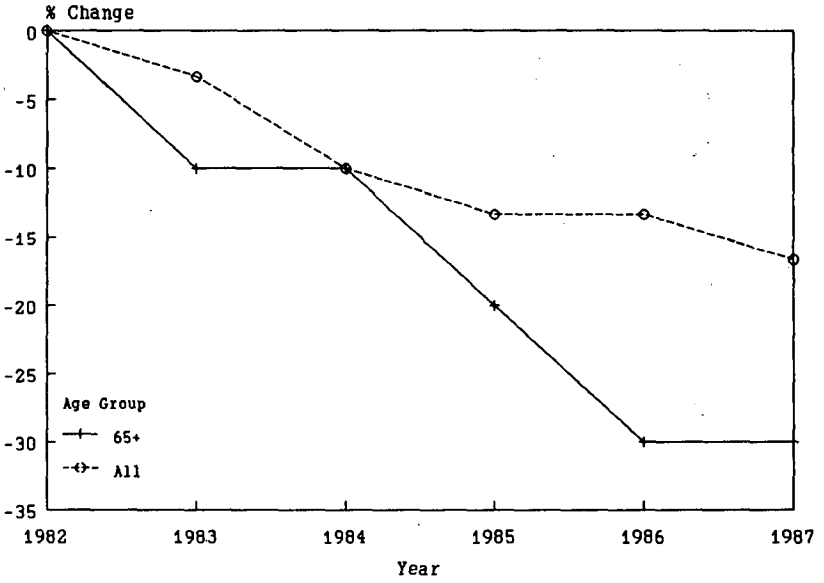
Source: U.S. DOT, 1988b

Figure 4-22: Percentage change in percentage drivers age 16-19 with BAC = .10%+ in fatal crashes by year, 1982-1987



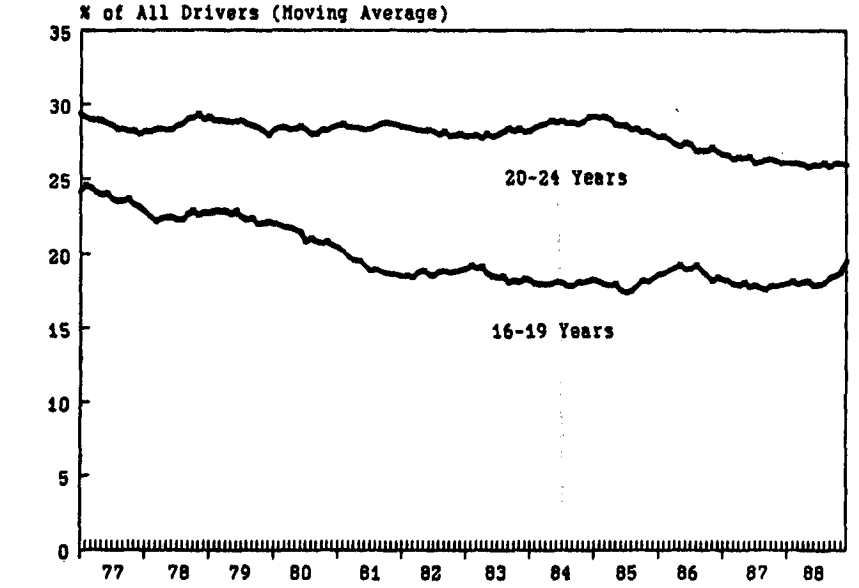
Source: U.S. DOT, 1988b

Figure 4-23: Percentage change in percentage drivers age 65+ with BAC = .10% in fatal crashes by year, 1982-1987



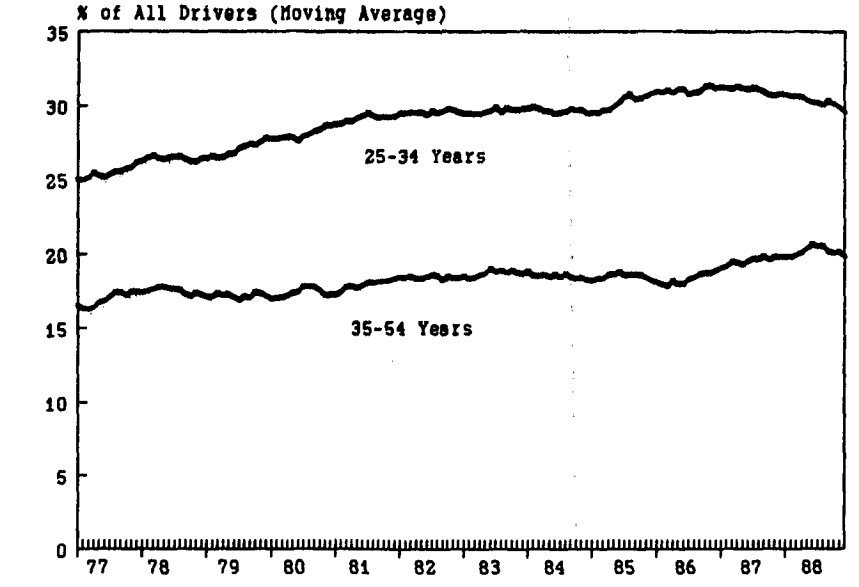
Source: U.S. DOT, 1988b

Figure 4-24: Percentage of young drivers in nighttime single-vehicle fatal crashes 1977-1988



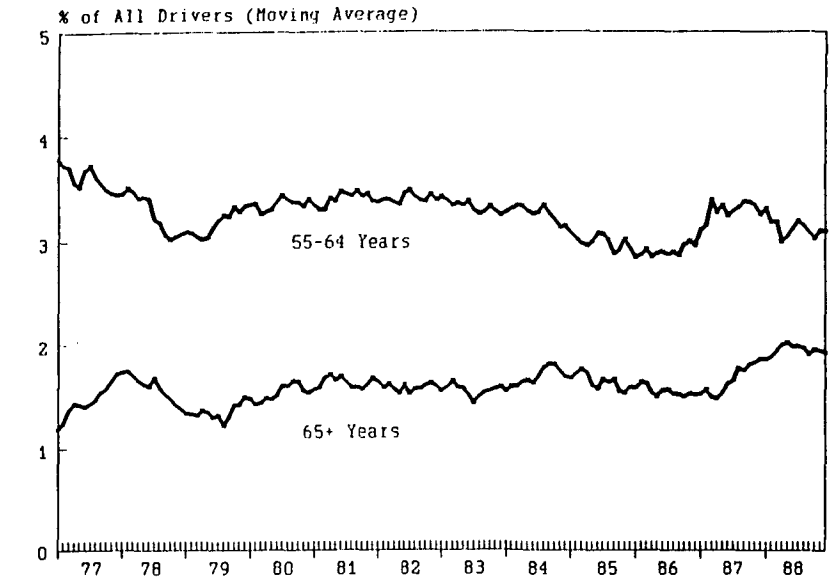
Source: FARS (ADAAS)

Figure 4-25: Percentage of mid-age drivers in nighttime single-vehicle fatal crashes, 1977-1988



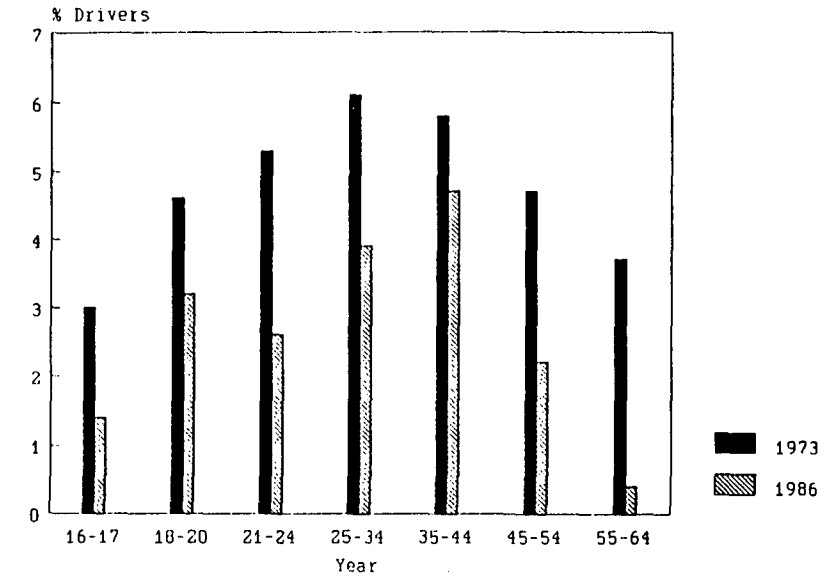
Source: FARS (ADAAS)

Figure 4-26: Percentage of older drivers in nighttime single-vehicle fatal crashes, 1977-1988



Source: FARS (ADAAS)

Figure 4-27: Non-accident involved drivers of various ages with BAC = .10%+, nighttime, weekend, 1973 and 1986



Source. Lund and Wolfe, 1989

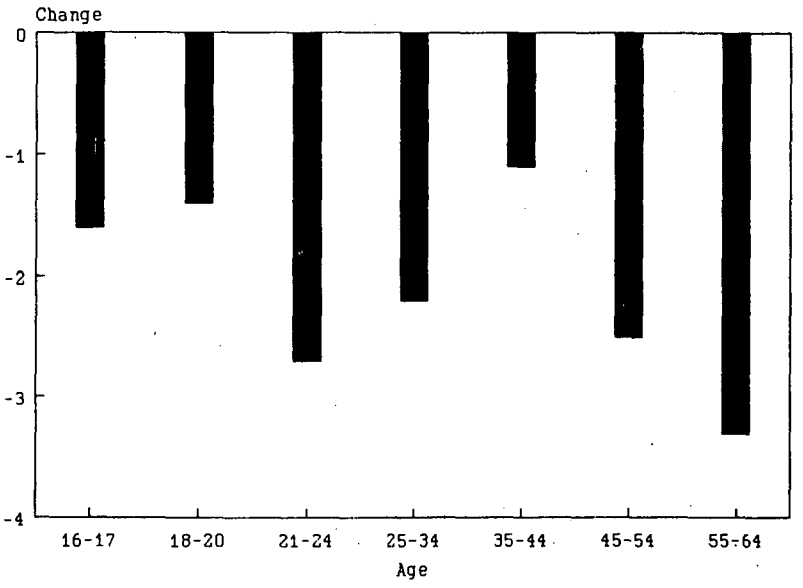
As noted above, there has been a decline in the *percentage of alcohol-impaired drivers on the road during nighttime weekend hours* in the 1973-1986 period (Lund and Wolfe, 1989) and this decline has also occurred for all age groups (Figure 4-27). (The 65+ age group has been omitted because of small sample size, i.e., less than 100.) However, the age distribution of the decline is different from the age distribution of the decline in alcohol-involved fatal crashes (Figure 4-28). There is no clear relation between reduction and age. Furthermore, there is no longer any sign of a U-shaped curve for the distribution of percentage decline (Figure 4-29). The distribution has no apparent regularity. Thus, we cannot say whether either the declines or percentage declines show an age effect. About all we can say is that the age distributions of percentage of alcohol-impaired drivers on the road during nighttime weekend hours were roughly similar in 1973 and 1986, peaking in the 25-44 years range.

Again, we have no reliable data on trends in alcohol-crash risk factors by age. Prior state-of-knowledge updates showed that the crash risk of very young drivers is much higher after drinking than it is for other drivers. Mayhew and Simpson (1985) present additional confirmation of this in a series of relative-risk curves developed from combining Canadian roadside survey data with Canadian data on fatal crashes. Further, these data reveal that relative risk varies very strongly with age for young drivers - the relative risk of drivers age 16 to 19 at a BAC of .10% is several times that of drivers of age 20 to 24. Most important, these youngest drivers have a high relative risk even at low BACs. The relative risk of the 16-19 age group at a BAC of .05% was the same as the relative risk of the 55+ age group at a BAC of .10%. As with the study by Zador (1989) in the U.S. (see Chapter 2), the crash-involved and the non-crash involved populations were not matched across all pertinent variables in this Canadian study.

Zador (1989) also studied the influence of the interaction of age and BAC on the rate of driver death in single-vehicle crashes. Though the overall interaction was not significant, there were some significant terms. Furthermore, the interaction became significant when multi-vehicle crashes were included in the analysis. The interaction pattern was not simple for drivers of 21-24 years: the risk increased more rapidly with BAC than for older drivers, but reached the same level for very high BAC values (Figure 4-30). For drivers under 21, the rate increased initially more rapidly, but the increase remained below the values for the older drivers at the higher BAC values. Whether such subtle differences are real is an open question, considering the low case numbers in some of the driver classes.

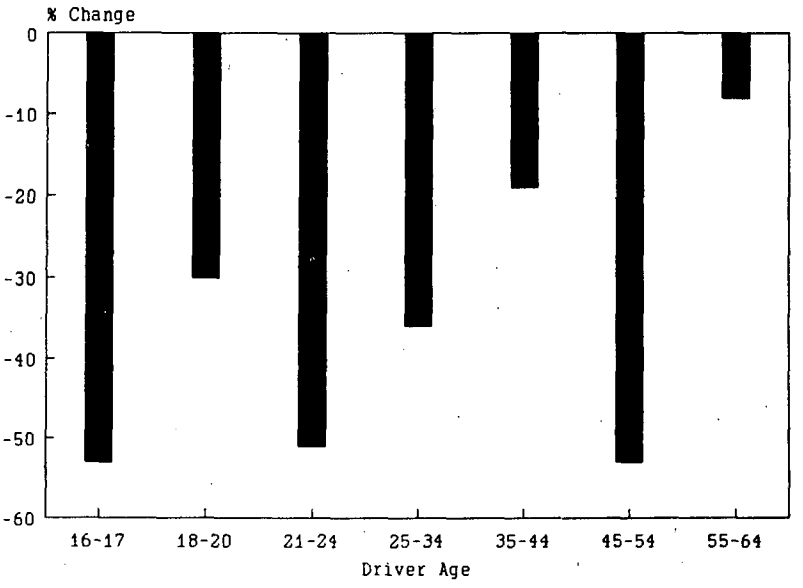
Other Biographical Variables. The 1978 state-of-knowledge update presented data on the biographical variables for crash-involved drivers, drivers using the roads but not involved in crashes, and alcohol-crash risk factors. Biographical variables addressed included marital status, occupational level and race, education, annual income, religion, and place of residence. Unfortunately, there have been no

Figure 4-28: Change in percentage of non-accident involved drivers with BAC = .10%+ by age, nighttime, weekend, 1973-1986



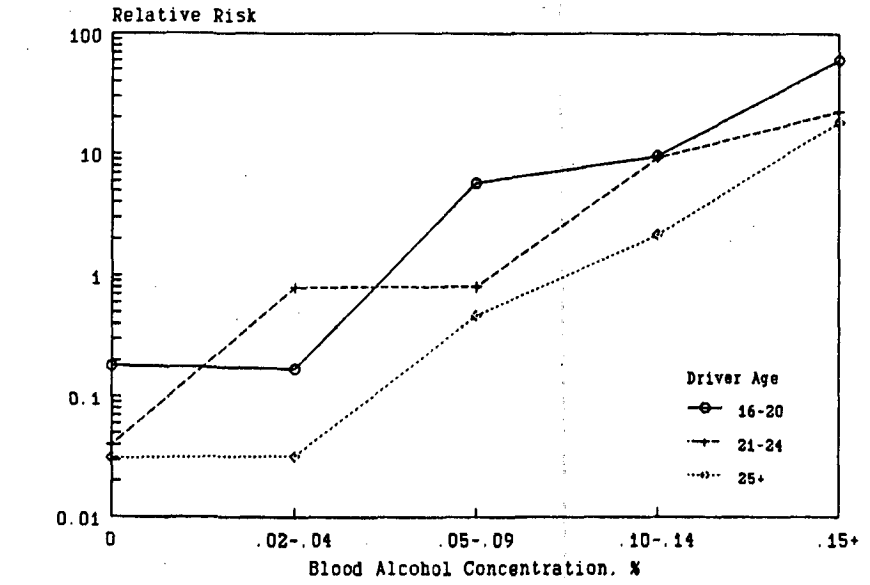
Source: Lund and Volfe, 1989

Figure 4-29: Percentage change in percentage non-crash involved drivers with BAC = .10%+ by age, nighttime, weekend, 1973 to 1986



Source: Lund and Volfe, 1989

Figure 4-30: Relative risk of a driver fatality in a single-vehicle fatal crash by driver age and BAC



Source: Zador, 1989

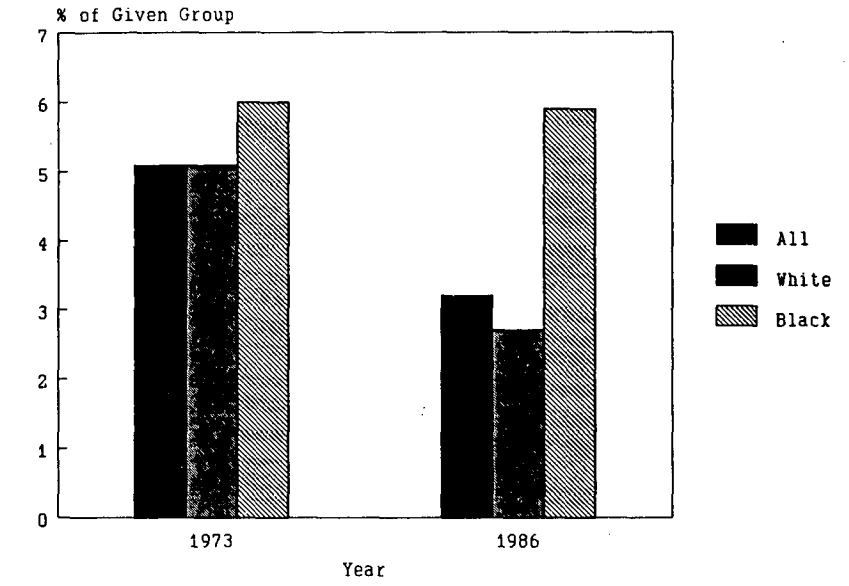
comparable studies since then for analyzing any *trends* for these variables in relation to alcohol-crash incidence and risk factors. However, there are some directly comparable data from the two national roadside surveys for non-crash involved drivers. These data are summarized in Figure 4-31 through Figure 4-33 which depict the percentages of various groups having a BAC of .10% or more. They suggest that:

- The percentage of white drivers with a BAC of .10%+ is about half what it was in 1973, but the percentage of black drivers at these BACs has remained essentially unchanged.

- The percentages of employed persons, retired persons, and students with a BAC of .10%+ are down in roughly the same proportion as the percentage of drivers as a whole having such a BAC. However, the percentage of unemployed persons with a BAC of .10%+ remained about the same.

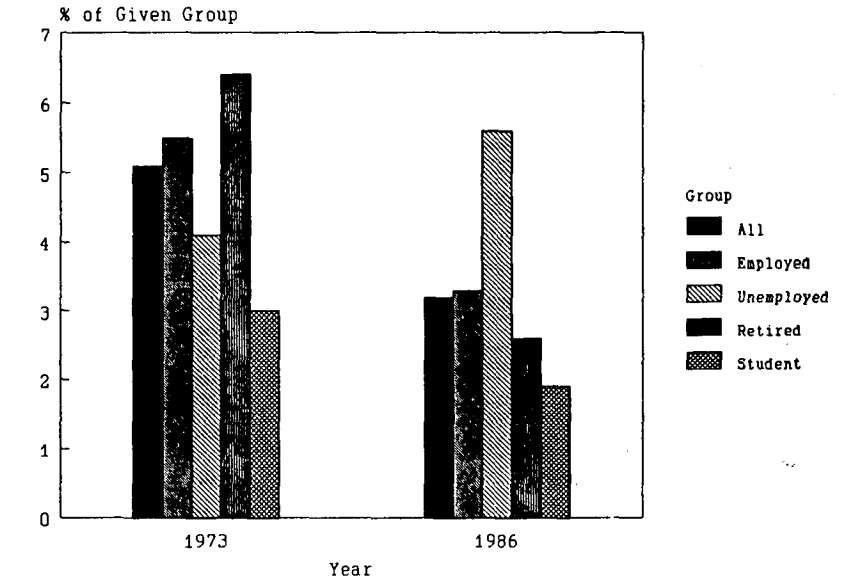
- The percentages of all groups except drivers who had finished high school but had not attended college followed the trend of the drivers as a whole. The percentage of these high school graduates with a BAC of .10%+ remained about the same at roughly 4½%.

Figure 4-31: Percentage of non-accident involved drivers with BAC = .10%+ by driver race, nighttime, weekend, 1973 and 1986



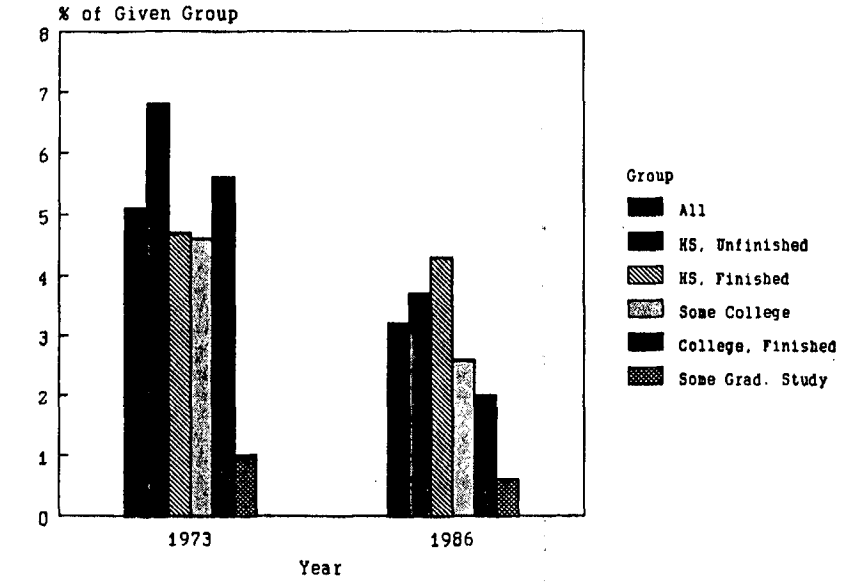
Source: Lund and Wolfe, 1989

Figure 4-32: Percentage of non-accident involved drivers with BAC = .10%+ by driver employment status, nighttime, weekend, 1973 and 1986



Source: Lund and Wolfe, 1989

Figure 4-33: Percentage of non-accident involved drivers with BAC = .10%+ by educational attainment, nighttime, weekend, 1973 and 1986



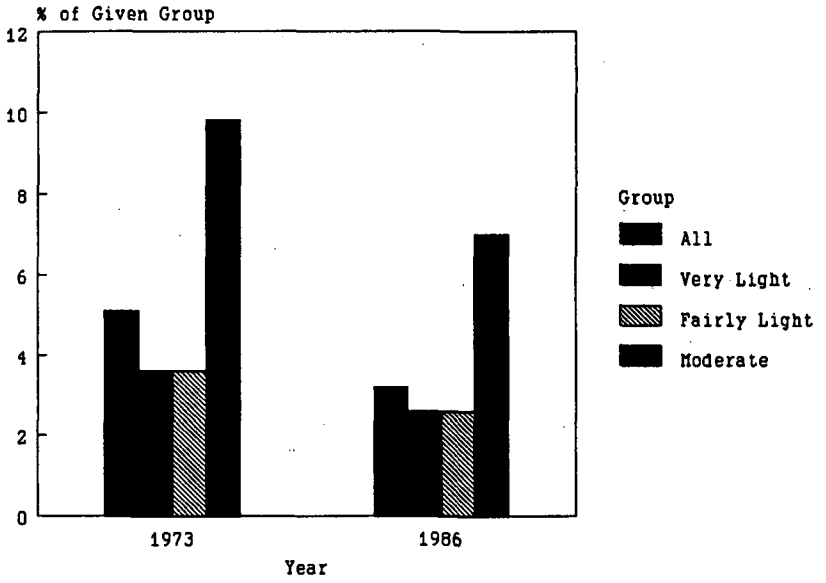
Source: Lund and Wolfe, 1989

Drinking Variables

There is much evidence that persons with drinking problems (particularly alcoholics) are overrepresented in alcohol-related traffic crashes. The number of such crashes actually "caused" by such individuals remains uncertain, so it would be next to impossible to estimate directly any trends in number of alcohol-related crashes. However, one characteristic often associated with crash-involved persons with drinking problems, a high BAC, is available from the FARS file, and in fact is plotted in Figure 2-2 of this report. The FARS data used in this figure show that the *percentage* of fatally injured drivers with a BAC of .20% or more (a very high BAC) has declined about 20% in the 1980-1987 time period, about the same percentage decrease that occurred in the *percentage* of fatally injured drivers with a BAC in the .05% to .10% range, a BAC not necessarily indicative of any drinking problem. (The *absolute* decrease in the percentage of fatally injured drivers with a BAC in the .05%-.10% range was about .08%.)

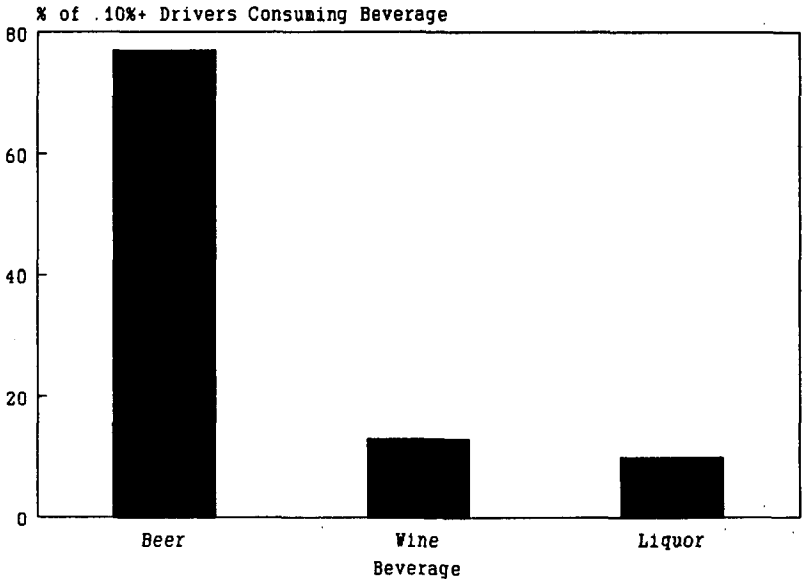
The national roadside surveys of nighttime week-end drivers suggest no differential trends in the percentage of alcohol-impaired drivers who were light to moderate drinkers (Figure 4-34). Note that data for heavy drinkers were omitted from this figure because of the small sample sizes involved (N=35 for 1973 and 33

Figure 4-34: Percentage of non-accident involved drivers with BAC = .10%+ by drinking habits, nighttime, weekends, 1973 and 1986



Source: Lund and Wolfe, 1989

Figure 4-35: Last beverage consumed by 1986 roadside survey drivers with a BAC = .10%+



Source: Lund and Wolfe, 1989

for 1986). Nevertheless, these sparse data do suggest a larger decrease for the heavy drinkers than for more moderate drinkers.

Prior studies have shown that drinking drivers prefer beer over other alcoholic beverages by a factor of about two, and that drivers with high BACs and drivers reporting that they are heavy drinkers have an especially high preference for beer. The 1986 roadside survey provides additional confirmation for this preference. Nearly 80% of the drivers who said they drank during the survey day and had a BAC of .10% or more said the last beverage they consumed was beer (Figure 4-35).

The 1986 national roadside survey also reports the responses of drivers stopped who said they were acting as the "designated driver" that night[3]. *About 10% of all drivers with a BAC of .10% or more reported they were a designated driver that night.*

Driving Variables

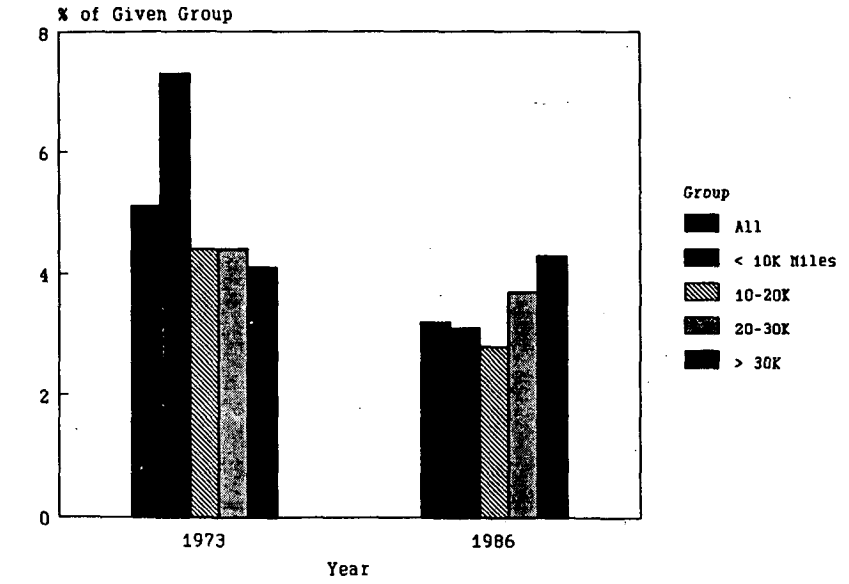
The percentage of non-crash involved, high-mileage drivers with a BAC of .10% or more remained about the same in 1986 as it was in 1973, while the percentage of low-mileage drivers with a BAC of .10% or more dropped disproportionately (Figure 4-36). Note that the data on annual miles driven is self-reported, as is the data for the other driving variables reported for the National Roadside Surveys. Its accuracy is limited by the ability of a driver to estimate his or her mileage.

There were also some interesting changes in nighttime weekend drunk driving with respect to trip purpose during the 1973-1986 period (Figure 4-37). The percentage of .10% drivers among drivers visiting friends and the percentage of .10% drivers among drivers whose trip purpose was cultural or recreational remained essentially unchanged. At the same time, the percentage of .10% drivers among drivers with other trip purposes, including visiting eating or drinking establishments, and going to and from work, decreased in accordance to the overall trend, that is, in the order of 50%.

Recent evaluations of alcohol-crash countermeasures have, in the course of their analyses, provided some new data on the characteristics of drivers who have driven with an illegally high BAC, and then been caught and convicted of DWI or equivalent offense. In reviewing some of this literature, Perrine, Peck, and Fell (1989) observed that DWIs are in many respects, a unique group that are different not only from the general driving population, but also from such groups as problem

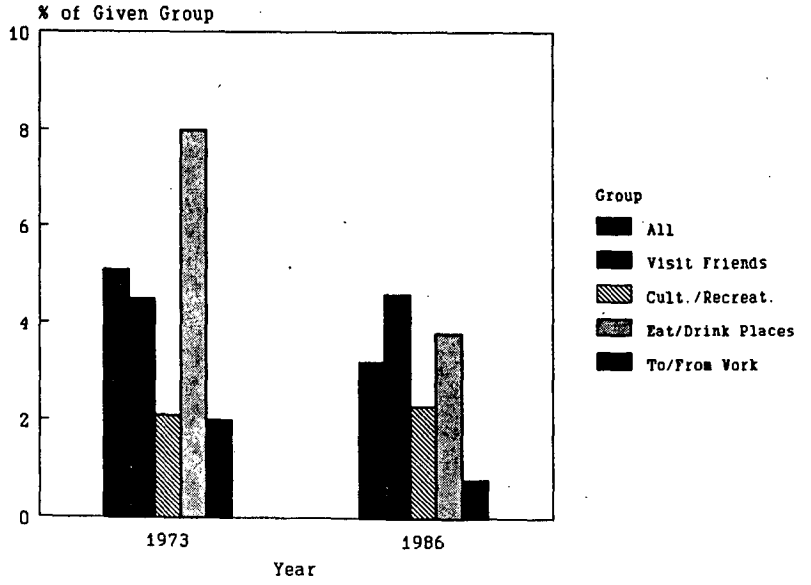
[3] Designated driver programs are discussed in PRIVATE-SECTOR APPROACHES in Chapter 5. A designated driver is a person who agrees not to drink or to drink moderately during a social outing and to serve as the driver for the other members of the group.

Figure 4-36: Percentage of non-accident involved drivers with BAC = .10%+ by annual miles driven, nighttime, weekends, 1973 and 1986



Source: Lund and Wolfe, 1989

Figure 4-37: Percentage of non-accident involved drivers with BAC = .10%+ by trip purpose, nighttime, weekends, 1973 and 1986



Source: Lund and Wolfe, 1989

drivers, alcohol-crash involved drivers, and alcoholics[4]. These researchers conclude that while DWIs share some of the characteristics of these groups, they also have "a substantial proportion of unique DUI-offender characteristics."

Arstein-Kerslake and Peck (1985) performed an extensive taxonomic study of California DWI offenders, including drivers not necessarily involved in crashes. They identified nine psychometric and nine non-psychometric clusters. Interestingly, none of these groups appeared to be a "social drinker" group. In commenting on this result, Arstein-Kerslake and Peck note[5]:

> In an intuitive sense, there are three dimensions which seem to characterize the differences between the nine psychometric clusters: (1) consumption of alcohol (moderate to excessive), (2) problem drinker predisposition (transient to chronic), and (3) negligent operator characteristics (none to many). Different weightings on these dimensions for each cluster contribute to the differential accident / conviction levels among clusters. Even those clusters with low accident / conviction levels (e.g., very low negligent operator characteristics) have high enough levels on other dimensions (e.g., problem drinker predisposition) to preclude their being classified as 'social drinkers.'

The Arstein-Kerslake / Peck taxonomy also identified no first-offender group that was distinguishable from a multiple-offender group, a finding that suggested to Perrine and Associates (1989) that "most first offenders are problem drinkers who have simply not yet had their second offense" (page 33).

Personality and Psychosocial Variables

Recent research in this area has built upon earlier work of such researchers as Selzer and Vinocur (1974, 1975, 1977), Pelz and Schuman (1974), and McBride and Stroad (1975)[6]. The recent research appears to include more well-designed studies than in the past, e.g., more reliable test instruments and larger sample sizes. This research has been especially concerned with the study of so-called problem behavior drivers. The hypothesis examined in these studies was succinctly stated by Jonah

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[4] The terms "social drinker," "problem drinker," and "alcoholic" are often used in the field of highway safety to describe three discrete points on what is really a continuum of alcohol involvement. They are generally defined now, as they were in the 1978 update. Briefly, social drinkers are those whose consumption of alcohol is part of their socially-defined interactions with family, friends, neighbors, and co-workers. Problem drinkers are those whose pattern of alcohol consumption either contributes to or is symptomatic of their disruption of their relationships with others. Alcoholics are persons whose nervous system has developed a tolerance for alcohol, and whose drinking is not just one of an array of problems as it is for problem drinkers, but is a problem in and of itself. The problem of differentiating the so-called problem drinker from the alcoholic and determining the role of each group in alcohol-related crashes remains unresolved. Popkin *et al.* (1988) found that numerous tests had been developed for classifying drivers according to type of drinker, but that none of these had ever been validated for DWI populations. The reader is referred to Popkin *et al.* for a more detailed treatment of the attributes associated with these various classifications and a discussion of the difficulty of classifying a given individual.

[5] Also quoted in Perrine, Peck, and Fell, 1989.

[6] See Jones and Joscelyn (1978) for full citations and a discussion of this earlier work.

and Wilson (1986), that many "...impaired drivers are a deviant group characterized by personal maladjustment and heavy drinking."

Typically, the research designs involve a survey research approach, sometimes augmented by driver records data from state files (see Table 4-2). Usually, the questionnaires are self-reports, but may also involve personal interviews. Sample sizes for the better studies range from a few hundred to several thousand. Populations surveyed include those of known high risk (e.g., drivers with multiple driving offenses or crashes in a recent time period), drivers in general, and special groups of drivers (e.g., high school students). Much of this work has been done in Canada.

The general findings of these studies are consistent with those of the better prior studies, concluding that impaired driving is just one behavior that is part of a deviant behavioral syndrome typified by high-risk behaviors. The personality characteristics of these drinking drivers with other problem behaviors are remarkably similar across studies, i.e., tending to be aggressive, thrill-seeking, impulsive, verbally hostile, and resentful. Other problem or risky behaviors found to occur commonly among these individuals include use of recreational or illicit drugs; heavy drinking; problems with parents, friends, teachers, and police; and non-use of seat-belts.

Table 4-2: Problem behavior drinking drivers, typical research designs

Study	Approach
• Wilson and Jonah, 1985	• Household survey of 2,000 Canadians nationwide
• Donovan, *et al.*, 1985	• Self-report questionnaire to 172 DWIs, 193 high-risk drivers, 154 drivers
• Swisher, 1988; Bierness and Simpson, 1988	• Self-report questionnaire to 11,175 and 1,986 high school students
• Donovan, Umlauf, and Salzberg, 1988	• Self-report questionnaire and driver records for 193 male first offenders

Because of the quality of this research and the consistency of its findings, it must now be acknowledged that impaired driving involves a deviant group. (It does not imply that *all* impaired drivers are part of a deviant group.) However, this research does not shed much light on the magnitude of the alcohol-crash problem caused by such deviant drivers compared to that caused by non-deviant drivers. This deviant group, which includes adolescents as well as adults, will be much more difficult to deal with than "normal" drivers, and as observed by Beirness and Simpson (1988), may require a "more global strategy directed at the level of general patterns of behavior - i.e., lifestyle."

SUMMARY AND CONCLUSIONS

The most important development since the last update is that the percentage of crashes involving alcohol has declined during the 1980s. One factor which may have contributed to this is that the long-term trend of increasing per capita alcohol consumption appears to have leveled off, perhaps even declined. Another factor may be the various drinking-driving countermeasure programs that were implemented in the 1980s. The nature and possible effects of these programs are discussed in the next chapter. The share of young drivers in alcohol-related crashes has been disproportionally reduced. This may be due, at least partially, to another countermeasure that was implemented in the 1980s, an increase in the minimum legal drinking age.

It is now clear that although the alcohol-crash problem is still predominantly a male problem, the share of female drivers is increasing. Epidemiologic data suggest that any lesser decrease or greater increase in drinking-driving by females will be reflected in a disproportionate increase in female drivers in alcohol-related crashes because of the higher relative alcohol-crash risk of females. At least during weekend nights, driving after drinking has apparently decreased more among female drivers than among male drivers over the past 15 years, while alcohol-related crashes have decreased less among females than among males.

Roadside survey data suggest a general downward trend in drinking-driving over the past 15 years, while the drinking-driving patterns of some groups have remained about the same. Included among these are high school graduates who have not attended college, unemployed persons, and blacks.

There is no strong indication of any change in the percentage of persons with severe drinking problems in either alcohol-related crashes or nighttime weekend driving populations. Roadside surveys continue to indicate a preference for beer among drivers with moderate to high BACs. A rather high awareness of the designated driver concept was suggested by the finding of the 1986 National Roadside Survey that 15% of the drivers responding to a question about whether they were a designated driver that night said they were. Of greater interest was the

finding that more than 6% of those reporting they were a designated driver had a BAC of .10% or more. In fact, self-reported designated drivers were about 10% of all drivers with a BAC of .10% or more.

High-mileage drivers, drivers visiting friends, and drivers who were travelling for cultural or recreational purposes also appeared to defy the general downward trend toward less involvement in higher-BAC driving, remaining about the same in this respect as they were in 1973. More recent studies of drivers who had been caught and convicted of DWI confirmed many of the characteristics of such drivers found in prior studies. One taxonomic study of DWIs failed to identify any clear-cut social-drinker group or to find any statistically-significant differences between first offenders and multiple offenders.

Finally, research has provided additional support for the hypothesis that drivers with a variety of behavioral problems are a factor in the drinking-driving problem, but does not provide a basis for estimating the relative importance of the role of such drivers in that problem.

CHAPTER 5

DEALING WITH THE ALCOHOL-CRASH PROBLEM

PRIOR FINDINGS

The 1978 report classified alcohol-crash programs according to the nature of the approach they took to the problem and identified five fundamental types of such approaches, *viz.:*

- Legal,
- Health,
- Public Information and Education,
- Technological, and
- Systems.

The *Legal* approach is based upon a set of official rules (laws) which specify and prohibit drinking-driving behaviors believed to present unacceptably high risks to society. Non-compliance with these rules can result in punishment such as fines, loss of the driver's license, or incarceration. These punishments are believed to act as a *deterrence* to those who have been caught and punished (called *specific deterrence* or *special deterrence*), as well as those who have not yet been caught and punished (*general deterrence*).

The *Health* approach targets the drinking problems that often underlie drinking-driving behavior. The objective of such programs is to induce more moderate drinking habits or to eliminate drinking entirely. Methods used include treatments and therapies as well as rehabilitation programs such as DWI schools.

Public Information and Education (PI&E) approaches inform and educate persons about drinking-driving and its consequences, either on a continuing basis, or in isolated campaigns. It was observed that PI&E approaches are most commonly used in combination with other approaches (usually the legal approach) to inform the public about control actions that will be undertaken and to create a climate of public support for those actions. PI&E was said to be used most often in combination with the legal approach.

The 1978 report defined *Technological* approaches as those that apply modern technology to interdict the sequence of events leading to drinking-driving. Examples given were pharmaceuticals for speeding up the sobering process and devices for measuring a driver's BAC. Again, some of these technologies were used in support of other approaches, in particular, the legal approach in which BAC measurement is essential.

The last major approach to the alcohol-crash problem was identified as the *Systems* approach in which two or more of the other four approaches were methodically applied. Only one example of the systems approach, NHTSA's Alcohol safety Action Projects (ASAP), was discussed in the 1978 report.

The 1985 report used a similar system for classifying alcohol-crash countermeasure programs. However, it added two new groups, one called *Vehicle / Roadway Engineering Programs* and the other called *Exposure Reduction Programs*, to cover countermeasures that were discussed in the 1978 report, but had not been widely implemented then. The first of these new groups included such vehicle-oriented concepts as separate brake and turn indicators for cars, and such roadway-oriented concepts as better roadway delineators. The second group (exposure reduction) was defined as those programs that are explicitly designed to reduce the crash exposure of certain high-risk groups such as drivers under the age of 21 (for example, laws raising the minimum legal drinking age) and alcoholics and problem drinkers (for example, barring the issuance of a driver's license to such individuals).

Both reports examined the design and results of these various groupings of alcohol-crash countermeasures. The 1978 report found that the great preponderance of formal, programmatic responses to the alcohol-crash problem had been directed at the human component of the highway transportation system. These alcohol-crash programs focussed on reducing the incidence of drinking-driving, rather than on improving highways, protecting occupants during a crash, or caring for crash victims after a crash.

Because of a lack of adequate evaluation, the 1978 report found it impossible to say unequivocally whether any of the five approaches it examined had actually worked in reducing crash losses caused by alcohol-impaired drivers. The report found only one instance (the British Road Safety Act of 1967) that strongly supported the legal-approach hypothesis that the threat of punishment will deter the drinking driver. However, it was not clear exactly why that application apparently worked and how the experience gained in the program could be transferred to other programs in other environments. A similar situation was found with respect to the health and health / legal approaches which had found success only in very limited applications (for example, the Lackland Air Force Base program). There was evidence, for example, that problem drinkers could be identified and processed, but little or none for concluding that the resulting treatments (including DWI schools) had a significant impact on the alcohol-crash problem. Little evidence was found that PI&E alone favorably changed either attitudes or behaviors with respect to drinking-driving, but that it was quite likely that the successes of some programs (including the British Road Safety Act and the Lackland program) were due to a large part to their strong PI&E components.

The 1978 report found that the only meaningful applications of the technological approach were in the area of BAC measurement which had an enormous impact in supporting the legal approach. Other promising technological concepts remained untested in the field. Finally, the report found no convincing evidence of a significant highway safety effect of the systems approach as implemented in NHTSA's Alcohol Safety Action Projects. It speculated that this failure might be due more to the "present primitive states of the technology of drinking-driver behavior modification and alcoholism treatment than to the process by which that technology is applied." In general, the report concluded, there was little scientific or empirical basis for choosing among the various approaches and that even many of the basic premises upon which these approaches were based could not be substantiated scientifically.

The 1985 report found some positive results from alcohol-crash program evaluations conducted since the 1978 report. For *legal approaches*, it found some evidence that very strong *police enforcement* may reduce the number of alcohol-related crashes. However, it noted that past studies of both the general deterrent effect and specific deterrent effect of the *penalties* used in alcohol-crash countermeasures had generally yielded negative results. This was due to such factors as the failure of adjudicators to impose the penalties prescribed by law and a lack of an adequate public information component for creating an awareness of the penalties among the driving public. Note that the negative results of these early programs do not invalidate the concept of deterrence. More recent studies (discussed later in this chapter) indicate that properly designed and executed deterrent programs can have a positive highway safety benefit. The 1985 report found that a variant of the legal approach controling alcohol availability by raising the legal minimum drinking age was found to offer considerable promise. The report also found some cause for optimism about the effects of *health approaches* on alcohol-related crashes, noting that a large-scale treatment program for multiple offenders in Sacramento, California had been effective in reducing DWI recidivism, and that another education program at the same site for first offenders was also effective in reducing recidivism.

The report's findings on *PI&E approaches* were essentially the same as those of the 1978 report. The 1985 report found that PI&E alone could increase the public's knowledge about drinking-driving laws and its understanding of the effect alcohol has on the body and on driving skills. The report also found that some programs using PI&E campaigns in conjunction with other countermeasures had also reduced crash rates. The 1985 report reiterated the conclusion of the 1978 report that there was little hard data to support the value of a *systems approach*, even though a NHTSA evaluation of ASAP found an overall reduction in nighttime fatal crashes at approximately a third of the sites. The 1985 report noted the emergence of a number of new techniques and publicly-supported programs and was hopeful

that our knowledge of how to control the drinking-driving problem would soon be significantly improved.

CONCEPTUAL FRAMEWORK

The structure used in the two prior updates of the state-of-knowledge of alcohol and highway safety is, with some modifications, still appropriate. The modified conceptual framework encompasses the following types of efforts:

- Legal,
- Health,
- Educational,
- Technological,
- Private-Sector, and
- Vehicular and Environmental.

Two new groups have been added, one group has been removed, and some of the groupings used before have been redefined.

The *Legal* approach now consists of two sub-approaches, *Regulating Alcohol Availability*, and *Deterrence and Incapacitation*. The first of these includes programs that use the legal system to control access to alcoholic beverages, and the second includes deterrent and incapacitative approaches, that is, the use of legal sanctions to deter drinking-driving or to prevent access to a motor vehicle. Public information and education approaches are now included as a part of the legal approach, because recent applications of PI&E have nearly always been in support of the legal approach.

The *Health* approach remains as defined in the 1978 report, being targeted at dysfunctional drinking related to drinking-driving. As indicated in the prior updates, nearly all applications of the health approach have been made in conjunction with the legal system and are more accurately defined as a health / legal approach. Rehabilitative educational programs are still included in the health approach. Note that this definition differs from that of what is sometimes called the *Public Health* approach, which includes prevention as well as treatment programs. In this report, prevention programs are discussed under the legal approach and the private-sector approach (defined below).

The *Educational* approach is new to this update. It consists of school-based programs that transfer information about drinking-driving and its consequences.

The *Technological* approach is defined as it was in prior reports, encompassing programs that are devoted primarily to the use of modern technology to prevent

drunk driving or to support other approaches (for example, BAC measurement technology).

The *Private-Sector* approach is also a new category. It involves a range of countermeasure efforts initiated and "managed" by private-sector organizations rather than by governmental agencies. It includes such activities as designated driver programs and training programs for bartenders in responsible serving practices.

The last grouping, the *Vehicular and Environmental* approach, was discussed in the 1978 report, but not identified as an "approach" because of a lack of implementation of pertinent countermeasures. It was also discussed under the heading of *Vehicular / Roadway Engineering Programs* in the 1985 report.

Note that the *Systems* approach, a major category in the two prior reports, is not discussed in this update. This is *not* because it was deemed to be no longer important, but was simply because we found no significant studies of comprehensive community-wide interventions that have occurred since the last update. We are aware that such programs are currently undergoing evaluations in several communities in Massachusetts, but no results have been reported as of this writing.

Finally, we have not discussed pedestrian countermeasures in this update. Again, this is not because such programs are not needed (Chapter 2 shows that alcohol impairment remains a significant factor in adult pedestrian injuries and fatalities), but is due to a lack of published literature in this area. In a conference session on alcohol-impaired pedestrians (Ost, 1989), experts in the field were unable to cite any new work in this area. Impaired pedestrians have proven to be an intractable problem over the years, and it appears that only traditional interventions such as vehicle-pedestrian separation and more forgiving vehicle exteriors (classified more appropriately in this report under the vehicular and environmental approach) are receiving active consideration at this time.

PROBLEMS IN EVALUATING ALCOHOL-CRASH PROGRAMS

Four major problems have plagued evaluators of alcohol-crash programs. These problems are:

1. Choosing appropriate measures of effectiveness: crashes, drivers using the roads, subsequent Traffic Law System actions, subsequent crashes, self-reported behavior, etc.

2. The practical necessity to use quasi-experimental designs;

3. Confounding interactions among countermeasures that are implemented at or close to the same time in the "treatment" and the "control" groups; and

4. Other confounding factors, including unexplained time trends.

A direct measure of the effectiveness of many programs would be the BAC distribution for drivers on the road. It would be most reliably obtained by breath alcohol tests obtained in roadside surveys of a random selection of drivers at properly selected locations and times. Collecting this type of data is costly and difficult, and is rarely done in studies of specific countermeasures. Telephone and written surveys of drivers are more frequently used. They may ask for self-reporting of drinking and driving habits, and about the perception and awareness of countermeasure programs. Self-reported drinking data may be biased and are of limited reliability. Therefore, such data are frequently used in addition to crash data.

The ultimate objective of a drinking-driving countermeasure is the reduction of alcohol-related crashes in the target group. Except in the case of fatally injured drivers, objective determination of alcohol involvement has been a rarity (see Chapter 2). NHTSA has used data for several studies from states which tested the BAC of at least 80% of the killed drivers. Though objective, these data may suffer from some biases, since not all killed drivers and relatively few of the surviving drivers (even those in fatal crashes) are tested. In non-fatal crashes, BAC is rarely tested. Also, the "good" states (whose numbers have recently rapidly increased) may not be representative of all states. Finally, there are operational problems associated with obtaining, storing, and analyzing blood that could affect the BAC data.

In most cases, researchers had to use proxies. Police officers' subjective assessment of alcohol involvement is an obvious choice, but it is clearly subjective, and the standards of judgement have probably changed over time, especially during recent years when the drinking-driving problem has been more widely publicized. More objective proxies are nighttime crashes, nighttime single-vehicle crashes, nighttime fatal crashes and nighttime single-vehicle fatal crashes. Nighttime crashes are used because alcohol-involved crashes occur disproportionately at night; single-vehicle crashes because drivers in those crashes are usually responsible for the crash, and because a high proportion of these involve alcohol; and fatal crashes because they, too, are more likely to involve alcohol. Of course, as the proxy measure becomes more specific, case numbers decrease, random fluctuations of the data increase, and the analysis becomes less sensitive. For example, single-vehicle nighttime fatal crashes tend to provide sufficient numbers of cases only in relatively large states, or groups of states, and only on a quarterly or annual basis, but not on a monthly basis.

A potential problem with these objective proxies, just as with the subjective proxies based on police officers' judgments, is that their relation to alcohol involved crashes may not remain stable over time; the relation of single-vehicle nighttime crashes to daytime multi-vehicle crashes may change for various reasons other than changes in drunk driving.

For most intervention measures intended to modify the behaviors of persons already arrested or convicted of DWI, a natural outcome measure is the probability of re-arrest and / or subsequent crash experience. Though such measures can be fairly objective, their analysis is subject to limitations because subjects may not be randomly assigned to a treatment and a control group. Therefore, an analysis must rely on statistical techniques to control for other factors relating to recidivism, such as a prior arrest or conviction, BAC at time of arrest, age, and sex, even if the effects of such factors by themselves are of no interest.

Problems of measurement also arise with regard to the countermeasures themselves. This is especially important if countermeasures in several jurisdictions are studied. The implementation of a countermeasure usually has quantitative and qualitative aspects. For instance, when introducing a jail sentence for driving under the influence, the frequency with which it is imposed may be its quantitative aspect; the duration of the sentence, its qualitative aspect. However, more parameters may be needed to describe it adequately. Since the effects of a countermeasure may strongly depend on these parameters, it may be necessary to include them in the analysis, if different jurisdictions are combined.

In an ideal environment, one would use an experimental design to evaluate a countermeasure: the "treatment" jurisdiction would be randomly selected from a set, the others retained as controls. No other countermeasures would be implemented during the study period. In reality, researchers have usually had to study countermeasures as they have been implemented by government agencies without special regard for their evaluations. In some cases, countermeasures may have been implemented in certain jurisdictions and not in others, for the special purpose of evaluation. However, even then, a random assignment is not always possible, and in most cases the participating agencies are self-selected. Therefore, the analysis has to use a "quasi-experimental" design. The more simplistic studies ignore the difference between a true experimental design and a quasi-experimental design, the more sophisticated studies try to control for confounding factors by analytical methods.

Often, not one but several countermeasures are implemented at one time. Sometimes states have changed their laws to introduce several drinking-driving countermeasures at one time. Then it is rarely possible to separate the effects of these countermeasures in this specific state. In other cases, states have introduced

different countermeasures within a few years. Again it will be difficult, if not impossible in most such cases, to separate the effects of these countermeasures.

It is relatively easy to get information on countermeasures at the state level. However, many countermeasures have been implemented at the local level. Information on this is much more difficult to obtain. Also, some of these are not "new" countermeasures, but merely an extensive or intensive application of already-available countermeasures.

During the last decade, most states have implemented various countermeasures against drink-driving, such as changing their driving laws with respect to drinking. Therefore, it is often difficult, if at all possible, to find true "control" states in which no changes similar to those in the treatment states occurred, especially if periods of several years have to be studied.

In addition to alcohol countermeasures, there are other factors which may confound the effects in the treatment states, and also affect the control states differently. First, there are long-term trends which differ among the states. Then there are the socio-economic effects related to the recent severe economic recession (1982) and the subsequent economic recovery, and these affect a period when many alcohol-countermeasures were implemented. There are also more specific effects, such as demographic changes, the passing of mandatory restraint use laws, increases of the speed limit on rural interstate highways to 65 mph, etc. To evaluate the effects of each of these measures is difficult enough; to explicitly incorporate them into an evaluation of alcohol-countermeasures is practically hopeless.

LEGAL APPROACHES

Regulating Alcohol Availability

Raising the legal minimum drinking age (LMDA) has been by far the most frequently introduced and studied availability measure. Important studies in this area include, among others, those by Wagenaar (1983c), DuMouchel *et al.* (1986), Hingson *et al.* (1983), and Hoxie and Skinner (1987). Wagenaar's study was an extensive treatment of the effects of minimum drinking age laws in the U.S. It gives detailed results of the authors' own studies for Michigan and Maine that used New York and Pennsylvania as comparison states. The study concluded, from the Michigan findings on property damage crashes and injury crashes, that "20% of all alcohol-related crashes involving young drivers can be prevented by removing access to alcoholic beverages" (page 101). The Maine study showed an effect only for property damage crashes.

In July, 1984, a federal law was signed by the President and passed requiring all of the states in the U.S. to adopt a minimum drinking age of 21 by September,

1986, or forfeit a portion of their federal highway funds. By 1988 all of the states had adopted a minimum drinking age of 21. In 1987, the United States General Accounting Office (GAO) reviewed and synthesized some 50 pertinent studies (U.S. Government Accounting Office, 1987). It found that raising the LMDA generally reduces alcohol-related traffic crashes for the affected age groups. The amount of reduction attributed to the LMDA varied. For example, in four "sound" studies using data from several states, the reduction ranged from 5 to 28 percent. The GAO study also found that the available evidence supported the claim that raising the LMDA also reduces alcohol consumption and driving after drinking. The GAO researchers found some evidence also of a small spillover effect for younger drivers who were not the direct target of the LMDA legislation. They concluded that there was insufficient evidence to assess the border crossing effect (the effect of different LMDAs in adjacent jurisdictions), or to assess the long-term effect of LMDA.

Several subsequent studies have also supported these findings. Among these is a study by Womble (1989) which examined the ratio of after-law to before-law fatal crash involvements per licensed driver for *potentially affected* drivers of 13 states. Womble then compared that ratio to the same ratio for *potentially unaffected* drivers. From this analysis, she estimated a 12% reduction in fatal crash involvements for the target age group.

Hoxie and Skinner (1987) studied the effect of raising the legal drinking age on the fatal crash involvement of 18-20 year old drivers, applying econometric techniques to FARS data for the 50 states during the period 1975-1984. They found that the affected age group had between 9% and 13% fewer fatal crash involvements after the drinking age was raised than they would have had otherwise. Alternative analyses make this result appear very robust. No spillover effect was found on drivers 14-17 years old, and neither was found for "beginning" drinkers.

Skinner and Hoxie (1989) updated their 1987 study. They estimated a reduction in fatalities of 10.3% to 12.8% attributable to the LMDA laws over the 1983-1987 time period studied. Differences in the effectiveness for the five-year period were not statistically significant, so no time trends in law effect could be estimated. The study found no spillover effect on 14 to 17 year olds (mainly because of relatively small sample size) or on 21 to 23 year olds.

It has been hypothesized that raising the minimum drinking age may reduce alcohol-related crashes in the directly affected age groups, but has the effect to make these drivers "inexperienced drinkers" when they reach the legal drinking age. According to this hypothesis, they will then have a greater involvement in alcohol-related crashes, until they have acquired experience in driving after drinking.

Males (1986) finds evidence that the incidence of fatal crashes is highest in the first year drivers are allowed to drink. His statistical techniques, however, are unconventional and not sufficiently described, so that his conclusions cannot be verified.

Asch and Levy (1987) performed cross-sectional econometric analyses with 1978 fatal crash data. They concluded that inexperience in drinking is an apparent factor in fatal crashes. Their technique, which used only one year's data, relied critically on the assumption that the variables they selected suffice to "explain" fatal crash rates. Thus, their conclusion should be considered with great skepticism.

A later study by the same authors (Asch and Levy, 1988) used data from 1975 through 1984 for 47 states, and a model which required much weaker and more plausible assumptions. It appears as if the intended logistic transformation of the dependent variable was performed incorrectly, and the weights used were wrong. Therefore, the results cannot be accepted.

Another mechanism for controling the availability of alcohol is to restrict sales by such retail outlets as bars, taverns and restaurants. O'Donnell (1985) reviewed the research literature on drinking locations of alcohol-impaired drivers, including drivers involved in alcohol-related crashes, drivers arrested for DWI, and drivers participating in roadside surveys. From these data, she estimated that 52.7% of impaired driving trips originated at such drinking establishments.

Mechanisms for controling the serving practices of such outlets could involve restricting the way in which beverage alcohol may be served in an outlet, restricting the number of outlets, or encouraging responsible serving practices through dram-shop liability or third-party liability laws. A number of studies have been conducted on this strategy with varying results.

Blose and Holder (1987) examined motor-vehicle crash patterns in North Carolina counties adopting liquor-by-the-drink (LBD) and compared these patterns to those occurring in counties not adopting LBD. Prior to adopting LBD, properly licensed establishments could sell beer and wine to patrons, but patrons desiring to consume distilled spirits would have to provide their own and purchase "set-ups" (ice and mixers) from the establishment. Using time-series methods, Blose and Holder found that alcohol-related and nighttime single-vehicle crashes involving male drivers age 21 and over increased from 16 to 24% in the LBD counties. However, the degree to which the LBD counties and the non-LBD counties were matched across all pertinent variables is unknown. Also, the analytical techniques used may not have been adequate to model some of the complex patterns in the data.

Several states still have counties which prohibit the sale of beverage alcohol altogether. Colon (1983a) categorized states as either wet or dry according to whether there were counties within those states that prohibited the sale of alcohol. If a county were dry, then the entire state was classified as dry. Using data from NHTSA's Fatal Accident Reporting System (FARS) for 1976, he calculated four different crash rates for the wet and dry state groups. Colon found all of the rates were significantly higher in the *dry* states. His tentative explanation for this surprising result was that drivers in dry counties may increase their crash exposure by driving to wet counties to obtain alcoholic beverages. However, simply comparing rates between "dry" and "wet" states is not an adequate statistical technique. Furthermore, a closer look at Colon's data shows that within his "dry" states the pattern of crash rates and the percentage of the population in "dry" counties (ranging from 0.4% to 42.2%) contradicts his hypothesis.

There are many who maintain that so-called happy hours have harmful effects on traffic safety. This practice involves proprietors attempting to attract patrons by selling drinks at reduced prices during specified time periods. Many jurisdictions in the United States have laws prohibiting happy hours for precisely this reason. Smart and Adalf (1987) examined the traffic safety effect of a such a law in Ontario, Canada, and found no traffic safety benefit.

Another approach to fostering more responsible serving practices is the adoption of server liability laws. Such laws impose civil liability on certain servers who provide alcohol to intoxicated or underage individuals (American Bar Association, 1986). Servers (both commercial establishments and social hosts) may be held civilly liable to those who suffer injury or other harm caused by the intoxicated or underage person's irresponsible use of alcohol. Most states have adopted this principle to varying degrees, either explicitly through so-called dram-shop laws, or implicitly through common law. Mosher and Colman (1986) advocate the adoption of a model dram-shop law which incorporates policies and programs encouraging responsible serving practices and an affirmative defense in dram-shop litigation. He argues that such a law would provide further incentives for responsible serving practices. A similar recommendation was made by the Criminal Justice Section of the American Bar Association in its 1986 assessment of drunk driving laws (American Bar Association, 1986). An evaluation of the traffic safety benefits of such a law has not yet been conducted, but NHTSA is currently sponsoring a study of the effects of dram shop liability laws and litigation on the availability of liability insurance, server behavior, and alcohol-related crashes.

It has been hypothesized that raising the price of alcoholic beverages, principally through increased taxes, will reduce alcohol consumption and therefore the number of alcohol-related crashes. It is generally acknowledged that demand for beverage alcohol is what economists call price-elastic, that is, as price goes up, the overall consumption of alcohol goes down (Levy and Sheflin, 1983).

A recent study by Saffer and Grossman (1987) examined the effects of the price of beer on traffic safety. They constructed models that related state motor vehicle death rates from 1975-1981 for persons in three age groups (15-17, 18-20, and 21-24) to a number of variables, including real (inflation adjusted) beer tax and several other variables. Saffer and Grossman found that a change in the beer tax of +1 percent would change the fatality rate by -.09% for the 15-17 age group, and by -.17% for the age groups 18-20 and 21-24. Simulating the effects of different increases in the beer tax, they estimated that indexing the beer tax to the inflation rate since 1951 would result in a 15% reduction in fatalities among 18 to twenty year olds, that equalizing the beer tax to that of distilled spirits would result in a 21% reduction, and that combining the two measures would result in a 53% reduction. Their analyses also indicated reductions for the other two age groups considered. These findings have to be interpreted with great caution. Though the authors present arguments for raising the beer tax rather than retail price of beer, it is the latter, not the former, that influences a consumer's behavior. Further, the variables are arbitrarily selected. For instance, a variable for inspection of motor vehicles is included, but none is used that reflects amount of travel, or the mix of urban and rural travel. Also, correlations among the regression coefficients are not examined. It is interesting that recent surveys in Michigan (Wagenaar and Farrell, 1988) and nationwide (Gallup, 1987) indicate the public would support (1) raising the alcohol excise tax to combat drinking-driving (86%) and (2) doubling the Federal alcohol excise tax (66%).

Deterrence and Incapacitation

Deterrence theory states that the effectiveness of laws designed to deter individuals from engaging in a legally-proscribed behavior is a direct function of the perceptions of those individuals of their risk of arrest, the severity and certainty of sanction after arrest, and the speed with which the sanction follows the arrest. Many recent drinking-driving programs in the United States and elsewhere have attempted to apply various elements of this theory.

Some jurisdictions have concentrated on the first component, increasing the perceived risk of arrest, through the application of an enforcement strategy known in the United States as *sobriety checkpoints*. Procedures used in implementing sobriety checkpoints programs vary among the various jurisdictions using them (American Bar Association, 1986). They are most often conducted at night and are well-publicized in advance, although their specific locations usually are not announced. Very often, a large team of police officers and their vehicles are involved. Typically, officers direct groups of stopped vehicles into an observation area and engage the drivers in a conversation during which the drivers are observed for signs of intoxication. Stops are made in such a way that each vehicle has about the same chance of being stopped (for example, every tenth car). Behavioral tests for alcohol-impairment may follow. In jurisdictions so equipped, the drivers may be

asked for a sample of their breath for a chemical test of their BAC by a Preliminary Breath Testing device (PBT). If the tests indicate impairment, the driver may be arrested for drunk driving.

A variation of sobriety checkpoints is widely used in Australia. Called *random breath testing*, it involves stopping drivers as they pass a stationary point and requesting of all of them to undergo a preliminary breath test. If the test indicates no alcohol, they are free to go, but if the test is positive, they must submit to an evidentiary test.

Homel *et al.* (1988) reports on the experience in New South Wales where random breath tests are so extensive that each year one test is administered for every three licensed drivers. The program has been well-publicized and has been maintained at a constant, high level over a period of years. Homel indicates a 36% reduction in the number of fatally injured drivers with a BAC of .05% or greater, and a 22% reduction in the total number of fatal crashes. In Victoria, where true random breath testing is not employed (as in the U.S., officers generally request a PBT only if they suspect drinking) and testing is much less extensive, experience indicates only temporary reductions in alcohol-related crashes. These reductions have been associated with the publicity surrounding the routine testing and the testing "blitzes" in specific areas (Homel *et al.*, 1988).

McLean (1984) incorporated roadside surveys into the evaluation of random breath testing as it was adopted in South Australia. Random breath testing was a controversial issue there and generated considerable publicity while it was being considered by the legislature, and while awaiting actual implementation after passage by the legislature. The roadside surveys revealed a 14% reduction in the proportion of drivers at or above a BAC of .08% after the law went into effect, but that reduction had disappeared within a year. A similar reduction in positive BAC's below the legal limit was also observed, and that reduction was maintained. This led the researchers to hypothesize that social drinkers were more likely to be deterred by the random breath testing program as it was being implemented (with limited resources and with stop rates well below those in New South Wales). In addition, in South Australia, random breath testing was confined to main roads, and this evidently led to a displacement of high-BAC casualty crashes to secondary roads as high BAC drivers attempted to avoid detection. Frank (1986) reported a similar displacement in Melbourne. A subsequent intensification and diversification of random breath testing in South Australia has resulted in more marked declines in high-BAC drivers tested in roadside surveys. McLean and associates also examined the effect of random breath testing on crashes, but their results were inconclusive.

The experience with sobriety checkpoints in the United States has not been as positive as it has been in Australia. This seems likely to be due to the different legal environments in the two countries. In Australia, random breath tests may be

conducted by as few as one or two officers and can literally be done at the whim of the officer. In the United States, because of rights guaranteed by the Fourth Amendment to the U.S Constitution in regard to search and seizure, several conditions must be imposed on checkpoint operations. Various court decisions have led to guidelines for meeting such legal constraints. (See Compton and Engle, 1983, for an overview.) Generally, checkpoints must be conducted at safe locations that can be justified on the basis of prior crash or arrest experience as high DWI areas and must be publicly announced. Vehicles may not be stopped randomly, but rather must be stopped or selected on some regular basis such as every fifth or tenth vehicle. Efforts must be made not to unduly delay traffic. A relatively senior police officer must be present and supervising the activity. Further, the officer must develop a suspicion that the operator had been drinking before requesting that the operator undergo roadside sobriety tests or take a PBT test in states which have legislation providing for PBT tests. At that point, if probable cause is established the officer may place the driver under arrest and request him or her to submit to an evidentiary chemical test. Typically, several officers are necessary for operating checkpoints in the U.S. In several states, meeting the standards described above will still not satisfy state courts or the state constitution, and checkpoints are not permitted at all.

Though there are rather strict legal requirements for the operation of checkpoints in the U.S., recent innovations have been proposed to help make checkpoint operations run more smoothly. Compton (1985) assessed the use of a variety of in-car screening procedures using dosed subjects in a simulated checkpoint situation. He found that, within a 40-second stop, well-trained officers could effectively use alcohol gaze nystagmus (a jerking of the eyes as they track towards the edge of the periphery of vision) to screen drivers and could correctly identify drivers having a BAC of .10% or more 95% of the time. By contrast, such drivers could be identified only 87% of the time when using the officers' normal procedure.

Compton also assessed the practicality of using passive alcohol sensors (PAS) in this environment[1]. Compton found that officers could correctly identify drivers as having been drinking 94% of the time. The advantage of the passive sensor in this setting is that it requires less of the subjects' cooperation and subjects can be screened more quickly (about 20 seconds for a passive sensor compared to about 40 seconds for a PBT device).

Jones and Lund (1985) evaluated the effectiveness of the passive sensor in a field checkpoint setting in Charlottesville, Virginia. Data were collected on the BAC level of drivers stopped at the checkpoint on evenings when passive sensors

[1] Passive alcohol sensors are hand-held devices, usually the size of a large flashlight. They use a small fan to draw the subject's breath over a fuel cell that can detect alcohol. The device is placed about six inches in front of the subjects mouth and does not require the subject to blow directly into the device for the test.

were in use and when they were not. These researchers found that police officers using conventional techniques correctly identified 45% of the drivers with a BAC of .10% or more, compared to 68% of such drivers using the passive sensor. In addition, the percentage of drivers with "false positives" (drivers with a very low BAC who were incorrectly classified as having a high BAC) was cut in half by using the passive sensor. The effect of using the passive sensor while on DWI patrol was also assessed in another study by Jones and Lund (1985) who reported that the proportion of legally intoxicated drivers correctly identified rose from 52% to 61% when the passive sensor was used.

Despite the limitations imposed on checkpoint use in the U.S., it appears that checkpoints have had some positive effects in many jurisdictions. Williams and Lund (1984) assessed the effect of roadblocks on public perceptions using telephone surveys. The responses of residents of Montgomery County, Maryland, a jurisdiction which was making extensive use of well-publicized roadblocks, were compared to those in Fairfax County, Virginia, another Washington, DC, suburb with a very high DWI arrest rate but with infrequent, unpublicized use of roadblocks. Even though Fairfax County had a higher arrest rate than Montgomery County, the perceived risk of arrest was much higher in Montgomery County. A similar survey of citizens residing in the state of Delaware and in the Maryland eastern shore was also conducted, with similar results. In all four areas, roadblocks were the most frequently mentioned effort being undertaken to deal with the impaired driving problem. However, there was no evidence of an effect on self-reported DWI behavior.

In a field test of the checkpoint concept, Charlottesville, Virginia police conducted roadblocks on every Friday and Saturday night for a one year period. Subsequent surveys indicated that 85% of nighttime drivers who were drinkers had heard of the checkpoints, half had seen one and nearly 25 percent had actually been stopped at one. There was a resultant 13 percent decrease in alcohol-related crashes (Jones and Lund, 1985).

Two cities in Florida, Clearwater and Largo, conducted a year-long program combining DWI enforcement and public information strategies as a part of a NHTSA-sponsored field experiment (Lacey *et al.*, 1986). Though checkpoints were but one of several enforcement approaches implemented and publicized, they were by far the most frequently recalled strategy when licensed drivers responded to a telephone survey. Alcohol-related (as judged by the police) crashes in the experimental cities relative to those in control cities dropped according to our model from about 65% by 12.5 percentage points, according to another model from about 70% by 20.3 percentage points. The percentage of nighttime crashes balanced similarly, dropping by 8 percentage points.

Publicity appears to be a critical element in successful checkpoint programs. Mercer (1985a) used regression methods to study the effects of various measures of checkpoint activity, DWI arrests, and the extent of media coverage on alcohol-related crashes in British Columbia over a 54-month period. He found that media coverage was the critical element in the reduction of alcohol-related crashes. Thus, the general legal requirement in the United States that checkpoints be announced to the public may work to the benefit of their effectiveness.

Deterrence theory postulates that there must also be a perception that an arrest will quickly lead to a conviction and appropriate punishment. The 1978 report noted that it was fairly common practice to reduce a DWI charge to some lesser offense. During recent years, some jurisdictions have adopted policies or laws prohibiting such charge reduction and plea bargaining (Ruschmann, Swantek, and Jones, 1985).

Surla and Koons (1989) examined the effect of adopting such policies on court operations, DWI recidivism and general deterrence in communities in Arkansas and Kentucky, two states that had adopted anti-plea bargaining legislation. They compared experience before and after adoption of such laws and found that convictions on the original DWI charge increased dramatically with implementation of the laws. Despite fears that the time required to process a case would be increased, the opposite occurred. Convictions for the original charge increased from 71.7 percent to 88.3 percent in Fort Smith, Arkansas, after the no plea bargaining law was passed. In Lexington, Kentucky, a community that had an anti-plea bargaining *policy* before a state law was adopted, the conviction rate changed little from 97.5% to 98.2%. In contrast, Louisville, Kentucky, a community without such a policy before the law, saw its DWI conviction rate increase from 20.8% to 63.7%. The study also found an increase in the severity of the penalties imposed for DWI, but this effect was confounded by a concurrent change in the law that increased penalties. Thus, the extent to which increased sanction severity depended on reduced plea bargaining could not be determined. Decreases in DWI recidivism and alcohol-related crashes were also reported in the no plea bargaining states, but these changes could not be attributed to the lack of plea bargaining alone because of other alcohol-crash countermeasures were implemented at the same time as no plea bargaining.

Another development reported since the last state-of-knowledge update is the use of an administrative process in addition to the judicial process for sanctioning of DWI offenders. In the United States, driver's license sanctions have been imposed on persons who refuse to submit to a chemical test by the licensing agency, an administrative agency, rather than a judicial agency. This was justified by the principle of *implied consent*, which states that when a person drives, that person implicitly consents to submit to a chemical test when asked by a police officer to do so if probable cause leads police officer to believe the driver is driving while

drunk. In recent years, an increasing number of states have begun to apply such an administrative process to persons who take and fail the test as well as to those who refuse the test. This process ensures that most persons arrested for DWI will have their driver's license suspended or revoked, a sanction that has consistently been associated with reductions in DWI recidivism. (Evaluations of driver's license sanctions are discussed later in this report.) In addition, the sanction is imposed relatively swiftly (generally within 30 days of arrest), in accordance with deterrence theory. In some states, through a separate judicial process, these same persons are tried in the courts on the criminal charge, and are given other sanctions upon conviction.

Studies by Jones (1985), Ross (1987a) and Lacey *et al.* (1989b) in separate states adopting such laws have all found that the adoption and awareness of administrative license revocation was associated with general deterrence as measured by decreases in alcohol-related crashes and their proxies.

Reporting on Oregon's experience with various types of crashes involving alcohol, Jones found that the percentage of fatal crashes reported to be alcohol-involved in the first six months after the law was implemented was 29 percent lower than that projected based on historical trends. For nighttime fatal crashes, that figure was 15 percent, and for nighttime serious injury crashes it was 23 percent. Implementation of Oregon's law was accompanied by an extensive public information campaign. Measures of awareness of the central theme of the campaign indicated high levels of public awareness (85 percent of respondents were aware of the law).

Ross examined trends on the proportion of drivers or pedestrians in New Mexico with a BAC of .05%. He observed a decline of approximately 10% coincident with implementation of the administrative license revocation law. These results were obtained despite a relatively low awareness of the particulars of administrative per se (37% of respondents were not aware of the provisions of the law).

The experience in Nevada indicates the importance of public awareness of the law to its effectiveness. Lacey, *et al.*, reported the proportion of crashes occurring at night were reduced by approximately 10% after implementation of the law and by a further 7% after the law was publicized.

Sanctions traditionally applied by the courts as a result of a conviction of the DWI offense generally may include confinement and fines, as well as driver's license action (suspension or revocation). Enrollment in an educational or treatment program for an underlying drinking problem is also often required of persons convicted of DWI. Since the prior updates, there has been considerable research on the effectiveness of these sanctions.

Although jail terms have been applied to some multiple DWI offenders in the past, use of jail terms for first offenders is a relatively recent phenomenon in the United States. Laws mandating jail sentences in some states seem to be due to pressures from citizens' activist groups on state legislatures. Other forms of confinement or incapacitation, including house arrest and requiring offenders to perform supervised community service work, have also been incorporated into law.

Falkowski (1984) and Cleary and Rogers (Minnesota House of Representatives Research Department, 1985b) examined the effect of a *policy* (not a law) adopted by Hennepin County, Minnesota judges to sentence all first-time DWI offenders to a two-day jail term. Falkowski found that the policy was indeed implemented, with 87.7% of convicted first offenders receiving the jail term. She reported a statistically significant 20% reduction in nighttime injury crashes, beginning two months after adoption of the policy. This reduction was greater than that observed in a comparison county. Cleary and Rogers compared Hennepin County's experience with fatal crashes with that of the rest of the State and again found greater reductions in Hennepin County.

Jones *et al.* (1988) studied the effect of the adoption of a Tennessee law mandating a two-day jail term for first offenders and a 45-day jail term for second offenders. Though there appeared to be some reduction in nighttime fatal crashes after the intervention, the timing did not coincide with the intervention. Comparison with the control states, Alabama and Kentucky, showed some similar patterns. Thus, no clear evidence for an effect could be found. They also examined recidivism patterns over an eight-year period and found a temporary reduction of 11% in recidivism rates after the law went into effect. However, this reduction was no longer evident three years after the law took effect. Although sanctioning patterns and jail records in two counties in the state indicated that the sanction was being applied to a large percentage of offenders (i.e., 80% or more), survey data from driver license applicants indicated relatively low awareness of the sanction and a general *perception* that it was not being applied to many offenders. Also, crowding of jails had the effect of increasing the time period between arrest and incarceration to as high as 18 months.

Earlier evaluations of laws and policies mandating jail terms for DWI offenders also had not shown such positive results as those reported by the Minnesota researchers (See U.S. Department of Transportation, NHTSA, 1985), and it has been hypothesized that the earlier programs were ineffective because the sanctions were not imposed on a large percentage of offenders. The finding by Jones *et al.* that the driving public did not believe that the sanction was being imposed even when it was being imposed may explain the disparity in the results of these earlier studies.

Two other studies of the effect of confinement combined with treatment on recidivism (Siegel, 1985b, 1985a; LeClair et al, 1987) studied recidivism of multiple offenders who received treatment in conjunction with confinement. The results of these studies are discussed below under HEALTH APPROACHES.

Despite the lack of consistently positive findings on the traffic safety effectiveness of jail, interest in incapacitating DWI offenders through confinement continues, and there appears to be growing concern about the cost and capacity of traditional jail. Two alternative forms of confinement are receiving more widespread use in response to this concern. These are community service and house arrest. House arrest using electronic monitoring devices has been used in some communities in the U.S. and Australia, but its effectiveness in incapacitating DWI offenders has not yet been objectively evaluated. Stenzel *et al.* (1987) studied the deterrent effects of a well-publicized community service program for DWI offenders in Baton Rouge, Louisiana. They found that public awareness of the sanction was brought to a high level, but had no effect on crashes.

Economic penalties are another traditional sanction for DWI. These have appeared in the form of fines, court costs, fees for rehabilitation programs, and increased insurance costs. Unfortunately, the traffic-safety effects of this general class of sanctions have not been studied carefully in the United States. However, a NHTSA-sponsored study of the effect of increased insurance costs is currently under way.

Traditional licensing sanctions, applied as a consequence of a DWI conviction, were reported in the prior reviews as effective in reducing DWI recidivism (Jones and Joscelyn, 1978 and U.S. Department of Transportation, NHTSA, 1985). This is in spite of the fact that research indicates that approximately two-thirds of drivers under suspension or revocation continue to drive to some degree (Wells-Parker and Cosby, 1988 and Ross and Gonzales, 1988). It has been hypothesized that many drivers who do drive after suspension or revocation do so less frequently and more carefully than they did prior to the license action. Recent studies have continued to confirm the traffic safety benefit of traditional license actions for DWI offenders. Blomberg *et al.* (1987) examined the effect of mandatory license suspensions for DWI convicts in Wisconsin where suspension rates went from 45 percent for first offenders in the year prior to the law to nearly 100 percent in the first year of the law. The new law group had a one-year recidivism rate 30 percent lower than that of persons convicted the prior year under the former law.

A follow-up study reported by Blomberg, *et al.* (1988) added additional years to the original study and found that the average number of alcohol-related crashes decreased about 25% after the new law. It also found that an intensive media campaign conducted by the Safety Commission in Milwaukee in early 1985 increased awareness of the law from 48% to 75% and increased the belief that everybody

convicted of DWI actually loses their license from 10% to 30%. Recidivism analyses indicated that re-arrest rates decreased nearly 50% after the adoption of the new law in the first six months after conviction, and that this reduction was maintained throughout the reporting period.

Many jurisdictions have offered rehabilitation programs for DWI offenders in lieu of license suspension or revocation. Studies of the effectiveness of these two different strategies typically have involved comparisons of groups of offenders receiving various combinations of rehabilitation "sanctions" and driver-license sanctions. These studies have also consistently shown license actions to be more effective in reducing subsequent drinking-driving than were the rehabilitation programs.

Several excellent studies of this type have been conducted in California. Peck (1987) summarized the results of six substudies conducted under the California DMV evaluation program[2]. Specific deterrent effects were assessed in all cases. The program evaluated several countermeasures: alcohol treatment, driver license suspension, implied consent legislation, warning letters for first-time DWIs, and a risk-assessment strategy for medically-impaired (including alcohol problems) drivers. Peck concluded overall that license suspension is generally more effective than rehabilitation in reducing alcohol-crash risk among DWI offenders, and that using both sanctions together is better than using either alone. Peck also found that the tougher sanctions and the *per se* law introduced in California in 1982 reduced the incidence of alcohol-related crashes and DWI recidivism. He recommended administrative *per se* suspension and mandatory suspension for both first and repeat offenders.

Peck's summary indicated that the evaluation of alcohol-abuse treatment as an alternative to license suspension found that the alcohol-treatment group had 70% more non-alcohol related crashes than did the license-action recipients. Drivers receiving 3-year suspensions had fewer non-alcohol related crashes and convictions than did those who received 1-year suspensions. However, the alcohol treatment group and the license suspension group had the same number of subsequent alcohol-related crashes. Further, the alcohol treatment group had 9% *fewer* alcohol-related crashes than did the license suspension group. Nevertheless, the license suspension still fared better with respect to alcohol-related and non-alcohol related crashes combined. Another evaluation of license suspension versus treatment for second offenders showed that the license suspension group had a subsequent crash risk close to that of the average driver, while the treatment group had a crash risk much higher than the average driver. Studies of first offenders showed similar

[2] The individual studies are described in a series of six separate reports: Marsh, 1987; Helander, 1986a; Perrine, 1984; Sadler and Perrine, 1984; Sadler, 1986; and Tashima and Peck, 1986.

results, and also showed that suspension alone was more effective that any other combination of sanctions studied, including a fine and jail only.

One argument often used against driver license actions is that it will cause the offender to lose his or her job. Wells-Parker and Cosby (1988) in Mississippi and Ross and Gonzales (1988) in New Mexico have examined this issue. In the Mississippi study, a group of convicted DWI offenders who had their licenses suspended, and a group who had not yet received their suspensions were queried about incidence and length of unemployment in the prior year with no significant differences detected. In New Mexico, 71 offenders receiving license revocations were interviewed, and 11% reported having lost their job because of the license revocation. The authors concluded that the reason more of the license-revoked drivers did not lose their jobs was that they continued to drive and did not report their revocations to their employers.

The *general deterrent* effect of driver license action has been studied much less than the specific deterrent effect. Vingilis *et al.* (1988) studied a variation of administrative per se license revocation in Canada involving a 12-hour license suspension at time of arrest for persons testing at .05% or above. They found a marginal effect on alcohol-related crashes, but pointed out that the law was not well publicized nor aggressively enforced (because of a lack of chemical testing instruments). They concluded that "laws to increase the celerity and certainty of punishment will have little deterrent impact without enforcement and publicity of the new laws."

Three recent studies have examined the deterrent effect of several sanctions with divergent results. Ross and Voas (1989) compared the results of roadside surveys and studies of DWI recidivism patterns in two Ohio communities, one where the judge imposed relatively harsh sanctions including jail, a high fine and license suspension, and another where less severe sanctions were given. Joksch (1988) compared the fatal crash experience of seven states in 1980 through 1985 which he characterized as having adopted severe penalties (jail, community service, mandatory loss of license or combinations thereof) with seven other states. Zador *et al.* (1988) examined fatal crash data in 1978 through 1985 from the 48 contiguous states to discern the effects of administrative license suspension/revocation, first offense mandatory jail or community service, and so-called per se laws (making driving with a BAC over a certain level a DWI offense per se).

The study by Ross and Voas employed roadside surveys of nighttime weekend drivers to attempt to measure general deterrent effects of the much more severe penalties imposed in the experimental jurisdiction. Drivers' BACs were measured, and questionnaires were administered asking drivers about their perceptions of risk of arrest and severity of sanctions. Though persons surveyed in the experimental jurisdiction consistently reported perceptions that the sanctions there were more

severe, the BAC survey results indicated no difference between the jurisdictions, nor were differences in recidivism rates observed. Because their sample size was relatively small and other potential threats to validity were present, the authors were tentative about rejecting the hypothesis that severe penalties may deter impaired driving. For example, they pointed out that the stringent jail penalties were not consistently carried out because of a lack of jail space, that their roadside surveys were publicized and that a street fair in a nearby community may have differentially affected the survey results from the comparison community. Nonetheless, they hypothesized that if the deterrence model is valid, its application in their study, though elevating the perception of risk of arrest and subsequent imposition severe sanctions, may not have had the desired effect because the actual risk of punishment was not high enough.

Joksch compared time series of the BAC distribution of fatally injured drivers in the jurisdictions with severe sanctions with the BAC distribution of fatally injured drivers in jurisdictions with less severe sanctions. He found that, although fatal crashes involving drivers with a high BAC were reduced in the experimental jurisdictions, there were similar reductions in the comparison jurisdictions. He qualifies his findings by stating that alternative explanations could be that earlier trends could have masked the effect in experimental states, that some comparison states could be voluntarily imposing similarly severe sanctions, that he had no measures of public awareness of the sanctions, and that lack of public awareness would make it difficult for the sanctions to have their desired effect. This study was criticized by Zador and Lund (1988) for using BAC data rather than selected crash data, for using "inappropriate" experimental and comparison states, and, in particular, including states adopting administrative license revocation among the comparison states.

Zador, *et al.* (1988) studied the effects of *per se* laws, administrative license suspension or revocation, and mandatory jail or community service for first offenders, using data from 48 states from 1978 to 1985. Overall, they found all three strategies reduced driver involvement in fatal crashes, 2.4% for *per se* laws, 4.6% for license suspension, and 2.2% for mandatory jail or community service. Detailed tabulations by time periods with different levels of alcohol-involvement, and by driver and crash factors showed complex, sometimes unexpected, patterns. *Per se* laws were associated with a significant increase in single passenger-vehicle crashes, and nearly always larger reductions at times when alcohol involvement tends to be low or moderate, than at times when alcohol involvement is usually high or very high. For administrative license suspension, and for mandatory jail or community service, the expected pattern appeared: reductions were larger at times when alcohol involvement is high or very high than when it is low or moderate. The authors employ alternative statistical techniques and obtain similar results. These findings are encouraging, but leave some questions unanswered. Among these is the effect of actual rather prescribed adjudication and sanctioning practices.

Actual practices often vary widely from those prescribed in statutes because of other laws with compensating effects or because of judicial discretion in imposing sanctions. For instance, Zador and associates included states allowing pre-trial diversion to treatment rehabilitation among the states with mandatory jail penalty, and no actual jail time had to be served for those so-diverted from the criminal justice system.

HEALTH APPROACHES

For purposes of this discussion, health approaches for intervention to reduce the drinking-driving problem will be characterized as efforts made with persons arrested for DWI to lessen their likelihood of engaging in that behavior in the future. These actions have typically taken place either through assessment of the individuals drinking problem, educational efforts, more intensive treatment efforts or some combination.

There is a trend in the United States toward requiring an increasing number of DWI offenders to undergo some form of alcohol problem assessment at some point in the process between arrest and release from probation or license revocation. Popkin *et al.* (1988) examined assessment procedures in the 50 states and critically reviewed several problem drinking assessment instruments either recently developed or currently in widespread use. The majority of the newer instruments employ either computerized administration, scoring or both. They observed that though recently developed instruments have attempted to sound psychometric principles in their development, the lack of a clearly defined criterion of problem drinking has prevented truly valid instruments from being developed. Nonetheless, assessments using these instruments and interviewer opinion are used in many jurisdictions to determine the extent and type of treatment required of such persons by the courts.

Earlier reviews (Jones and Joscelyn, 1978 and U.S. Department of Transportation, NHTSA, 1985) found little evidence of effectiveness of either educational or treatment interventions in reducing impaired driving recidivism among DWI offenders. Mann *et al.* (1988) reviewed evaluations of the effectiveness of such "rehabilitation" programs with respect to design, assessment instruments, follow-up procedures, and results. They concluded that several of the programs evaluated may have reduced recidivism, and note that only 15 rehabilitation evaluations have used control groups with random assignment of subjects, and only six evaluated traffic safety impact. The study gives a detailed discussion of major research design issues (lack of control groups and random assignment, and failure to use impact measures), and then reviews the evaluations with respect to these issues. The authors discussed the difficulty of using impact measures (e.g., need for large samples because of small effects of most programs) and concluded that multiple measures are needed. They pointed out the flaws in using recidivism alone as a follow-up measure (i.e., its dependence upon criminal justice system actions), and

gave supplemental measures (e.g., treatment / lifestyle measures). The authors believe that past rehabilitation programs may have been more effective than their evaluations showed, because of poor research designs, etc.

Nevertheless, more recent studies that were methodologically sound fail to provide any convincing evidence that rehabilitation alone can have much of an effect on highway safety. Stewart *et al.* (1987) reported on an extensive test of a carefully developed program incorporating both information about drinking and driving and an orientation toward building skills to help offenders separate drinking from driving. The full program had two segments, a 15-hour educational program over six weeks and an 11-hour counseling program over seven weeks. The experimental design used random assignment to treatment and control groups. Four groups were involved: (1) the traditional program in the county; (2) a 6-week education-only model program; (3) a 13-week education-plus-counseling program; and (4) a community service "control" group with minimal programmatic content. Departures from a pure random assignment procedure (as described) were minimal. The study found no significant differential program effects on drinking patterns and drinking-driving, but concluded that there was a small decline in heavy drinking and drinking-driving regardless of type of program. Because the differences between programs were so small, the authors concluded that the lack of differential effects was probably not due to small sample size. Also, no differential program effects were found in arrest recidivism, but this finding was inconclusive because of the short follow-time available for tracking subjects.

In the past, many of the educational programs for first offenders have been used in lieu of hard license suspension. That is, offenders have been "diverted" from receiving real licensing sanctions into education or treatment programs. In fact, it is the evaluation of the effectiveness of such programs that gave early indications of the effectiveness of license suspension or revocation in reducing recidivism. The more recent California studies discussed above confirmed this finding and also found that rehabilitation, in addition to license suspension was more effective than license suspension alone. Another recent study by Popkin, Rudisill, Waller and Geissinger (1988) indicated that educational programs when implemented in addition to licensing sanctions may also have some traffic safety effect. It found that, after controling for other factors related to DWI recidivism (for example, age and BAC at time of arrest), there was a small, statistically significant benefit as a result of attending the course. Although the main focus of the study was recidivism, no effect was found on crashes.

These findings conflicted with their earlier study of the effect of a similar program which, in effect, served as a diversion from a hard license suspension (Popkin, *et al.*, 1983). In that study, persons who attended the educational program and thus were entitled to restricted driving privileges, had higher recidivism rates than those who did not attend the program and received a hard license suspension.

More extensive treatment approaches have also been found effective in reducing DWI recidivism when conducted in concert with other sanctions. Siegel (1985b, 1985a) reports on the experience of the Weekend Intervention Program (WIP) in Dayton, Ohio. This program involves a weekend-long residential education, assessment and referral program for convicted DWI offenders. Siegel found a slightly-increased, non-significant, recidivism rate for first offenders attending WIP when compared to the experience of a non-equivalent group attending an educational program. The results for multiple offenders varied as a function of time after treatment, but were also statistically non-significant. A Massachusetts program combining treatment with incarceration for multiple offenders also reports positive results (LeClair *et al.*, 1987). In this program, inmates may receive detoxification, educational programs, and individual counseling while incarcerated. Six percent of 99 inmates participating in this program were incarcerated for 30 days or more within the next twelve months as opposed to 19% of inmates in other minimum security facilities. However, eligible participants were highly selected, and finally had to volunteer. Thus, the results cannot be generalized.

Some unexpected results have emerged from evaluations of health approaches. For example, Neff *et al.* (1983) evaluated the effect of probation, rehabilitation, and rehabilitation plus probation, on DWI recidivism. A group receiving none of these was used as a control. These researchers found that the administration of the Life Activities Inventory, an instrument used to assess intermediate measures of program effectiveness, had an effect on DWI rearrest rates for persons defined as non-problem drinkers, but that the interventions actually being evaluated had no such effect.

EDUCATIONAL APPROACHES

New knowledge about educational approaches to controling drinking-driving has come primarily from evaluations of the effectiveness of school-based programs aimed at transmitting knowledge about drinking-driving, influencing attitudes about drinking-driving, and reducing self-reported drinking-driving. Mann *et al.* (1988) in their review of this approach used the following dichotomy to characterize these programs:

- An informational approach, using affective processes involving either fear arousal or student involvement through participation or value clarification, or

- A learning-theory, behavior-based approach to developing skills necessary to avoid drinking and driving.

Recent evaluative work has included an assessment contrasting the effectiveness of a nine-hour, behavior-based program involving peer intervention in the drinking-

driving behavior of others (i.e., the NHTSA Peer Intervention Program) with that of a traditional informational program (McKnight and McPherson, 1986). In the evaluation, high school driver education students were randomly assigned to the two groups. Both programs showed immediate benefits in terms of knowledge and self-reported behavior, but only the peer intervention program showed self-reported behavioral benefits six months later. As with other evaluations of educational programs, the evaluation design did not permit measurement of actual DWI or crash behavior. In addition, Mann and his associates concluded that "the literature to this point suggests that behavior-based programs may have the greatest net positive effects, followed by affective involvement programs, informational programs and affective arousal programs."

Wodarski (1987) reported the results of a field test of a technique called Teams, Games, and Tournaments (TGT) teaching students about alcohol and its effects on driving. It employs a group approach that encourages students being supported and awarded by their peers. Student teams compete against other teams in weekly tournaments in which games are played that require students to answer questions on the class materials. More than 1,300 students in the ninth, tenth, and eleventh grades in five schools participated in the test which compared the TGT group with two other groups, a "traditional" educational instruction group, and a group that received no instruction. The study found that, compared to the other two groups, the TGT group had a significant increase in knowledge about alcohol, a significant improvement in attitudes about drinking and driving, a significant decrease in self-reported consumption of alcohol, and a significant increase in alternative behaviors for driving after drinking by themselves or others. These changes were maintained when measured two years after the instruction.

Simons-Morton and Simons-Morton (1988) argued that the conceptual basis of educational efforts be expanded to include as target groups at-risk populations and proximal others, the general public, and decision makers in organizations, communities and governments with such objectives as altering (1) personal alcohol and safety behaviors, (2) social norms, and (3) environmental influences. The careful implementation and evaluation of such broad-ranging educational approaches remains to be done.

TECHNOLOGICAL APPROACHES

The major recent application of technology to control drinking-driving has been the development of more advanced and practical devices to prevent or discourage a driver from starting his or her car. The idea that if a car could be designed to "automatically" prevent or deter drunk driving is a notion that has many desirable features in principle. Research and development related to the practical application of this concept has gone on since the 1960s. The basic approach is to require a driver to pass an in-vehicle test related to alcohol impairment before they start their

car. A test failure is linked to some action to deter driving--preventing the ignition system from working (ignition interlock) or activating a warning system that alerts the driver and others to the danger.

Both warning systems (Drunk Driving Warning System) and ignition interlock systems (Alcohol Safety Interlock System) were discussed in prior updates. With a Drunk Driving Warning System (DDWS) not taking the test or test failure triggers the emergency flashers. Also, if the car is driven above a certain speed, the horn honks intermittently. On the other hand, with the ASIS, test failure prevents the vehicle from being started.

A number of organizations concerned about the alcohol crash -problem have advocated the use of interlocks and in-vehicle test systems, including the American Medical Association (Anonymous, 1986a), and the Parliament of Victoria, Australia (Victoria, 1988a). In 1966, the U.S. Department of Transportation sponsored a workshop that brought interested persons together, including manufacturers, legislators, researchers and others to consider the state of the art of in-car warning and ignition interlock systems and to identify relevant issues regarding their development and application. And based on Congressional interest, the Department of Transportation prepared a report to Congress (Compton, 1988) on the potential application of ignition interlock devices.

Two basic types of alcohol test devices have been tested. One type requires the driver to pass a performance test, where performance correlates with BAC level, before starting their car. During the 1980s, a Drunk Driving Warning System was tested in California with drivers convicted of DWI. This system incorporated a Critical Tracking Test (CTT) where the driver had to center a needle in a dial by turning the steering wheel either clockwise or counterclockwise. The CTT was also tested in Canada and in Victoria, Australia for its accuracy in discriminating between drivers who were legally intoxicated or sober. Another performance-based device called the Tracometer was tested in Canada. In summarizing the findings from this research, Compton concluded that practical performance-test based devices (where performance correlates with BAC level) have not yet been developed. However, Compton believed the approach may be feasible for preventing alcohol-impaired driving if performance tests are identified that have high accuracy at low BACs and minimal individual differences in performance so that universal (rather than individually tailored) cutoff scores can be used. Such a performance-based device might have a collateral benefit of detecting impairment due to causes other than alcohol.

Meanwhile, considerable progress was being made in the technology of chemical testing devices for measuring a driver's breath alcohol concentration. Several devices appeared on the market that were shown in laboratory tests to be capable of correctly preventing 100% of vehicle starts at a BAC as a low as .04%.

However, all were susceptible to circumvention by relatively uncomplicated ploys. For example, some devices could be fooled by filling a balloon with ambient air and venting the balloon into the sensor. (See also Frank, 1988.)

California currently has a law authorizing judges to order the use of an interlock as a condition of probation for drivers convicted of DWI. That law, which is set to expire at the end of 1989, is currently being evaluated. An interim report (EMT, 1989) on the California study suggested that at least one of three ignition interlock devices could be successfully bypassed with relative ease: Nearly half of the group using this interlock in one county bypassed the device at least once. Similar data were not collected on the other two devices, so the extent to which these devices were bypassed remains unknown. The interim report also concluded that the interlock can prevent a substantial number of vehicle starts by drinking drivers, an average of 6.8 times per probationer over a period of about six months. However, prevented starts may not translate into prevented trips, since drivers could retake the test until they pass. The final report of the project is scheduled to be submitted to the California legislature in January, 1990.

At this juncture, there is not yet enough evidence available to judge how effective these devices will be in deterring alcohol-impaired driving and related crashes. In addition to the California evaluation, evaluations are planned or underway in other States (Ohio, Oregon). Also, NHTSA is conducting a project to develop model performance guidelines and test procedures that states can use in developing their own certification standards.

Another application of breath testing technology is the installation of coin operated breath testing instruments at retail sales outlets. Though this approach was studied in the late 1970s and found to be ineffective, it is again being aggressively marketed and further opportunities for effectiveness evaluations may soon exist.

PRIVATE-SECTOR APPROACHES

The approaches discussed above have been applied almost entirely by governmental agencies. One development since the last update of the state-of-knowledge of alcohol and highway safety has been a more active involvement of the private sector in alcohol-crash countermeasure efforts. Private-sector programs have focussed primarily on providing transportation alternatives for drinkers. The three strategies employed are:

- Encouraging social groups to use a designated driver who does not consume alcohol;

- Providing alternative sources of transportation to drinkers; and
- Promoting more responsible serving practices for alcoholic beverages.

Designated driver programs have taken one of two forms (Apsler, 1988). The first of these is having the social group identify an individual who will not drink or will drink moderately during an outing. In the second, more formal designated-driver program, the sponsor is a drinking establishment or some community organization that provides incentives for participation in the program, for example, free non-alcoholic drinks and snacks, or free alcoholic drinks at some later date. Evaluations of such programs have been limited to those using self-reports from surveys of target groups. Gallup Poll responses (Apsler, 1988) have indicated that virtually all Americans who attended social events where alcohol was present wanted people to employ designated drivers and would be willing to serve in such a capacity. A 1987 survey by Apsler and Harding of licensed drivers who were also drinkers indicated that over half of respondents had been in a group having a designated driver. However, reports from the more formal designated driver programs indicate that actual use of designated drivers was much less widespread (Apsler, 1988).

Safe ride programs involve providing safe transportation to potential impaired drivers. In these programs, friends and hosts provide a ride home to an impaired associate, or a commercial drinking establishment provides transportation (usually a taxi) to impaired patrons. Alternative forms include expanded availability of mass transit services during high risk evenings, round trip limousine service, etc. Harding *et al.* (1988a, 1988b) collected information that was descriptive of 52 such programs. They found that the typical year-around community program cost approximately $12,000 to operate. About one-half of the programs reported delivering over 400 rides per year, and one-quarter delivered 1,000 or more rides per year. As with designated driver programs, information about actual program effectiveness in terms of reduced impaired driving is lacking. NHTSA is planning to conduct a field test of the effectiveness of one or more of these programs for reducing the number of DWI trips.

While designated driver and safe-ride programs are intended to intervene to insure that intoxicated persons are transported safely, *responsible beverage service policies and practices* are intended to reduce the possibility that a guest or patron consumes too much alcohol, or that an underage person is served alcohol at all. Such programs typically involve developing sound management practices for proprietors of drinking establishments, and training servers in appropriate techniques to identify potentially impaired or illegal patrons and modify their consumption. To date, evaluations of such programs have been confined to examining the extent to which responsible serving practices are followed. Their effects in reducing drinking-driving have not been evaluated to date.

Saltz (1987) assessed the effect on serving practices at Navy enlisted clubs of a program involving extensive interaction with club management and an 18-hour training course for staff. Policy changes included promoting non-alcoholic beverages and food, and discontinuing the service of beer in pitchers. The five-week training course included monitoring customers' consumption and using techniques to pace and, if necessary, cut off service. This relatively extensive program in a somewhat controled environment resulted in a halving of intoxicated patrons at the test site. This result was based on computations from responses to interviews.

A six-hour course for servers (TIPS) was evaluated by Russ and Geller (1987) using pseudo-patrons (research assistants posing as customers) to evaluate the effect of the training on the serving practices of employees. The serving practices of trained staff were contrasted with those of all staff before the training and with those of untrained staff after the training. The number of interventions (attempts to modify pseudo-patrons drinking behavior) per pseudo-patron were counted and compared. It was found that the interventions of trained staff increased from an average of .75 per patron before the training to 3.24 per patron afterward. There was no change in the number of interventions per patron among the untrained group. Further, the mean BAC of patrons served by trained staff in the after period was .059% compared to .103% for untrained staff. Although these results appear promising, they must be viewed with caution because of small sample sizes (17 trained staff, nine untrained), the use of researchers as patrons, and the lack of detailed data about the server and the serving environment.

McKnight (1987) also used pseudo-patrons in evaluating a server program that incorporated training in management and serving techniques at establishments in Michigan and Louisiana. Program effect was also measured by contrasting pre-test and post-test scores of patrons' knowledge and attitudes, and by surveying 245 servers and managers about serving practices. Respondents in both states had increases in knowledge and improvements in attitude, and reported increases in responsible serving practices. However, managers in Michigan indicated an improvement in serving policies, while those in Louisiana did not. Analysis of pseudo-patron data indicated to McKnight that there were increases in interventions in Michigan but none in Louisiana. McKnight concluded that intervention will occur only where there is strong management support.

Another program aimed at responsible serving practices has been designed for large gatherings of persons such as sports events or rock concerts. The project is called TEAM, an acronym for Techniques of Effective Alcohol Management and was initiated in 1985 (Dickman, 1988). It involves a coalition that includes NHTSA; Allstate Insurance Company; CBS, Inc.; the International Association of Auditorium Managers, Major League Baseball, the Motor Vehicle Manufacturers Association of the United States, Inc.; the National Basketball Association; the National Safety Council; and the National Association of Broadcasters. TEAM assists managers of

sports arenas and stadia in developing policies to control the sales and consumption of alcohol and to prevent alcohol abuse. Training in strategies for impairment prevention and intervention is provided for food and beverage personnel and facilities staff. The program focusses on sports facilities as a locus of activities involving a broad range of groups interested in reducing alcohol-related traffic crashes. We are informed by NHTSA that, to date, 20,000 employees of public-assembly facilities have been trained in TEAM workshops in 78 facilities spanning 70 cities, 32 states, and five Canadian provinces. The effectiveness of this ongoing program has not yet been determined, but NHTSA was planning an evaluation effort as this report was being completed.

VEHICULAR AND ENVIRONMENTAL APPROACHES

Prior state-of-knowledge updates have recommended the development of countermeasures aimed at making the driving task easier for alcohol-impaired drivers. Unfortunately, very little effort appears to have been directed explicitly toward this initiative, although many suggested vehicular and highway improvements targeted at drivers in general would certainly benefit alcohol-impaired drivers. For example, as indicated in Chapter 3 of this report, some modalities of vision begin to be impaired at relatively low BACs. Failure of an impaired driver to distinguish the edge of a roadway could lead to a run-off-the-road crash. Epidemiologic data indicate that alcohol-impaired drivers are highly over-represented in single-vehicle crashes, especially at night. This could be due in part to alcohol-impaired drivers having difficulty in recognizing the edge of the roadway. If this is so, making the roadway more visible could reduce the number of run-off-the-road crashes by alcohol-impaired drivers.

Ranney and Gawron (1986a) conducted a simulator study involving 12 subjects to determine the effects of highly-visible pavement edge lines on driver performance negotiating curves. Subjects' performance was examined at BACs of .00%, .07%, and .12%. They found, among other things, that, compared to a no-edge line condition, a standard 4-inch edge line reduced the simulated vehicle's lateral position error at high driver BACs by about a foot. No effect was found at low BACs. Wide edge lines were associated with additional, although statistically non-significant, benefits.

Similarly, measures designed to make the vehicle and roadside environment more forgiving after a crash has occurred, should also benefit alcohol-impaired drivers more than non-impaired drivers, particularly in light of the recent findings (also discussed in Chapter 3) of the injury-potentiating effect of alcohol. Further, research indicates that alcohol-impaired occupants are even less likely to use an active restraint than are non-impaired occupants.

SUMMARY AND CONCLUSIONS

The most significant new development in the area of alcohol-crash countermeasures is the enormous increase in the level of activity. Not only are there many more programs, but there are also many more *evaluations* of these programs. In the 1978 report, we were able to discuss only two examples of legal-approach countermeasures in the United States that had been evaluated. In this report, we discussed one review of the effects of legal minimum drinking age laws that cited 82 evaluations of those laws (U.S. General Accounting Office, 1987). Overall, this report's bibliographic database on countermeasures contains approximately 350 documents.

However, the distribution of countermeasure activity has not been uniform across the various countermeasure approaches (see table below). Twenty-eight percent of all countermeasures documents in our collection deal with some form of control of alcohol availability, a subject that was mentioned only in passing in the 1978 report[3]. Not surprisingly, an even larger percentage (49%) deal with legal deterrence and incapacitation, and a moderate percentage (16%) examine the health approach. Relatively few of our documents address the other approaches.

Breakdown of Countermeasure Documents by Approach

Approach	Percentage of Documents
• Legal	
Availability	28
Deterrence	49
• Health	16
• Educational	6
• Technological	4
• Private-Sector	6
• Vehicular and Environmental	5

All of this activity has generated substantial new knowledge about ways to deal with the alcohol-crash problem. In particular, it has become clear that checkpoints

[3] The total of the percentages exceeds 100, because some documents are concerned with more than one approach.

may be one of the most effective enforcement strategies for deterring impaired driving, and that their effectiveness can be enhanced through the use of more advanced technology in the form of passive alcohol sensors and preliminary breath testers.

Among sanctions for those identified through enforcement and adjudication as impaired drivers, license actions remain the most consistently effective for reducing DWI recidivism. License actions have also been shown to have a general deterrent effect, particularly when well-publicized and applied administratively. Studies of the effect of other severe sanctions such as mandatory jail terms and community service have not yet yielded consistent results. This may be due in part to a disbelief by the public that the sanctions are actually applied.

A number of evaluations have shown that public information and education (PI&E) programs enhance the effectiveness of deterrence-oriented countermeasures. When used with a credible deterrent threat, PI&E has been found not only to increase awareness and knowledge of a threat, but also to decrease recidivism and, in some instances, to reduce alcohol-related crashes.

Reducing the availability of alcohol by raising the minimum legal drinking age has been shown to markedly reduce alcohol-related fatalities. In addition, evidence is building that raising the cost of beverage alcohol through increased taxes may have potential. Treatment and education for convicted impaired drivers still appears to be an ineffective or marginally effective countermeasure, both in terms of special deterrence and general deterrence. However, more recent studies continue to confirm past studies indicating that such rehabilitative sanctions can be effective when applied in addition to traditional sanctions such as driver's license suspension or revocation. New knowledge is also being gained in the area of server intervention and alternative transportation for alcohol-drivers, but the traffic-safety impact of these two countermeasures is not known.

Other suggested approaches have either been insufficiently developed, insufficiently evaluated, or both. Programs in this group include school-based educational programs, alcohol-interlock devices, occupant protection devices that impaired drivers will or must use, and roadway improvements designed with the impaired driver in mind. It seems likely that, as limits are reached in further marginal returns from some other popular approaches (particularly those applying the deterrence model), more attention will be given to these largely untried and unproven approaches. It may then be appropriate to begin to design and test large-scale systems approaches using an integrated combination of other approaches.

CHAPTER 6

CONCLUSIONS AND RESEARCH NEEDS

This chapter presents the major conclusions of this state-of-knowledge update, and identifies areas where research is needed. It lists the most significant findings with respect to trends and new developments about:

- The nature and extent of the alcohol-crash problem in the United States and
- Responses to that problem.

THE ALCOHOL-CRASH PROBLEM

The most significant development since the last state-of-knowledge update is the reduction in alcohol-related fatalities and in drunk driving in general. Data from the Fatal Accident Reporting System indicate that about 40% of fatally injured drivers have a BAC of .10% or more rather than the 50% experienced in the early 1980s. The number of alcohol-related fatalities has also decreased about 9%, and the overall alcohol-crash risk per person in the general population has decreased about 14%. It is reasonable to expect reductions in other kinds of alcohol-related crashes (though at lower levels, due to the smaller percentage of alcohol-impaired drivers in less severe crashes), but this cannot be stated conclusively because of a lack of scientific studies of trends in alcohol involvement in non-fatal crashes. Finally, roadside surveys indicate that there has been a large reduction in the percentage of non-crash involved drivers with a BAC of .10% or more.

With respect to the components of the alcohol-crash problem, research indicates that female drivers are becoming more involved in alcohol-related crashes than they were when prior updates were published. Nevertheless, the alcohol-crash problem is still an overwhelmingly male problem. It is also apparent that the general decline in alcohol-related fatal crashes has been reflected in a decline for drivers of all age groups during this period, with the largest decreases in the two youngest age groups. Data suggest that the youngest drivers now represent a significantly smaller proportion of the alcohol-crash problem than they did 10 years ago and that drivers in the 25-34 age group account for a significantly larger proportion of the problem than they did 10 years ago. Data suggest little or no change in the age distribution of alcohol-crash risk per licensed driver in recent years. There is no strong indication of any change in the percentage of persons with severe drinking problems in either alcohol-related crashes or nighttime weekend driving populations. Finally, research has provided additional support for the hypothesis that drivers with a variety of behavioral problems are a factor in alcohol-related crashes. The magnitude of the problem created by such individuals is not known.

Despite this progress, drinking-driving still remains a serious public health problem, comparable in magnitude to such other problems as suicide, homicide, arteriosclerosis, liver cirrhosis, and diabetes. The size of the problem is indicated by our having to describe as progress a situation in which 40% of all fatally injured drivers have a BAC of .10% or more.

Major topics for *epidemiologic research* are:

- The incidence of alcohol-related non-fatal crashes;
- The incidence of drinking-driving among non-crash involved drivers;
- Alcohol as a risk factor by type of traffic crashes, including fatal, injury, property damage, and pedestrian accidents;
- Risk factors associated with personality characteristics, their relation to alcohol abuse, and the magnitude of the alcohol-crash problem attributable to the so-called alcohol-impaired problem driver; and
- Trends in drinking patterns and trends in alcohol-crash risk factors.

Topical areas for *experimental research* are:

- The biochemistry of alcohol effects;
- The effects of amount of alcohol consumed (especially at the lower BAC levels) on degree of impairment of various sub-groups of persons under different conditions; and
- The mechanism and nature of alcohol tolerance.

RESPONSES TO THE ALCOHOL-CRASH PROBLEM

Substantial new knowledge has been gained about legal-system interventions for drinking-driving. Checkpoints can be effective in deterring alcohol-impaired driving, and driver-license sanctions are effective for achieving both specific deterrence and general deterrence. Public information and education campaigns can enhance the effectiveness of enforcement-based countermeasures, driver-license countermeasures, and, perhaps, other countermeasures that are applied by the criminal justice system. The effectiveness of other severe sanctions such as mandatory jail terms and community service remains to be established.

CONCLUSIONS AND RESEARCH NEEDS

Reducing the availability of alcohol, especially through raising the minimum legal drinking age, clearly reduces alcohol-related fatalities, and there is some evidence that raising the cost of beverage alcohol through increased taxes may also be effective. Treatment and education for convicted impaired drivers still seems to have little effect on DWI recidivism, but could be effective when applied in addition to traditional sanctions such as licensing control.

Areas where more *developmental and evaluative research* are needed include:

- School-based educational interventions;
- Programs for developing responsible alcoholic beverage serving practices;
- Countermeasures for alcohol-impaired pedestrians;
- A workable criterion measure for problem drinking and refinement and validation of instruments for problem drinker identification within the DWI population;
- Comprehensive community-based programs to reduce impaired driving;
- Initiatives for regulating the price of beverage alcohol;
- The deterrence value of economic sanctions (including fines) for DWI offenders;
- The use of public information and education (PI&E) to enhance the deterrent effects of the legal approach; and
- Various countermeasures using the legal approach for general deterrence and specific deterrence of drinking driving, for example:
  - ✓ Sobriety checkpoints;
  - ✓ Administrative license sanctions;
  - ✓ "Hard" versus restricted license suspensions and revocations;
  - ✓ License plate and vehicle confiscation;
  - ✓ Special driver license sanctions for young drivers;
  - ✓ Interlock devices;
  - ✓ Server liability laws;
  - ✓ Lower legal limits for blood alcohol concentration; and
  - ✓ Laws prohibiting plea bargaining.

NHTSA is currently sponsoring several deterrence-oriented research projects of the type listed above, including projects dealing with: the use of PI&E in combination with various sanctions and enforcement strategies, increased insurance premiums as an informal "sanction" for DWI, youth license sanctions, dram shop liability laws, in-vehicle alcohol testers, and administrative driver license sanctions.

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