Alcohol and Highway Safety 2001:

A Review of the State of Knowledge

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT HS 809 383		

4. Title and Subtitle	5. Report Date
Alcohol and Highway Safety 2001: A Review of the State of Knowledge	November 2001
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
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9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Mid-America Research Institute 611 Main Street Winchester, MA 01890	11. Contract or Grant No. DTNH22-98-C-05109

12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
National Highway Traffic Safety Administration Office of Research and Traffic Records 400 7th Street, S.W. Washington, DC 20590	Final Report
	14. Sponsoring Agency Code

15. Supplementary Notes

Amy Berning was the Contracting Officer's Technical Representative (COTR) for this project.

16. Abstract

Examines the state of knowledge of alcohol-impaired driving at the millennium. The review covers the entire spectrum of related research, from the nature of the societal problem created by alcohol-impaired driving on through the description and effects of programs that have addressed that problem. The review covers scientific literature published since 1990.

17. Key Words	18. Distribution Statement
DWI, DUI, alcohol-impaired drivers, alcohol safety, program effectiveness, alcohol-crash problem, alcohol-safety countermeasures, alcohol-related traffic crashes, traffic crash risk	This report is available from the National Technical Information Service, Springfield, Virginia 22161, (703) 605-6000, and free of charge from the NHTSA web site at www.nhtsa.dot.gov

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
unclassified			

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EXECUTIVE SUMMARY

This report is a comprehensive review of the state of knowledge of alcohol-impaired driving. The review covers the entire spectrum of related research, from the nature of the societal problem created by alcohol-impaired driving on through the description and effects of programs that have addressed that problem. The review covers scientific literature published since 1990.

METHOD

This report deals with two major areas, the alcohol-crash problem and possible solutions to that problem. In the first area, the alcohol-crash problem, we briefly discuss the epidemiologic literature addressing crashes in which drivers, pedestrians or bicyclists have measurable amounts of alcohol in their blood. Both the number and risk of such crashes are examined in order to obtain an estimate of the magnitude of the alcohol-crash problem nationwide. Next, we examine in more detail how alcohol affects people and degrades their performance in driving or walking in ways that may lead to crashes. Finally, we describe the characteristics of individuals who drink and drive.

The second major area of this review is concerned primarily with alcohol-crash countermeasures that have been tried and evaluated. We define several types of countermeasures and discuss the impact of specific countermeasure programs of each type. The possible impact of some other countermeasures that have been proposed but not implemented or evaluated is also discussed briefly.

We have exercised considerable care in selecting the materials used in this report, concentrating on the most scientifically reliable studies that are available to the general reader. The main focus is on studies relevant to the alcohol-crash problem in the U.S., but some studies from other countries are included as appropriate. Sources include both collections and individual documents that have not been placed in traditional collections.

While the emphasis was on documents published since 1990, some earlier studies are included where needed to provide perspective and a basis for comparison with more recent studies. Also, some studies have been reported in more than one document. We have cited only one of the documents for such studies.

Not all of the studies identified in our literature search are discussed in detail in the review. We have sought those studies that best illustrate current thinking and have looked for background material from earlier research that led to current thinking. For the most part, the treatment is from the perspective of the traffic safety generalist, with departures into more specialized technical matters occurring only when these matters are central to the subject under discussion. The reader is asked to refer to the studies cited for a more detailed treatment.

Finally, we have emphasized literature that defines alcohol-crash involvement and risk objectively in terms of the *blood alcohol concentration* (BAC) of the individuals that were studied. Exceptions to this rule include studies based on well-designed surveys and some studies that measure impairment or alcohol-crash involvement by the opinion of a police officer who investigated the crash. Studies have used a variety of units for measuring BAC. In this review, we use percent alcohol, weight per unit volume of blood, as the unit, and have converted BACs measured in other units to this unit.

FINDINGS

The Alcohol-Crash Problem

At the millennium, a driver's blood alcohol concentration (BAC) remains as the single most important independent variable for measuring the extent of the alcohol-crash problem. Prior research has clearly established that human performance related to driving is substantially impaired in virtually everyone at BACs of .10 and higher, and recent research provides evidence that many such behaviors are impaired significantly at BACs as low as .05. Epidemiologic studies provide evidence that impaired performance at such low BACs is manifested in increased crash risk

The BAC level at which crashes involving alcohol becomes a societal problem deserving of widespread societal action is dependent upon the level of alcohol-crash risk an informed public is willing to tolerate, given available alternatives to reducing that risk. A level of .10 has been used in prior state of knowledge reviews in defining crashes of sufficiently high alcohol-crash risk to use the number of crashes involving a driver at .10+ as a measure of the alcohol-crash problem. By this measure, the alcohol-crash problem currently includes about 12,500 *fatalities* per year in the U.S. This figure would be even higher if a lower BAC level (such as .05) were used in defining the alcohol-crash problem. The National Highway Traffic Safety Administration (NHTSA) has described the problem in terms of fatalities with *any* alcohol present, that is, a BAC of .01 and higher. By that metric, the number of alcohol-related fatalities would be about 16,000 per year.

This measure (and related measures) of the alcohol-crash problem have declined markedly since objective data on the problem became available. The fatality *rate*, an especially important measure since it accounts for population growth, has declined nearly 50% since 1982, but has flattened out in recent years, suggesting that the problem needs increased emphasis to maintain the overall downward trend. Clearly, alcohol-related fatal crashes are a much smaller societal problem at the millennium than they were 20, or even 10, years ago.

The situation with respect to non-fatal crashes involving alcohol is less clear -- BACs are not routinely measured in non-fatal crashes. However, data from

NHTSA indicate that 9% of the injury crashes and 5% of property-damage-only crashes involved alcohol in the judgement of police officers investigating the crashes.

Research continues to show that young drivers are more often involved in alcohol-related crashes than any other comparable age group. Alcohol-crash involvement rates, share of the alcohol-crash problem, and alcohol-crash risk all reach their peaks with young drivers, with the peaks for fatal crashes occurring at age 21.

A large proportion of the alcohol-crash problem involves young White males. In 1998, 84% of fatal-crash involved drivers with BACs of .10+ were male, and more than 70% were White. However, certain racial / ethnic subgroups have higher involvement *rates* than other subgroups. Of these, American Indians have the highest rate, and Asian / Pacific Islanders the lowest.

The impact of other biographical variables on drinking and driving is less understood. Crash data suggest that:

- drivers who are unemployed are much more likely to be alcohol-positive than those who are employed;
- drivers in the mid-income range have the highest prevalence of alcohol use, and drivers in the high-income range and the low-income range have the lowest;
- and drivers with the least formal education have the highest prevalence of alcohol use, and drivers with the most formal education have the lowest.

Many studies have found that beer is the preferred beverage of drinking drivers. There is evidence that heavier drinkers prefer to drink at bars and other persons' homes, and at multiple locations requiring longer driving distances. Younger drivers have been found to prefer drinking at private parties, while older, more educated drivers prefer bars and taverns.

Studies continue to show that drinking-driving is primarily a nighttime, weekend phenomenon. Household surveys indicate that male drivers make three times as many trips within two hours after drinking any amount of alcohol than do females. Using this measure, such drinking drivers as a whole made 1.7 drinking-driving trips in the past 30 days, with the oldest drivers making the most trips and the youngest drivers making the fewest. Motorcycles have the highest rate of alcohol-related fatal crashes, followed by light trucks, passenger cars, and large trucks in that order.

Data from the Fatality Analysis Reporting System (FARS) suggest that only a few percent of fatal crashes involve drivers who have recent convictions of DWI, and studies in California have found that only 8% of drivers in fatal crashes had one or more DWI offenses on their driver record. However, studies in Minnesota suggest a much higher percentage. In California, crashes of all types actually decreased with number of priors, and in terms of sheer number of alcohol-related

crashes, persons with no priors had the highest rate of involvement. The characteristics of repeat offender DWIs and first offender DWIs have in general been found to be quite similar in many respects, but DWIs with large numbers of priors have been found more often to have long-standing problems of alcohol dependency, and to differ on the severity of their alcohol problems, rather than on their demographics. A history of participation in multiple treatment programs is common for these individuals, as well as diagnoses of psychiatric pathology.

Research suggests that experiencing a prior negative event (such as an arrest or a crash) has a positive effect on one's decision to drive after drinking, tending to make a driver less inclined to drive after drinking or to drive more cautiously after drinking. Factors that have a negative effect include a lack of knowledge of the impairing effects of alcohol or a misinterpretation of the cues of impairment, a reduction of inhibitions at higher BACs, a lowered perception of alcohol-crash risk, and a neglect of social norms after drinking. Research suggests that it is not just the impairing effects of alcohol that favors a decision to drive after drinking; some drivers plan to drink knowing they will drive afterward.

The scientific literature on the characteristics of *alcohol-impaired pedestrians and bicyclists* indicates that the alcohol-crash problem for pedestrians is, as it is for drivers, predominately a male problem. Very high BACs are common for pedestrians in alcohol-related fatal crashes, especially for those in the 35-44 age group (which is estimated to have 41% at .10+ and 18% at .20+). Alcohol-impaired bicyclists in fatal crashes are also more likely to be male, with the highest percentage of bicyclists at .10+ occurring for those the 45-54 age group, an older peak age group than that for either drivers or pedestrians.

Locations of pedestrian alcohol-related crashes as a whole are most likely to be near the victim's home or a short distance from the starting point of the trip. Recent research on race and ethnicity indicates that Native Americans have the highest prevalence of alcohol-related pedestrian crashes, roughly three time that of Caucasians at .20+. Blacks and non-Black Hispanics fall somewhere between these two extremes.

Response to the Alcohol-Crash Problem

We find that the literature reporting scientific evaluations of alcohol-crash countermeasures deals overwhelmingly with countermeasures using strategies of deterrence and incapacitation carried out by elements of the criminal justice system, that is, the Traffic Law System (TLS). These evaluations clearly indicate that many TLS-based countermeasures have been effective in reducing alcohol-related crashes. These countermeasures include those seeking general deterrence as well as specific deterrence.

Among those that were primarily *legislative* in nature, laws establishing administrative license revocation (ALR) have been found to reduce alcohol-related fatal crashes by up to 40%. This adds support for prior research showing

the effectiveness of driver license sanctions in general. Also, there is considerable evidence that laws that lower the legal BAC limit from .10 to .08 can reduce alcohol-related fatalities by some 6-8%.

Zero tolerance laws for persons under 21, which in effect prohibit driving with any alcohol in one's system, have been shown to result in reductions in alcohol-related fatal crashes ranging from zero to 40%. The key elements for this law are also effective enforcement and increased awareness of the law. States where DUI or DWI cases are essentially diverted into zero tolerance cases and there is no net increase in youth alcohol-related driving citations, are less likely to receive the potential beneficial effects of such laws.

Recent evaluations of comprehensive changes in State laws that have been accompanied by activities to implement those laws have shown positive results in reducing surrogates of alcohol-related crashes from 8% to 20%.

Enforcement-oriented programs that use multiple strategies (including sobriety checkpoints and saturation patrols) and are supported by strong public information and education efforts can be effective in reducing various surrogates of alcohol-related crashes by some 10% - 30%. Sobriety checkpoint programs alone can achieve positive impacts on alcohol-related crashes of the order of 20%.

Countermeasures emphasizing *sanctions* for drivers convicted of DWI have received considerable attention in the recent evaluative literature. There is now evidence that treatment and rehabilitation combined with driver's license suspension can be more effective than suspension alone, obtaining recidivism reductions in the 30% range.

Three forms of *sanctions used as an alternative to jail* can be effective in reducing recidivism for DWI. These sanctions are: intensive supervision probation, electronic monitoring, and sanctions tailored expressively for individual offenders. For these sanctions, 33% - 50% recidivism reductions over traditional sanctions have been found. Other alternative sanctions that show promise but need further evaluation are day reporting centers, and possibly, victim impact panels.

A number of evaluations of *vehicle-oriented sanctions* provide evidence that sanctions that require the vehicle to be impounded or seized can achieve recidivism reductions of 50% or more. A similar effect has been noted for just seizing and destroying the offender's license plates. Ignition interlocks that prevent an offender from starting his or her car can also reduce recidivism (by up to 69%) during the period in which interlocks are attached, but the effect disappears after the interlocks are removed. The use of specially marked license plates for DWIs also reduced recidivism in one state.

Large-scale experimentations with countermeasures not involving the Traffic Law System (TLS) have begun to appear in recent years. Two recent *community trials programs* had TLS components, and one of these evaluated the TLS components which were composed primarily of enforcement system support. The evaluation indicated a positive impact on alcohol-related crash surrogates in the

10% - 20% range. A large-scale, long-range prevention program consisting of *school-based education* in avoidance of alcohol-related problems suggested reductions in alcohol use and misuse, and a recent study suggests a positive effect on alcohol-related crashes as well. Another education-oriented program has just been developed, this time to enable medical practitioners to identify and help patients with alcohol problems, but its impact on alcohol-related crashes is not yet known. A year-around *ride-service program* providing a transportation alternative to drinkers has been evaluated recently and appears promising.

Another class of countermeasures has been aimed at limiting the availability of alcohol. Of these, legislation *raising the legal minimum drinking age* has been the most extensively evaluated, with results that clearly indicate a reduction of 9% to 14% in alcohol-related fatal crashes for the affected age group. Early attempts to limit alcohol availability have not shown any positive impact on alcohol-related crashes, but preliminary evaluations of alcohol-server programs indicate positive results. *Server training* now appears to offer alcohol-crash reduction potential, especially if used as a component of a broad community-based program. Evaluations of behavioral tests that help servers and social hosts identify alcohol-impaired guests also suggest potential impact on alcohol-related crashes. Finally, there is some hard evidence that more vigorous *enforcement of alcohol sales to minors* through such programs as "Cops in Shops"can reduce alcohol-related crashes for under-21 years old drivers.

Several countermeasures that attempt to *reduce the probability of an impaired driver becoming involved in a crash* have been suggested and even tested in field experiments, but their possible impact on crashes has not been determined. Included among such countermeasures are wider and better-marked road edges, rumble strips to warn drivers they have left the roadway, and drunk driver warning systems to alert roadway users of the presence of an alcohol-impaired driver.

While a significant number of alcohol-related crashes involve pedestrians and bicyclists, there have been very few evaluations of countermeasures for this component of the alcohol-crash problem. A multi-faceted pedestrian countermeasure program in Baltimore, Maryland, involving an extensive public information and education (PI&E) campaign, reflective caps for persons in high-risk zones, and improvements to the roadway environment in the high-risk zones was evaluated recently. The program achieved positive results, reducing surrogate measures of pedestrian alcohol crashes by 16 - 22%.

The recent scientific literature on programs to reduce excessive drinking among college students (and resultant alcohol-related crashes) does not reveal many program evaluations, although many colleges have such programs in place. We found four types of programs that had been the subject of an evaluation:

- normative programs - education and publicity aimed at changing the perception of the norm regarding heavy binge drinking;

- alcohol education - education on the nature, consequences, and avoidance of excessive drinking;
- peer education - involvement of students' peers in alcohol education; and
- brief interventions - short-term, intensive motivational sessions.

Three evaluations of *normative programs* were identified, all indicating a positive effect on excessive drinking. The evaluations of the alcohol education programs (at six colleges) could be more accurately described as assessments and also indicated a positive effect on excessive drinking. The one evaluation of a *peer education program* found a positive effect, but the *brief intervention* evaluations obtained conflicting results, one indicating a positive effect and the other indicating no effect. While none of these evaluations measured drinking-driving or alcohol-crash impact, the normative programs seemed to offer the most potential. Also, other non-evaluative studies suggest that the programs that have a component that promotes the use of designated drivers could reduce the prevalence of drinking-driving.

In short, the literature on anti-drinking programs for college students provides considerable information on the nature and location of such programs, but very little information on the effects of such programs, especially their effects on the alcohol-crash problem.

Some of the limitations to alcohol-crash countermeasure evaluations should be kept in mind when interpreting the above findings on effectiveness. It is especially important to note that many evaluations have been conducted against a background of other anti-DWI activity, making it difficult to ascribe an observed effect to any single countermeasure. This is especially true of multi-state evaluations of legislative countermeasures where the evaluations often have not analyzed the level of activity supporting the implementation of the countermeasure in the various States. Clearly, when considering the simultaneous application of more than one countermeasure, one cannot assume that their total impact would be the sum of their individual impacts. For programs involving many countermeasures, this could lead to the absurd conclusion that the program would eliminate more than 100% of the alcohol-crash problem.

Another limitation is that most of the evaluations were of countermeasures that were implemented in just one or a few jurisdictions. Thus, it cannot be assumed that such a countermeasure would be effective in every jurisdiction, regardless of local conditions. Similarly, a finding of no effect in one or two jurisdictions does not necessarily mean that the countermeasure would be ineffective in every jurisdiction. And of course, the lack of any evaluation at all also does not necessarily indicate that a countermeasure is ineffective.

CONCLUSIONS AND RECOMMENDATIONS

The Alcohol-Crash Problem

We conclude that currently available hard data on the nature of the alcohol-crash problem are adequate for defining the gross prevalence of alcohol-impaired drivers in fatal crashes. For example, it is known that some 12,500 persons are killed each year in crashes in which one or more drivers had a BAC of .10+. (This figure increases to about 16,000 for crashes in which a driver had a BAC of .01+.) There is also evidence that drivers at BACs much higher than .10 account for a disproportionate share of the alcohol-crash problem. Since virtually all drivers are impaired at .10+ (and recent research indicates impairment and high risk at even lower BACs), using a BAC of .10+ as a measure is reasonable for determining a lower bound to the current magnitude of the problem. Less is known about the role of alcohol in non-fatal crashes, since comprehensive data based on objective measures of impairment (such as driver BAC) do not exist at the national level.

Research also clearly indicates that the size of the alcohol-crash problem in general has declined significantly in recent years, to the point that it can be said that alcohol-related fatal crashes are a smaller societal problem at the millennium than they were 10 or 20 years ago.

The characteristics of persons who drink and drive are also generally better known than they were at the times of prior state-of-knowledge updates. Basic demographic data for such variables as age and sex exist in abundance, and data are starting to appear on ethnic and racial characteristics. From this knowledge, it is more clear than ever that, overall, young drivers, and especially, young White males account for a large share of the alcohol-crash problem. Other demographics are available for certain groups of drinking-drivers (e.g., DWIs), but, except in small studies, generally not for drivers in crashes. Also, the drinking patterns and drinking-driving patterns of drinking drivers are becoming better defined. The role of prior DWI convictions in drinking-driving, is now better understood, indicating that while multiple DWI offenders have higher recidivism rates than first offenders, persons with no priors at all may have the highest involvement in total crashes and in alcohol-related crashes of all degrees of severity. Further, research suggests that repeat DWI offenders and first offenders share many of the same characteristics.

Our review found that pedestrians and bicyclists account for a much smaller, but still highly significant, portion of the alcohol-crash (approximately 1,500 fatally injured pedestrians at .10+ BAC). Data from FARS indicate that fully 34% of fatal pedestrian crashes involved either a pedestrian or a driver whose BAC was .10 or higher, and that very high BACs were common among alcohol-positive pedestrians. The contribution of alcohol-impaired bicyclists to the problem is much lower than that of pedestrians, probably of the order of a few hundred fatalities a year at the .10+ level.

In general, the literature suggests that data from existing research are sufficient for defining broad groups of alcohol-crash targets, but are still inadequate for identifying more narrowly defined target groups. For example, there are sufficient data to say that young male drivers should be a target group, but not enough data to say that young, unemployed males without a college diploma who drive light trucks are an important subgroup to be singled out for special countermeasure action. In a word, more research is needed on the characteristics of alcohol-crash involved drivers and their relative risk. Specific areas where significant knowledge gaps exist and where significant research efforts are recommended are:

- non-fatal alcohol-related crashes,
- characteristics of drivers not involved in alcohol-related crashes,
- alcohol-crash risk as a function of biographical and other pertinent variables,
- the relationship of biographical variables other than age and sex (especially race and ethnicity) to alcohol-related crashes,
- data on a range of other variables needed for more detailed definition of the alcohol-crash problem, for example, sociological, economic, and environmental variables, and
- driving history and its relationship to alcohol-related crashes.

Responses to the Problem

Our review reveals that nearly all alcohol-crash countermeasure programs that have been evaluated have focused on the pre-crash phase. Their objective has most often been to reduce driving after drinking, although there has been increasing attention given to reducing excessive drinking before driving. The great majority of programs have used strategies of deterrence and incapacitation carried out by elements of the criminal justice system.

Countermeasures with strong evidence favoring their effectiveness are:

- Administrative license revocation (ALR) laws in conjunction with strong public information and education activities and efficient case processing procedures;
- Laws reducing the legal BAC limit to .08, in conjunction with ALR laws;
- For drivers under the age of 21:
  - ✓ laws raising the legal minimum drinking age and
  - ✓ laws lowering the legal BAC to zero or near-zero;
- Comprehensive changes to state laws accompanied by enhanced activity to implement those laws;
- Enforcement of existing DWI laws in general (and sobriety checkpoints in particular) with strong PI&E components;

- Traditional sanctions using actions against the driver license;
- Carefully designed treatment and rehabilitation programs when used in combination with other sanctions;
- Certain alternative sanctions requiring extended contact with offenders, including intensive supervision probation, electronic monitoring, and sanctioning programs tailored to individual offenders;
- Removal of an offender's vehicle (or access to it);
- Alcohol interlocks (while the interlocks are installed);
- Comprehensive community-based programs; and
- Multi-component pedestrian programs.

Countermeasures that have shown promise but for which evaluations of alcohol-crash impact are as yet inconclusive are:

- Other alternative sanctions such as day reporting centers;
- Enforcement of laws against alcohol sales to minors;
- Year-around ride-service programs;
- Server training programs; and
- School-based education programs.

While the state of knowledge about ways of dealing with the alcohol-crash problem has grown enormously since the first comprehensive report on alcohol and traffic safety, significant knowledge gaps remain. The most glaring of these is knowledge about the effect of countermeasures that do not rely on the Criminal Justice System. These other countermeasures include approaches focusing on technology, the vehicle, the highway environment, and the more effective control of alcohol consumption. To date, such approaches have either been insufficiently developed, insufficiently evaluated, or both. Two additional areas where significant new knowledge is needed are: countermeasures targeted at specific groups of drinking drivers, (e.g., groups defined by such variables as race, ethnicity, and type of vehicle), and pedestrian countermeasures.

We recommend a coordinated program of countermeasure research and development to fill these gaps. For the short term, the major thrust of operational programs should be on maintaining the 20-year downward trend in alcohol-related crashes. This will require refining current deterrent / incapacitation programs and generating and evaluating new such programs. But concurrently, new approaches will have to be developed, evaluated, and refined for later widespread adoption as the marginal utility of deterrence-based programs becomes exhausted.

1 - INTRODUCTION

This report is a comprehensive review of the state of knowledge of alcohol-impaired driving. The review covers the entire spectrum of related research, from the nature of the societal problem created by alcohol-impaired driving on through the description and effects of programs that have addressed that problem. The review covers scientific literature published since 1990. A special review of the scientific literature about drivers who have been convicted more than once of driving while impaired by alcohol (DWI) was also performed under this contract, and has been published as a separate report (Jones and Lacey, 2000).

BACKGROUND

More than thirty years have passed since the first comprehensive review of the state of knowledge about alcohol and highway safety conducted by the U.S. Department of Transportation (1968). NHTSA has sponsored three updates of the landmark 1968 study, the first published in 1978 (Jones and Joscelyn, 1978), the second in 1985 (U.S. Department of Transportation NHTSA, 1985), and the third in 1989 (Jones and Lacey, 1998a). The 1978 update was a complete re-work, both in form and content. It re-examined the literature used in the prior review, added new material published since 1968, and developed a new structure for integrating and synthesizing the material.

The 1985 update had more modest objectives. Called an "interim update" by its author, it included the "most clearly important studies and findings from the period from January 1978 to December 1982," and left "large portions of the original. . .intact." The 1985 update included the citations from the 1978 report in a separate section from the citations used in the 1985 report. Together, the two reports contain some 500 citations.

The third and most recent NHTSA-sponsored comprehensive review (Jones and Lacey, 1989) covered the same subject matter as the 1978 review, but its focus was more restricted, concentrating on trends and new developments in the field since 1978.

Shortly after completing the 1989 review, NHTSA sponsored an in-depth review of the literature on alcohol-crash countermeasures published during the period 1980-1989 (Jones and Lacey, 1991a; Jones and Lacey, 1991b). This review was the first of the NHTSA-sponsored reviews to incorporate separate critical reviews of each of the more important documents, most of which were cited in a synthesis of the literature.

The last NHTSA-sponsored review (Jones and Lacey, 1998a) was limited to research dealing with characteristics of drinking-drivers and drinking-driving that are associated with increased levels of alcohol-crash risk and/or alcohol-crash incidence. It covered the period 1989-1994.

Two other comprehensive treatments of the subject have been conducted since 1978. The first was the report of the Presidential Commission on Drunk Driving (1983). It incorporated commentary and opinions, as well as literature, but its objective was to generate action rather than to provide an integrated source of information.

The second examination of the entire subject occurred shortly after the 1984 update was published. The vehicle was an international conference sponsored jointly by The Johns Hopkins Medical Institutions and the Alcoholic Beverage Medical Research Foundation. The U.S. Department of Transportation and the National Safety Council were co-sponsors. The results of the conference were published in the conference proceedings (Turner, Borkenstein, Jones et al., 1985). Ten years later, Wagenaar, Zobeck, Williams, et al. (1995) attempted a meta-analysis of evaluations of countermeasures employing one or more components of the criminal justice system, and gave rough estimates of the effects of broad categories of countermeasures. However, the lack of data needed for such an analysis, plus several other factors, precluded a rigorous analysis of the effects of the countermeasures.

Other reviews of varying quality have been conducted since 1978, but their scope has been more restricted -- see, for example, (American Bar Association, 1986). Meanwhile, the level of activity in the field since 1989 has been high. Citizen activist groups have continued to play a large role in stimulating new legislation, and there has been increased emphasis on drinking-driving by other elements of the Traffic Law System. Most important, there has been a very large increase in both quantity and quality of evaluative research, much of which has been sponsored by NHTSA. This report draws together new research in all pertinent areas and places it in perspective in the spirit of the 1978 and 1989 reports.

SCOPE AND APPROACH

The first scientific studies of the alcohol-crash problem in the United States began to appear in the 1930s. One of the first of these (Heise, 1934) defined the four basic approaches to studying the alcohol-crash problem, *viz.*:

1. measurement of the amount of alcohol in the body,
2. measurement of alcohol effects on human performance in a laboratory setting,
3. measurement of alcohol effects on actual driving performance, and
4. estimation of alcohol usage among various populations of drivers.

The 1978 update noted that these four approaches were still being followed, and indeed, they are still being followed today, although approaches 2 and 3 are sometimes combined into a single, "experimental," approach.

In addition to defining the alcohol-crash problem, solutions to the problem were being sought as it was currently understood. The 1978 report observed:

> "Early efforts at prevention and control in the U.S. were, with few exceptions, nonscientific and noncomprehensive. Moreover, few alcohol safety programs in this country have been formally evaluated. However, the effectiveness of several alcohol safety programs in foreign countries has been examined with some care, so that there is at least an initial knowledge base on means of dealing with the problem." (p. 3).

As indicated above, this is no longer the case. There is now an extensive scientific literature on alcohol-crash countermeasures, much of which has been published in recent years.

This report deals with both of the major areas alluded to above, the alcohol-crash problem and possible solutions to that problem. The first area, the alcohol-crash problem, is discussed in three chapters, covering the approaches set forth by Heise, but in a different order that is consistent with prior state of knowledge reviews. First, in Chapter 2, we present a broad overview of the epidemiologic literature addressing crashes in which drivers, pedestrians or bicyclists have measurable amounts of alcohol in their blood. Both the number and risk of such crashes are examined in order to obtain an estimate of the magnitude of the alcohol-crash problem nationwide. In the next chapter, we examine in more detail how alcohol affects people and degrades their performance in driving or walking in ways that may lead to crashes (Chapter 3). Then, in Chapter 4, we describe the characteristics of individuals who drink and drive.

The second major area of this review is concerned primarily with alcohol-crash countermeasures that have been tried and evaluated. This material is presented in a single chapter (Chapter 5), which defines several types of countermeasures and discusses the impact of specific countermeasure programs of each type. The possible impact of other countermeasures that have been proposed but not implemented or evaluated is also discussed briefly.

Next, we examine possible future directions of the alcohol-crash problem over the remainder of the decade (Chapter 6), and then present our conclusions and recommendations of the study (Chapter 7). An extensive bibliography containing references cited in the review and other pertinent documents not cited is presented following Chapter 7.

We have exercised considerable care in selecting the materials used in this report, concentrating on the most scientifically reliable studies that are available to the general reader. The main focus is on studies relevant to the alcohol-crash problem in the U.S., but some studies from other countries are included as appropriate. Sources include both collections and individual documents that have not been placed in traditional collections. Types of repositories that were contacted include:

- Specialized libraries of highway safety literature maintained by such organizations as NHTSA and The University of Michigan Transportation Research Institute;
- Specialized computerized information services such as TRIS (and its highway transportation subfile, HRIS), MEDLARS, MEDLINE, and EMBASE;
- Specialized information clearinghouses and abstracting services such as NIAAA; Johns Hopkins; Alcohol, Drugs, and Driving: Abstracts and Reviews; Addiction Research Foundation; Alcohol, Drugs and Traffic Safety: Current Research Literature, and Alcohol Epidemiologic Database;
- General libraries having collections in related disciplines such as medicine, law, and the social sciences at Harvard University; and
- General repositories and information services maintained by governmental agencies such as NTIS and the Library of Congress.

The University of Michigan Transportation Research Institute (UMTRI) library was the central focus and coordinating element of the literature search and collection activities. This facility now has a collection of some 90,000 documents relating to highway safety, not including some 50,000 on microfiche. We also searched the internet for pertinent documents using such search engines as Altavista and Yahoo.

As indicated above, the emphasis was on documents published since 1990, but some earlier studies are included where needed to provide perspective and a basis for comparison with more recent studies. Also, some studies have been reported in more than one document. We have cited only one of the documents for such studies.

Not all of the studies identified in our literature search are discussed in detail in the review. We have sought those studies that best illustrate current thinking and have looked for background material from earlier research that led to current thinking. For the most part, the treatment is from the perspective of the traffic safety generalist, with departures into more specialized technical matters occurring only when these matters are central to the subject under discussion. The reader is asked to refer to the studies cited for a more detailed treatment.

Finally, we have emphasized literature that defines alcohol-crash involvement and risk objectively in terms of the *blood alcohol concentration* (BAC) of the individuals that were studied. Exceptions to this rule include studies based on well-designed surveys and some studies that measure impairment or alcohol-crash involvement by the opinion of a police officer who investigated the crash. Studies have used a variety of units for measuring BAC. In this review, we use percent alcohol, weight per unit volume of blood, as the unit, and have converted BACs measured in other units to this unit. Thus, in our units, a BAC reported as .05% or .05 would be interpreted as .05 grams of alcohol per 100 milliliters of blood.

2 - OVERVIEW OF THE ALCOHOL-CRASH PROBLEM

Prior research has established that there is a significant alcohol-crash problem in the United States. At the millennium, we need to know the size and nature of that problem and its etiology. This chapter is concerned with the general magnitude of the alcohol-crash problem nationwide as can be estimated from (1) studies of the crash involvement of drinking drivers, pedestrians, and bicyclists; and (2) studies that have examined the involvement of such persons relative to that of others. The alcohol-crash problem as it involves specific groups is discussed further in Chapter 4.

DRINKING DRIVERS

Crash Involvement

Fatal Crashes. The 1978 report noted the lack of any national study methodically investigating the many variables that describe highway crashes, and had 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.

By the time the next update was completed (U.S. Department of Transportation NHTSA, 1985), initial data from NHTSA's Fatality Analysis Reporting System (FARS) had become available. 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 where the midpoint for this group of drivers was 47%.

More useful data from FARS became available for use in the next update which was published in 1989 (Jones and Lacey, 1989). The newly available data revealed a steady decline in the percentage of drivers with BACs exceeding .10 since 1980. *The decline amounted to about 11 percentage points in absolute terms, or a relative percentage of 22%.* A similar decline was reflected in NHTSA 's expansion of the data from 15 states that measured the BAC of a high percentage of fatally injured drivers to all states[1], and there was also a decline in the percentage of fatally injured drivers at the higher BACs. The next update (Jones and Lacey, 1998a) reported a continuing downward trend in the percentage of drivers in fatal crashes who had been drinking, both for drivers with any

[1] The NHTSA algorithm is described in (Klein, 1986).

measurable amount of alcohol in their blood (.01+) as well as those at or exceeding most states' illegal limit[2] for blood alcohol concentration (BAC) of .10. For the latter group, this percentage had gone from 30% to just under 19%, a decrease of 37%.

The latest FARS data available for this review (U.S. Department of Transportation NHTSA, 1999) adds another year (1998) to the alcohol-related fatal crash time series. **Figure 2-1** plots annual number of fatalities in fatal crashes involving a driver with .01+ BAC and with .10+ BAC. The continuing downward trend for both measures over the entire range of years is apparent, but there is also a distinct flattening out of the .01+ series starting in about 1992. The same effects are present in series for the alcohol-related fatalities as a percent of all fatalities (**Figure 2-2**) and for the fatality *rate* per 100,000 population (**Figure 2-3**).

The 1999 FARS report of 1998 data also shows that 39% of all fatal *crashes* involved a driver or non-occupant with a BAC of .01+ but did not report the percentage of all fatal crashes that involved a driver or non-occupant with a BAC of .10+. However, analysis of the FARS data for 1998 by the authors of this report indicated that about 30% of the fatal crashes involved at least one driver or non-occupant with a BAC of .10+. This is about 60% of the percentage estimated in the 1978 and 1985 state of knowledge reports.

We also examined 1998 FARS data on the BACs of fatally injured drivers. We used the data from the 15 "good reporting states" that have been studied in past examinations of the alcohol-crash problem (Fell and Nash, 1989). The 15 states were selected for these studies because the states measured the BACs of at least 80% of fatally injured drivers. **Figure 2-4** shows the percentage of the fatally injured drivers that exceeded various BACs, and includes a plot of the midpoints of data from various early studies *circa* 1970 analyzed in the 1978 update. Three points from NHTSA's 1999 FARS report of 1998 data are included on the graph.

Figure 2-4 is interesting in several ways. First, it illustrates very clearly the large reduction during the past 30 years in the percentage of fatally injured drivers at all BAC levels. Percentage reductions from 1970 were in 30%-35% range for all BACs except the very highest, which appear somewhat lower. Second, the percentages from the FARS report (which used NHTSA's algorithm for filling in missing data) are a bit lower than those from the fifteen "good reporting states." This suggests that the percentages of all fatally injured drivers at given BACs in the 15 states really were lower than those for the U.S. as a whole, or that the missing data from the 15 states were from drivers with low BACs.

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[2] We use the term "illegal limit" rather than the commonly used "legal limit" to make clear that this is the level at and above which it is clearly illegal to drink and drive.

Figure 2-1: Alcohol-Related Fatalities with a Driver at BAC .01+ and .10+, 1982-1998

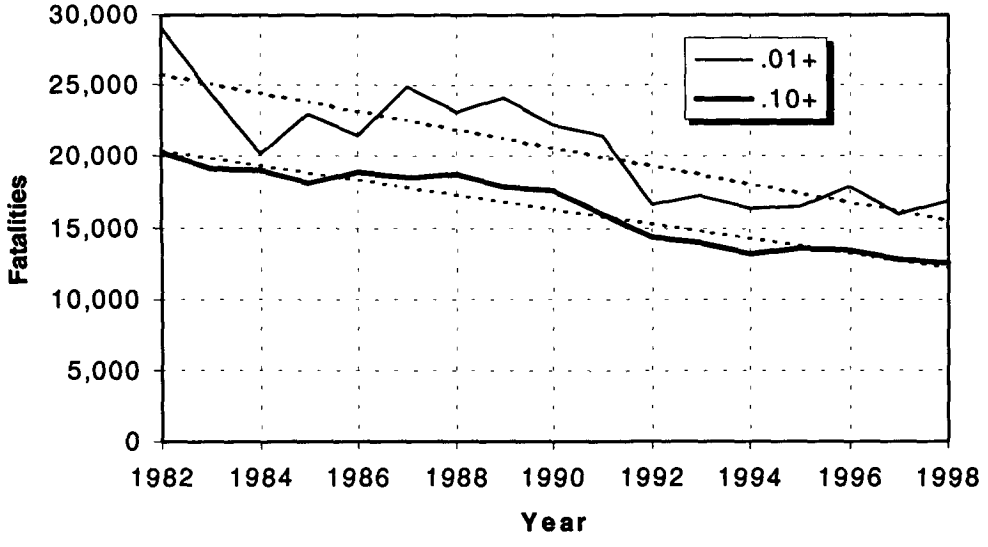

Figure 2-2: Alcohol-Related Fatalities as a Percentage of All Fatalities, 1982-1998

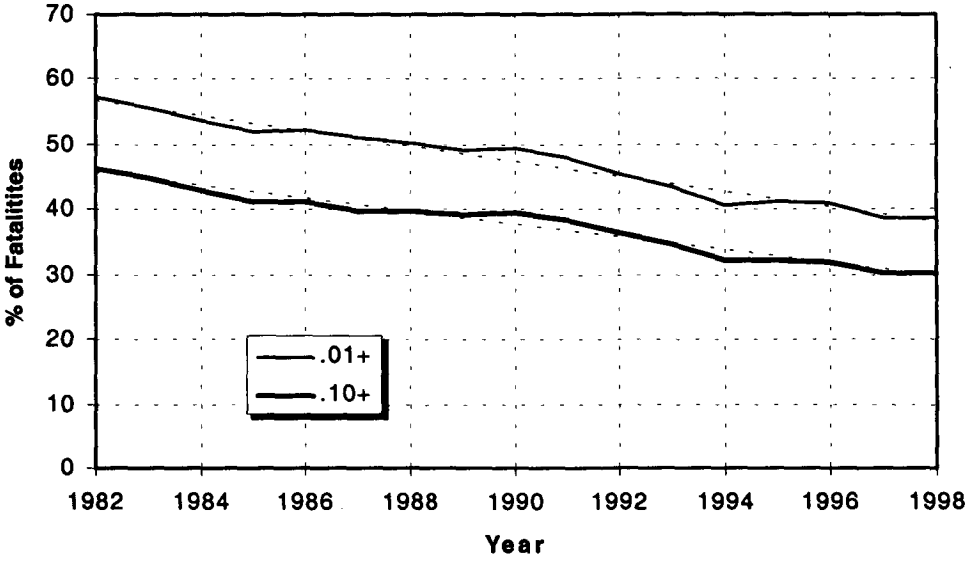

Figure 2-3: Alcohol-Related Fatality Rate per 100,000 Population, 1982-1998

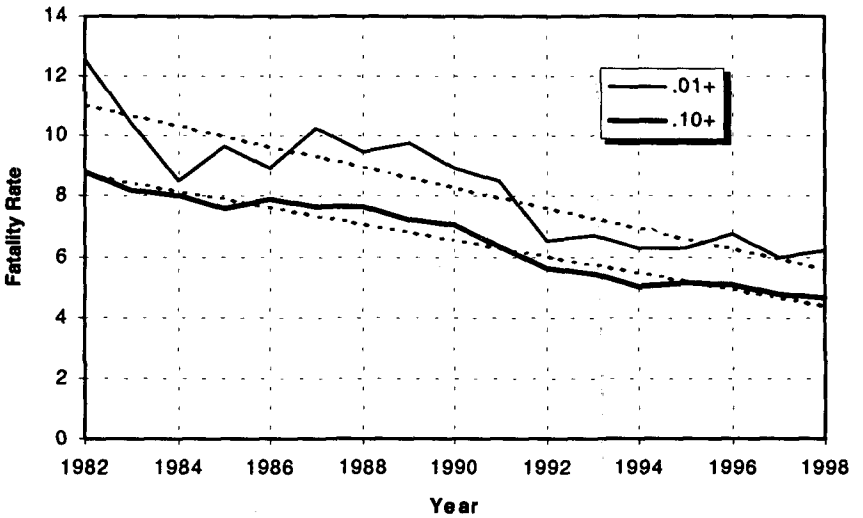

Figure 2-4: Percentage of Fatally Injured Drivers Exceeding Specified BAC by Data Source

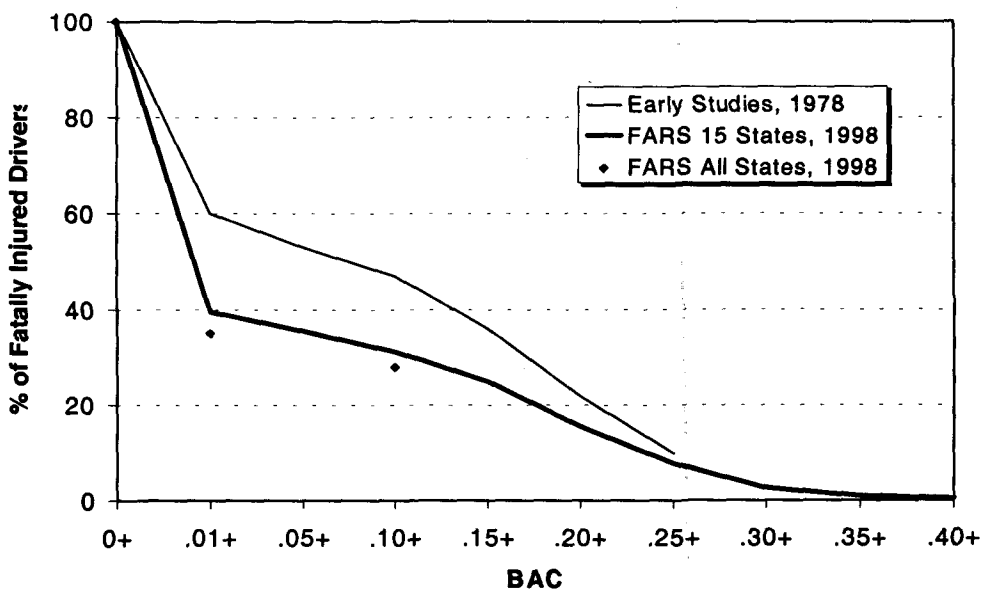

Figure 2-5: BAC Distribution of Fatally Injured Drivers in 15 States, 1998

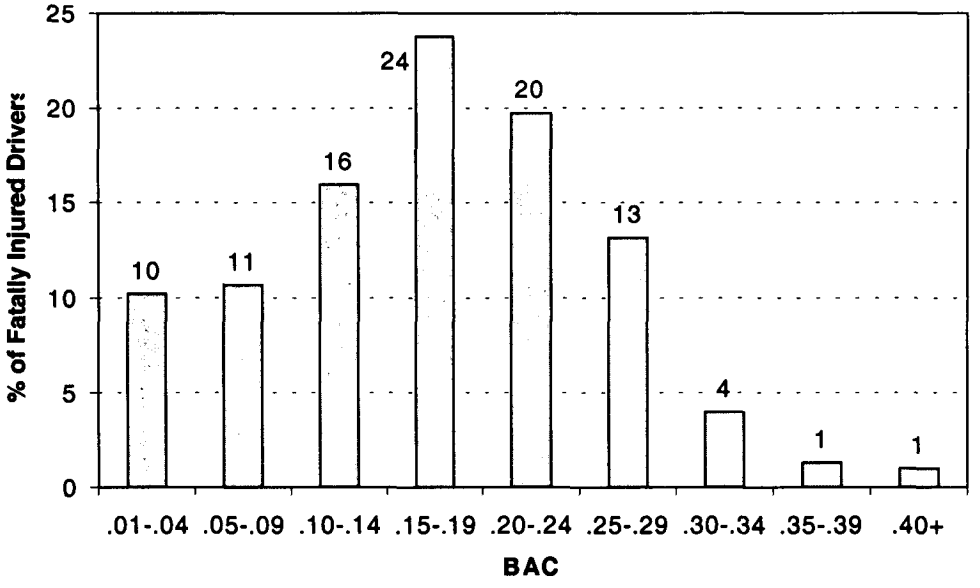

Figure 2-5 shows the BAC distribution of the fatally injured drivers with non-zero BACs. The largest percentage of such drivers (24%) had BACs in the .15 - .19 range. Only 10% were in the .01 - .04 range, and 11% were in the .05 - .09 range. Seventy-nine percent had BACs of .10+, and 63% had BACs of .15+. Other researchers (Simpson and Mayhew, 1991; Simpson and Mayhew, 1992) have reported similar results for high-BAC drivers in earlier examinations of FARS data, labeling such drivers as "hard-core" drinking drivers.

Non-Fatal Crashes. The 1978 report reviewed four U.S. studies dating back to 1938, concluding that 9-13% of drivers in injury crashes and about 5% of drivers in property damage crashes had a BAC of .10+. The 1985 report estimated that, *circa* 1980, 18% of injury crashes and 5% of property damage crashes involved drivers with a BAC of .10+.

Recently, non-fatal crash data from NHTSA's General Estimates System (GES) became available. The GES contains data obtained from a national probability sample of traffic crashes for which a police accident report (PAR) was prepared. About 50,000 such PARs are collected and coded each year by NHTSA. The GES includes data on the *investigating officers's judgement* of whether alcohol was involved in the crash. The latest reported data from GES (U.S. Department of Transportation NHTSA, 1999) indicate that 9% of the injury crashes and 5% of property-damage-only crashes involved alcohol in the officers's judgement. These percentages are remarkably close to those in the1978 state of knowledge report quoted above; however, the 1978 estimates were for crashes involving drivers with a BAC of .10+.

Non-Crash Involved Drivers

Objective measurement of the drinking behavior of drivers using the roads who are not involved in crashes has been examined in a number of studies. Some of these have been studies of the relative risk of a crash. Relative risk is defined here as the probability of a crash involving a driver at a given non-zero BAC divided by the probability of a crash at a BAC of zero. Citing an earlier article by Hurst, the 1978 update showed that relative risk defined in this way can be calculated by dividing the percentage of crash-involved drivers at a given non-zero BAC by the percentage of crash-involved drivers at zero BAC, and then dividing that number by the percentage of non-crash involved drivers at the given BAC divided by the percentage of non-crash involved drivers at zero BAC. Thus, the percentage of non-crash involved drivers at any given BAC was a by-product of the relative-risk studies.

The 1978 update presented data from five such studies dating back to 1938, indicating that some 1%-3% of the non-crash involved drivers had a BAC of .10+. All but the 1938 study selected the non-crash involved drivers from drivers of vehicles traveling at the same times and places as those of the crashed vehicles. The "roadside survey" method was used for collecting the data in all of these studies of non-crash involved drivers. This method involves stopping drivers selected from the traffic stream. The BACs of those agreeing to cooperate are measured, and they are asked to respond to a short survey.

In the early 1970s, more than 100 roadside surveys were performed to help evaluate the effectiveness of the 35 sites that participated in NHTSA's Alcohol Safety Action Projects (ASAP). For the most part, these were conducted during nighttime hours during weekends. In 1973, the University of Michigan conducted a NHTSA-sponsored nationwide survey of 24 cities and counties with populations over 20,000. Its data were collected on Friday and Saturday nights between 10:00 p.m. and 3:00 a.m. These studies found that 5%-6% of these nighttime weekend drivers had a BAC of .10+, compared to the 1%-3% percent of the drivers sampled around the clock in the relative risk studies.

Since 1973, two other nationwide roadside surveys have been conducted, the first in 1986 and the second in 1996. The first survey (Lund and Wolfe, 1989) was conducted by Mid-America Research Institute under the sponsorship of the Insurance Institute for Highway Safety. Its locations were designed to match the 1973 locations as closely as possible. It found that 3% of the drivers had a BAC of .10+, compared to 5% in the 1973 survey, a reduction of about 40%. The reduction in the percentage of drivers with a BAC of .05+ was also nearly 40%.

The 1996 survey was conducted at locations chosen to produce data that would be comparable to that from the 1986 survey and was carefully designed to do so (Voas, Wells, Lestina et al., 2000). It found that the percentage of drivers at .10+ to be 3% (all percentages rounded to the nearest integer), and the percentage

at .05+ to be 8%. Both figures were unchanged from 1986. However the percentage of drivers in the .01-.05 range changed considerably, from 18% to just 9%.

In recent years there have been several nationwide telephone surveys querying a sample of drivers in general about their drinking-driving and related topics. These surveys provide another perspective on the alcohol-crash problem. NHTSA has sponsored such a survey every two years since 1991. Respondents have been a nationally representative sample of persons age 16 or older.

The latest NHTSA survey was conducted in 1999, but its results were not available at this writing. Balmforth summarized the results of the 1997 survey (n=4,010) and compared some of its results with those from prior surveys (Balmforth, 1998). She found that 24% of the 1997 respondents said they had driven within two hours after consuming alcoholic beverages at least once during past year. These individuals were defined as "drinking-drivers" and, on average, consumed 2.5 drinks prior to driving. The drinking-drivers also said they made an average of 1.7 drinking-driving trips in the past 30 days. The report by Balmforth also estimated the BACs of the drinking-drivers, finding that 13% had a BAC of .05+ and that 5% had a BAC of .08+.

In comparing the 1997 results with those from prior surveys, data from respondents of age 16-64 were used. The percentage of drinking-drivers in this group changed very little in the four surveys, amounting to 28% in the first two surveys and 24% and 25%, respectively, in the last two surveys. With respect to number of self-reported drinking-driving trips made in the past 30 days, there was a significant decline during the first three surveys (from 2.3 to 1.5), followed by a small increase to 1.6 in the 1997 survey[3]. No comparisons of BACs among the four surveys were included in the report.

The National Household Survey on Drug Abuse (NHSDA) conducted by the Federal Government is another source of self-reported information on drinking and driving in the United States. This survey has been conducted periodically since 1971, and the 1996 survey contained a special Driving Behaviors Module funded by NHTSA. A summary of the design and findings of the 1996 survey drawn from this module is contained in a government report (Townsend, Lane, Dewa et al., 1998).

The Driving Behaviors Module involved 11,847 personal interviews in a nationally representative sample of households. The respondents were individuals age 16 and older reporting that they had driven a motor vehicle in past 12 months, and whether they had driven within two hours after drug or alcohol use. The findings relative to alcohol did not differ greatly from those of the NHTSA survey discussed above. Twenty-seven percent of the respondents reported that they had driven within two hours of alcohol use, including 4% who had used both alcohol and other drugs. The report also presented estimated BACs of those who had

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[3] Drinking-driving trips are discussed in more detail in Chapter 4.

driven within two hours after alcohol use, indicating that 8% had a BAC of .08+ and that 30% had BACs in the .02 - .079 range.

Crash Risk

One way of assessing the role of alcohol in causing a traffic crash under a given set of conditions is to estimate the relative risk of a crash, where relative risk is defined as in the above discussion of non-crash involved drivers. This approach recognizes that crashes are probabilistic events and that one must express the role of alcohol in probabilistic terms. Prior studies of relative risk have relied on the *case-control* method to obtain data for estimating relative risk. The term derives from the study of diseases, and MacMahon and Pugh (1970) describe the method as:

> " . . . an inquiry in which groups of individuals are selected in terms of whether they do (the cases) or do not (the controls) have the disease of which the etiology is to be studied, and the groups are then compared with respect to existing or past characteristics judged to be of possible relevance to the disease." (p. 241)

Most important, MacMahon and Pugh point out that such studies are better described as *case-comparison* studies since they do not incorporate the type of control that may be obtained in experimental studies that are conducted in the laboratory. This distinction has to be kept in mind when interpreting the results of so-called case-control studies in the field of traffic safety. Note that the case-control method has many variants and does not require pair-wise matching of cases and controls.

Using data from several studies of relative risk, the 1978 update concluded 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.

Prior reviews found no rigorous studies of relative risk nationwide, nor has this review found any such study that was designed *a priori* to measure relative risk nationwide[4]. However, a very careful "case-control" analysis of relative risk was performed recently using 1995 and 1996 data from FARS for the "case" component and data from the 1996 roadside survey for the "control" component (Zador, Krawchuk, and Voas, 2000).

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[4] NHTSA has sponsored a new study of alcohol-crash risk in two locations, but no results were available at this writing.

The Zador study matched the FARS cases to the roadside survey cases as closely as was possible under the constraints of the study. Two notable exceptions were made to help increase the sample size of the FARS drivers, (1) retaining crashes that occurred during the midnight and 1:00 a.m. hours and (2) accepting crashes for the Friday and Saturday nights for the whole year rather than for just the period during which the roadside surveys were conducted. Drivers of four-wheeled passenger vehicles who were in the FARS group were classified by the number of crash-involved vehicles (one, two, and any number of vehicles). Both fatally injured drivers and drivers involved in fatal crashes were studied for each classification of number of crash-involved vehicles, resulting in a total of six groups. Relative risk was calculated for each group as a function of driver age, sex, and BAC. In calculating relative risk, Zador used the odds of a crash at a given BAC relative to the odds of a non-crash at the same BAC, the resulting unadjusted odds ratio being equal to the relative risk calculated as described above.

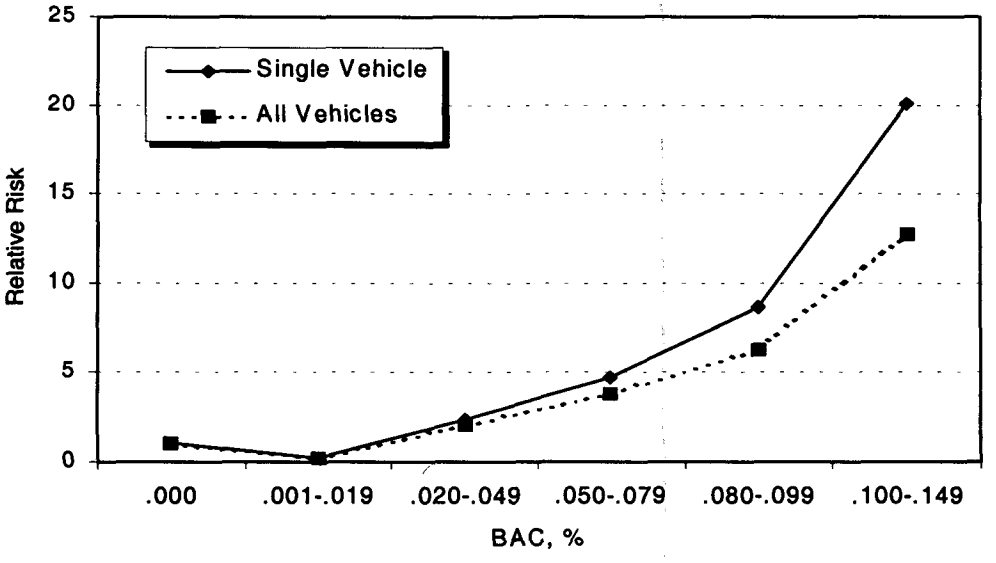
Figure 2-6 shows the results of the analysis for two groups of drivers of age 21 and over, (1) drivers involved in single-vehicle fatal crashes and (2) drivers involved in all fatal crashes. Risk curves of both groups are roughly the same for both groups up to a BAC of about .05, and then start to diverge. At BACs in the .080-.099 range, single-vehicle drivers in fatal crashes had a relative risk of about nine, compared to a relative risk of about six for drivers of all vehicles.

Of interest is the reduced relative of risk below 1.0 (≈.2) at BACs in the .001-.019 range, implying a lower risk than at BAC=0. This is remindful of the infamous "Grand Rapids Dip" (noted in the 1978 update) found in the well-known 1963 case-control study, but since discredited as being due to disproportionate representation of demographic subgroups in different blood alcohol concentration class intervals (Hurst, Harte, and Frith, 1994). Hurst and associates found no such dip after applying a statistical model to the data that accounted for such differences, finding that relative risk increased monotonically with BAC regardless of self-reported drinking frequency. (An earlier hypothesis for the dip was that the persons at low BACs were more often higher frequency drinkers who, for some reason, were safer drivers at low BACs.)

Relative risk did not vary by driver sex for these two groups of age 21+ drivers. Relative risk rose to over 80 (not shown on the graph) at BACs of .15+, but with large variances, apparently due to the small number of drivers at these BACs. The relative risk of drivers under the age of 21 also had high variances at the higher BACs and is discussed later in Chapter 3.

We found no new studies of the relative risk of non-fatal crashes. The state of knowledge in this area is essentially unchanged from that reported in prior updates. Data from the 1960s and1970s indicate increasing relative risk as BAC increases, but much lower levels of risk at any BAC (in the 2 to 4 range for all but the very high BACs) than for fatal crashes.

Figure 2-6: Relative Risk of Fatal Crash Involvement for Drivers Age 21 and Over (Zador, et al., 2000)



DRINKING PEDESTRIANS AND BICYCLISTS

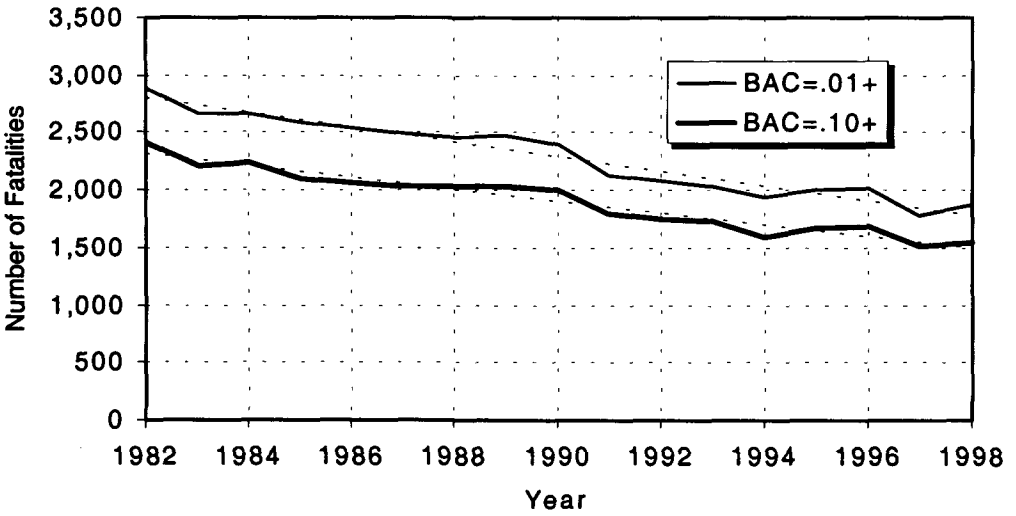
Impaired Pedestrians and Bicyclists in Crashes

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.

One interesting finding discussed in the 1985 report (from a study in New Orleans by Blomberg, Preusser, Hale, et al.) was that the relative risk of involvement in a fatal pedestrian crash did not begin to rise until the pedestrians reached a BAC of .15 to .20. This is consistent with the hypothesis that safe walking is generally easier than safe driving, since the relative risk curve for fatal motor vehicle crashes starts to rise at a much lower BAC.

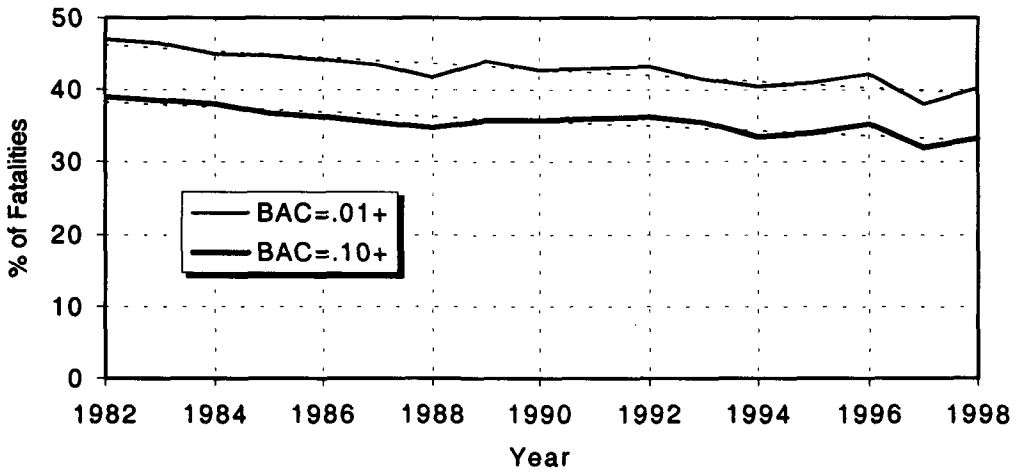
FARS data indicate that the pedestrian component of the alcohol-crash problem has also been decreasing since 1982, but with some flattening out in recent years **Figure 2-7**. There were 855 fewer fatalities at BACs of .10+ in 1998 than in 1982, a percentage decrease of 36%.

Figure 2-7: Number of Pedestrian Fatalities in Alcohol-Related Crashes at Two BAC Levels by Year



However, there was a much smaller decrease in the *percentage* of pedestrian crashes that were alcohol-related **Figure 2-8**, amounting to about 16% from 1982 to 1998 for those with a BAC of .10+.

Figure 2-8: Percentage of Pedestrian Fatalities in Alcohol-Related Crashes at Two BAC Levels by Year



The latest FARS report did not present data on the role of alcohol in bicycle crashes[5]. Li, Baker, Sterling, et al. (1996) analyzed medical examiner data on all fatally injured bicyclists aged 10 years or older from 1987 to 1994 in Maryland (fatal cases, n = 63) and compared the data with trauma registry data on all injured bicyclists who were treated at a regional trauma center during the same time period (nonfatal cases, n = 253). Variables studied were those related to BAC, demographic characteristics, and injury circumstances. The researchers found that fatal cases were more likely than the nonfatal cases to have positive BACs (30% vs. 16%, $p < .01$) and to have a BAC of .10+ (22% vs. 13%, $p < .01$).

Applying the percent of bicyclists with BACs of .10+ to nationwide fatality data from FARS and injury data from NHTSA's General Estimates System for 1998, provides a rough order of magnitude estimate of the size of the alcohol-bicycle crash problem in the U.S., amounting to some 200 fatalities and 7,000 injuries. Li and associates also found that bicyclists who died at the scene were four times as likely as those who died at hospitals to be legally intoxicated (35% vs. 9%, $p < .02$). Given a serious bicycling injury, intoxication was associated with significantly increased likelihood of fatality, with an adjusted odds ratio of 2.8 (95% confidence interval, 1.3 to 6.3).

Finally, we note a Finnish case-control study that estimated the relative risk of and alcohol-related bicycle crash (Olkkonen, 1993). The study involved 200 bicycle victims who were injured fatally in road traffic accidents during the years 1982-1988, and 700 cyclists who were used as unmatched controls for these cases. The study found that alcohol was involved in 25% of the collision accidents and in 63% of the single accidents involving cyclists aged 15 to 64 years and whose blood alcohol was measured. Only 4% of the controls were under the influence of alcohol. A relative risk was of the order of 3 over all, and 58 for the collisions related to alcohol use.

Impaired Drivers in Pedestrian Crashes

Not all of the alcohol-related fatal pedestrian and bicyclist crashes involved drinking walkers or riders. FARS 1998 data indicate that 11% of over 5,000 fatal pedestrian crashes occurring in 1998 involved a driver with a BAC of .10+, and that nearly half of the 11% involved a pedestrian at *zero* BAC (**Table 2-1**).

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[5] We performed a separate analysis of 1998 FARS data in analyzing age-sex-BAC interactions of fatally injured bicyclists in Chapter 4, page 82.

Table 2-1: Alcohol Involvement in Fatal Pedestrian Crashes, 1998

	No Driver Alcohol Involvement	Driver Alcohol Involvement, BAC .01–0.09	Driver Alcohol Involvement, BAC .10 or Greater	Total
No Pedestrian Alcohol Involvement	55%	3%	5%	3,264 63%
Pedestrian Alcohol Involvement, BAC .01–.09	5%	1%	1%	324 6%
Pedestrian Alcohol Involvement, BAC .10 or Greater	23%	3%	5%	1,573 30%
Total	4,242	335	585	5,162
	82%	6%	11%	100.0%

SUMMARY AND CONCLUSIONS

At the millennium, 1998 data indicate that about 12,500 *fatalities* in the U.S. traffic crashes involve a driver with a BAC of .10+. This amounts to about 30% of the 41,471[6] traffic crash fatalities that occurred in 1998. Further, an estimated 30% of all *fatal crashes* involve a driver or non-occupant with a BAC of .10+, and also, about 30% of all *fatally injured drivers* have a BAC of .10+. Finally, the *fatality rate* of persons in crashes with a driver at .10+ was 4.6 per 100,000 population in 1998.

Crashes involving pedestrians and bicyclists are not as well defined as those involving only motor vehicles. In 1998, over 1,500 fatally-injured pedestrians had a BAC of .10+, a decrease of about 36% since 1982. The percentage of fatally-injured pedestrians has also declined, but by a much smaller percent (about 15%). In addition, an estimated 5% of fatal pedestrian crashes involved a driver with a BAC of.10+ and a pedestrian of zero BAC. The precise number of fatally-injured bicyclists nationwide at BAC .10+ is not known, but is estimated to be in the hundreds.

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[6] This number is from the 1999 FARS report. A later update of FARS data gives a figure of 41,501 fatalities.

All of these measures of the alcohol-crash problem have declined since objective data on the problem became available. The fatality rate, an especially important measure since it accounts for population growth, has declined nearly 50% since 1982. Nevertheless, there has been a distinct "flattening out" of these measures in recent years, suggesting that the problem needs increased emphasis to maintain the overall downward trend.

The situation with respect to non-fatal crashes involving alcohol is less clear. In recent years, NHTSA's General Estimates System (GES) has helped clarify this component of the alcohol-crash problem, providing data on the *investigating officers's judgement* of whether alcohol was involved in the crash. Data from GES (U.S. Department of Transportation, NHTSA, 1999) indicate that 9% of the injury crashes and 5% of property-damage-only crashes involved alcohol by this criterion.

Obviously, not all drinking-drivers become involved in alcohol-related traffic crashes. Surveys of driving behavior help define the percentage of non-crashed drinking drivers using the roads at given times. Roadside surveys suggest that some 3% of drivers on the road during nighttime hours during weekends have a BAC of .10+, a somewhat higher percentage than found in earlier studies conducted around the clock during all days of the week. Other surveys of drivers in general have asked questions about their respondents's driving after drinking. NHTSA's 1997 nationwide telephone surveys found that 24% of the 1997 respondents said they had driven within two hours after consuming alcoholic beverages at least once during the past year, and it was estimated that 5% of these had a BAC of .08+. A 1996 survey, involving personal interviews in households, obtained similar results, estimating that 8% had a BAC of .08+.

The above estimates have used a BAC level of .10+ in defining the general magnitude of the alcohol-crash problem in the United States. This is because the fatal-crash risk is so high at that level as to become societally unacceptable. This has resulted in extensive societal pressures (including criminal sanctions) to prohibit driving at a BAC of .10+, and at this writing, even at .08+ in 29 states and the District of Columbia and Puerto Rico. The greatly increased risk at BAC= .10+ over that at BAC=.00 is evident simply by comparing the percentage of .10+ drivers in fatal crashes (about 30%) to the percentage of .10+ non-crashed drivers on the road (roughly 3%). This suggests alcohol-crash over-involvement by a factor of ten[7].

This is, of course, only a rough estimate. More careful analyses of the relative risk of a fatal crash due to alcohol have been performed over a period of more than 40 years, attempting to account for factors other than alcohol that can influence risk estimates. The latest estimate of relative risk for drivers of age 21 and higher of is of the same order of magnitude as the rough estimate, and also

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[7] Note that this figure is not the same as relative risk as defined on page 10. Relative risk calculated from this raw data would closer to 16 at this BAC.

indicates significant risk at lower BACs. In addition, one study found that fatally injured drivers with BACs of .10+ were about 50% more likely to have been responsible for their crash than were drivers at zero BAC[8].

Other levels of risk could be used for defining the size of the alcohol-crash problem. For example, defining acceptable risk at the .01+ BAC level would add another 4,300 fatalities to the estimate of approximately 12,500 indicated on page 7, while defining it at the .20+ level would subtract 6,300.

In closing this chapter, we repeat a comment from the 1978 update of the state of knowledge of alcohol and highway safety:

> "The above figures, while indicative of a large-scale national problem, do not, of course, prove that alcohol *caused* the crashes in which drinking was involved. Traffic accidents are probabilistic, with many factors entering into the probability equation. The most that can be said on the basis of epidemiologic evidence is that, on the average, alcohol beyond a certain amount, is associated with increased crash risk." (p. 32)

Thus, the magnitude of the alcohol crash problem at the millennium depends on the level of alcohol-crash risk an informed public is willing to tolerate, given available alternatives to reducing that risk. In any case, the inescapable conclusion is that alcohol-related crashes are a much smaller societal problem at the millennium than they were 20, or even 10, years ago.

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[8] Mounce and Pendleton (1992), cited in Jones and Lacey (1998). The study analyzed the records of 595 fatally injured drivers in Texas.

3 - ALCOHOL EFFECTS ON PEOPLE

The prior chapter has summarized the current state of knowledge of the size and magnitude of the alcohol-crash problem in the U.S. at the millennium. This chapter discusses the current state of knowledge of the more basic interactions between alcohol and various parts of the body, and of more direct interest to the topic of alcohol-safety, how alcohol affects human behavior related to driving.

BIOCHEMISTRY AND PHYSIOLOGICAL EFFECTS OF ALCOHOL

Absorption, Metabolism, and Elimination of Alcohol

The 1978 update briefly discussed the elementary aspects of how the body processes alcohol. No significant changes in our understanding of the fundamentals of these processes have occurred since then, although significant new knowledge of interest to specialists has been gained.

Processing of alcohol by the body begins with absorption by the stomach and small intestines, a process that generally requires some one to three hours, depending on the type and quantity of the alcoholic beverage, and the presence of food in the stomach.

Alcohol enters the bloodstream by simple diffusion, and does not have to be digested. The presence of food in the stomach slows the rate of alcohol absorption, but absorption is also influenced by other factors including the type of alcoholic beverage, the drinker's gender, body temperature, the presence of certain medications in the body, and the types of spices in the food. Distribution to various parts of the body then occurs.

Body fat and skeletal mass absorb very little alcohol. Thus, an identical quantity of alcohol per unit of body weight will induce a higher BAC in women than in men because of differences in body constitution (Bode and Bode, 1997). Some recent research suggests that, in a social drinking setting, a shorter time to peak BAC and a faster absorption rate may occur when alcohol is consumed over an extended period. In contrast, earlier studies found longer absorption times (Winek, Wahba, and Dowdell, 1996).

The variability of absorption time is illustrated by a study by Friel, Baer, and Logan (1995). The study examined alcohol disposition in 77 female and 97 male college seniors who were regular drinkers who exceeded legal intoxication levels at least twice a month by history. After receiving a standard alcohol dose (lower for females than for males) over 10 minutes, after a four-hour fast, breath alcohol concentrations (BrACs) were measured for two hours. The time to peak BrAC varied from 10 to 91 minutes after the start of drinking, and mean BrACs were significantly lower in females than in males.

Absorption and peak BAC vary by type of food as well as amount of food. For example, a study of a small sample of women subjects found that the peak BAC was significantly higher in those drinking alcohol and sodium (simulating salty food) than in those drinking alcohol with no sodium (Talbot and La Grange, 1999).

Alcohol is metabolized primarily in the liver, but metabolism occurs also in the stomach and small intestine. Gastric alcohol metabolism, which is significant only at low alcohol concentrations, is more efficient in men than in women, which helps explain why the same amount of alcohol produces higher blood alcohol concentrations in women than in men. There is also evidence that alcohol can be metabolized by bacteria in the large intestine. Bode and Bode (1997) note that alcohol is not only degraded, but also *produced* in the gastrointestinal tract as a by-product of bacterial breakdown of ingested carbohydrates.

Finally, of the alcohol absorbed, 90-98 % is oxidized, 1-5 % is excreted in an unaltered state in urine, and another 1-5 % is expired via the lungs (Vrij-Standhardt, 1991). The total time to eliminate alcohol from the body is dependent upon the variables that influence absorption (see above).

Measurement of Alcohol Presence

Since alcohol's immediate effects are due to its effect on the brain, it would be desirable to know the alcohol concentration in the brain after drinking. Obviously, direct measurements are impractical for most purposes, and other means must be used for estimating "brain-alcohol concentration."

Chemical tests of blood drawn from a vein or capillary are the preferred indirect way of estimating alcohol concentration in the brain in live humans. Other chemical tests that relate alcohol presence elsewhere in the body to alcohol presence in the blood, have also been used, the most common now being tests of alcohol in air expired from the lungs[9].

Breath-alcohol measurement has become more precise and reliable since the 1978 update, and also more convenient and easy to perform, especially in forensic settings. The 1978 update noted that the factor (estimated at 2,100 at that time) for converting breath alcohol measurements to blood alcohol measurements could not be precisely determined, and also presented data from 28 studies on the blood/breath deviation. The data indicated that breath testers typically underestimated BAC by up to 10% or so.

More recent studies using improved technology indicate that the conversion factor may be closer to 2,400 than 2,100, (Jones and Anderson, 1996). This means that, on average, using a conversion factor of 2,100 would underestimate BAC by about 10%. Jones and Anderson note the fairly high variability of the

[9] Jones (2000) provides and excellent review of the evolution of the technology of blood-alcohol and breath-alcohol testing over the past 50 years.

conversion factor and discuss some of the factors that may influence the variability. Jones and Pounder (1998) discuss current practices for measuring alcohol concentration in clinical and forensic laboratories and recommend methods for assuring quality in laboratory procedures.

Two major advances in instrumentation of interest in the drinking-driving field are: much more precise and less expensive portable breath testers for operational use, and the development of "passive" breath testers that test the breath of expired air near the mouth without the need for collecting air directly from the mouth (Farmer, Wells, Ferguson et al., 1999). Other measurement techniques now under study in this country are the use of saliva (Flores, Spicer, and Frank, 1992) and "sweat patches" (Deveaux and Gosset, 2000) for estimating BAC. Saliva measurement devices are being used more often outside the United States and have been found to perform favorably for rapid estimation of BAC (Keim, Bartfield, and Raccio-Robak, 1996; Kiesow, Simons, and Long, 1993). Practical self-testing devices have also been developed and are being used in Australia (Haworth and Bowland, 1995; Haworth, Bowland, Vulcan et al., 1997). Exploratory studies of the use of laser technology to detect alcohol presence in a closed vehicle have also been conducted, but no formal reports of their results were found in our literature search.

In addition to chemical tests, improved behavioral tests for alcohol impairment are now being employed widely to assist police officers in identifying alcohol impairment among drivers suspected of a drinking-driving law violation. The standardized field sobriety test (SFST) of one's performance in a set of three sub-tests is being used in jurisdictions in all 50 States (Burns, 1999). The sub-tests are: horizontal gaze nystagmus (HGN), walk-and-turn (WAT), and one-leg-stand (OLS). HGN requires the subject to visually follow a moving object, and the angle of onset and degree of nystagmus (an involuntary jerking of the eye) is observed. Alcohol-impairment causes an earlier onset and a greater degree of nystagmus.[10] HGN has been found to be the best index of alcohol of the three tests.

Subjective estimates of BAC by persons (e.g., police officers, physicians, and bartenders) who deal with drinkers in various settings have been shown to be notoriously inaccurate (Hansen, Popkin, Campbell et al., 1991). In another study of police officers's ability to detect even the odor of alcohol at various BACs up to .13, researchers found that odor strength estimates were unrelated to BAC levels and that estimates of BAC level "failed to rise above random guesses" (Moskowitz, Burns, and Ferguson, 1999).

Methods for calculating one's own BAC after consuming a given amount of an alcoholic beverage have been published in various forms, including formulas, procedures, tables, computer programs, and nomograms. South (1992) summa-

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[10] An excellent discussion of HGN and its use by police officers can be found in a recent NHTSA report prepared by the National Traffic Law Center (Dietrich and Frost, 1999)

rized factors affecting BAC and presented a formula calculating it, deeming the formula "complex to use and not very accurate." This assessment holds true for self-determination methods in general, which give only a rough idea of one's BAC after drinking. South, a resident of Australia, recommended that those wanting to know much they can drink and drive legally use a combination of counting drinks and using a coin-operated breath testing device.

Alcohol measurement techniques are discussed in more detail in Chapter 4 in conjunction with their use in alcohol-crash countermeasures.

Acute and Chronic Effects of Alcohol

The short-term or *acute effects of alcohol* of interest here are those related to alcohol's depressant effect on the brain. The exact nature of the mechanisms involved is not known. Fromme and D'Amico (1999) discuss basic knowledge of the neural systems that are implicated in alcohol's acute and chronic effects and suggest two relatively distinct neuroanatomical and neurochemical response systems to account for the subjective and behavioral effects of alcohol: (1) a simple reinforcement/motivation system, and (2) a complex neurochemical system that mediates higher-order cognitive functions and conditioned effects of alcohol. The U.S. Department of Health and Human Services's Ninth Special Report to Congress on Alcohol and Health (1997) provides an extensive discussion of the neuromolecular actions of alcohol on the brain and the ability of alcohol to influence many cellular functions.

It is known that the depressant effect increases with BAC; hence, the importance of BAC as an index of impairment. Extreme amounts of alcohol (e.g., BAC $\approx$ .40) can paralyze the respiratory system and cause death, but some persons can survive and even drive at these and still higher concentrations. Jones (1999) examined 81 drinking drivers in Sweden who had unusually high blood alcohol concentrations (BAC= .40+) when apprehended. He concluded that "drinking alcohol to reach a BAC of .40 or more and attempting to drive a motor vehicle indicates an exceptionally high cellular tolerance to the impairment caused by this drug. The alcohol burn-off rate [mean= .023 per hour] was relatively high in these heavy drinkers, which probably reflects the development of metabolic tolerance as well."

However, alcohol's effects begin to occur at much lower BACs. The 1978 update found that alcohol impairment of both simple processes involving the ability to perform relatively uncomplicated tasks not requiring high degrees of motivation and understanding begins to occur at BACs as low as .03. A recent review of literature published from 1981-1997 concluded that the majority of studies reported significant impairment in driving skills by BACs of .05, and that "alcohol impairs driving skills beginning with any significant departure from zero BAC" (Moskowitz and Fiorentino, 2000). The effects of alcohol on behavior are discussed further in the next section of this report.

Finally, of particular interest to this review is a study by Waller, Stewart, and Hansen (1986) which used data from North Carolina crash reports, driver records, and medical examiner reports to estimate the effects of alcohol on increasing the severity of injuries suffered in traffic accidents. They concluded that alcohol increases vulnerability to injury in *any* given crash. A more recent case-control study examined the risk of injury of any cause after the recent consumption of alcohol (McLeod, Stockwell, Stevens et al., 1999). The 797 cases were injured patients from a hospital emergency unit. The 797 controls were matched on residence location and were interviewed at home regarding activities leading up to the time of their matched case's injury. Cases and controls were breath tested and questioned about the injury event and alcohol and other drug use consumed in the six hours prior to the injury. Analysis of the data produced an odds ratio of 3.4 of sustaining an injury from any cause after consuming more than 60 grams of alcohol in a 6-hour period, after controlling for demographic variables.

Study of the *chronic effects of alcohol* used over a long period of time has generated a large body of literature since the 1978 update. Much of this literature in existence *circa* 1997 is reviewed in U.S. Department of Health and Human Services (1997). More recently, Dawson (2000) examined the effects of alcohol consumption and alcohol dependence on the overall risk of mortality in the United States using data from the 1988 National Health Interview Survey Alcohol Supplement matched to the National Death Index for the years 1988 to 1995. The author found that very heavy drinkers had a significantly increased risk relative to past-year abstainers and a risk of 1.65 relative to lifetime abstainers.

Hart, Smith, Hole et al. (1999) studied the relationship between alcohol consumption and mortality from all causes of 5,766 Scottish men, aged 35-64. The subjects entered the study in 1970-1973 and were followed for 21 years. The study found a similar relative risk for all-cause mortality for nondrinkers and for those drinking up to 14 units a week; and increasing risk with consumption, amounting to 1.34 for 15-21 units a week, 1.49 for 22-34 units, and 1.74 for 35 or more units. The authors concluded that "the overall association between alcohol consumption and mortality is unfavorable for those drinking more than 22 units a week," and that "there is no evidence for any protective effect at any level of consumption."

Of foremost concern has been the effects of alcohol on the liver which bears the major burden in metabolizing alcohol. Liver cirrhosis (a degeneration of liver tissue, resulting in fibrosis and nodule formation) has received particular attention. The path toward cirrhosis starts within the liver as inflammation (hepatitis), and progresses to fatty liver, and cirrhosis. The epidemiology of cirrhosis is complicated by the fact that heavy drinking is not its only cause, and that not all heavy drinkers develop cirrhosis. Other conditions that lead to cirrhosis include viral hepatitis, inherited diseases, diseases of the bile duct, and diseases of the blood. While it has been estimated that the incidence of cirrhosis is 3 out of 10,000 people, only about 10% to 15% of alcoholics have cirrhosis at the time of death.

DeBakey, Stinson, Grant et al. (1995) estimated that, during 1970 - 1992, age-adjusted death rates from alcohol-related liver cirrhosis dropped by 24.1% (5.4 deaths per 100,000 in 1970 to 4.1 deaths per 100,000 in 1992). An analysis of the relationships between cirrhosis mortality and per capita consumption of distilled spirits in the United States in the years from 1949-1994 found that there is a consistent long-term trend relationship between mortality from cirrhosis and per capita consumption of distilled spirits, but could not establish a direct causal link between consumption of distilled spirits and long-term cirrhosis mortality (Roizen, Kerr, and Fillmore, 1999). Kernochan and Yee (1999) even suggest that societal changes could be partially responsible for the development of serious liver disease in populations, and that spirits consumption may serve as marker for some societal event that occurred many years earlier and affected cirrhosis mortality.

The effects of alcohol consumption on the risk of various types of cancers has also been studied extensively. A meta-analysis of 123 studies found not only higher risks for cirrhosis, but also "weaker but significant" relationships for colorectum, liver, and breast cancers (Corrao, Bagnardi, Zambon et al., 1999). The authors found that: "For all these conditions, low intakes, corresponding to daily consumption of two drinks or two glasses of wine (25 g/day), have shown significant risks." The authors concluded:

> "The small number of sufficiently reliable studies, the strong indications of heterogeneity across them, and the suspicion of publication bias suggest a great need for well-conducted epidemiological studies in several countries to examine the dose-response relationship between alcohol intake/drinking pattern and the risk of several alcohol-related conditions."

Finally, an extensive recent study on carcinogens in general (U.S. Department of Health and Human Services, 2000a) concluded that "consumption of alcoholic beverages is known to be a human carcinogen based on sufficient evidence of carcinogenicity from human studies that indicate a causal relationship between consumption of alcoholic beverages and cancer in humans," and, specifically, that:

> "Consumption of alcoholic beverages is causally related to cancers of the mouth, pharynx, larynx, and esophagus. Cohort and case control studies in a variety of human populations are notable for their consistency in reporting the presence of moderate to strong associations with dose-response relationships for these four sites. Evidence also supports a weaker but possibly causal relation between alcoholic beverage consumption and increased risk of cancers of the liver and breast."

By contrast, numerous studies have found a protective effect of moderate drinking on heart disease. The American Heart Association (AHA) issued an advisory in 1997, stating that:

> "More than a dozen prospective studies have demonstrated a consistent, strong, dose-response relation between increasing alcohol consumption and decreasing incidence of coronary heart disease (CHD). The data are similar in men and women in a number of different geographic and ethnic groups. Consumption of one or two drinks a day is associated with a reduction in risk of approximately 30-50 percent. Studies of coronary narrowings defined by cardiac catheterization or autopsy show a reduction in atherosclerosis in persons who consume moderate amounts of alcohol. In general, the inverse association is independent of potential confounders such as diet and cigarette smoking. Concerns that the association could be an artifact due to cessation of alcohol consumption in persons who already have CHD have largely been disproved. No clinical trials have been performed to test the alcohol-CHD relation. However, the large numbers of observational studies support a true protective effect of moderate consumption of alcohol. While 100,000 excess deaths have been attributed to alcohol-related diseases each year, approximately 80,000 excess deaths would occur if all current consumers of alcohol abstained from drinking." (Pearson, 1997)

Many other, but not all, studies and reviews have arrived at similar conclusions, including a large-scale study of the responses of over 43,000 respondents to the 1988 National Health Interview Survey (Hanna, Chou, and Grant, 1997). However, the study by Hart and associates cited above found no strong association between alcohol consumption and mortality from coronary heart disease after adjustment of the data. Puddey and associates (1997) cautioned that balanced public health advice based on studies should take into account the full spectrum of alcohol's effects on the cardiovascular system, particularly its well documented potential to increase blood pressure and the prevalence of hypertension. An editorial by Criqui (1997) offered stronger advice, concluding that, "while it is clear that a modest intake of alcoholic beverages affords some protection against CHD [coronary heart disease], a general public health recommendation endorsing drinking is contraindicated."

The above discussion merely touches on the extensive literature on the acute and chronic effects of alcohol on the human body. A more detailed discussion of the literature can be found in recent reports by the U.S. Department of Health and Human Services (1997; 2000b). All in all, heavy drinking has been found to adversely affect bodily functions and general well-being. Light to moderate drinking does not appear to have adverse long-term effects on the bodies of healthy persons, and seems even to have a protective effect in some instances. However, even light drinking can have adverse short-term effects on behaviors that lead to such harmful events as traffic crashes, and can increase the severity of injuries that result from those events.

BEHAVIORAL EFFECTS OF ALCOHOL

Driving-Related Performance

The 1978 update reviewed a number of laboratory studies of the effects of alcohol on one's ability to perform various tasks related to driving, summarizing its conclusions as follows:

> "With respect to the simpler behavioral processes, there is evidence that neuromuscular responses may be impaired in some individuals at BACs as low as .04% to .05% w/v [weight per volume] and that many more individuals suffer such impairment at BACs in the range of .10% w/v. However, studies indicate that experienced drinkers can, if motivated, overcome these impairing tendencies at BACs as high as .20% w/v. Vision per se is not greatly affected by alcohol at BACs of less than .10% w/v, but above that it becomes impaired in most persons. 'Simple' tracking performance does not appear to be seriously degraded at BACs of less than .10% w/v, but the performance of 'complex' tracking tasks has been degraded in many individuals at BACs in the .05% to .10% w/v range. The ability to divide attention between tasks can be impaired at very low BACs (i.e., .02% w/v) and is often impaired at BACs above .08% w/v.
>
> Studies of the more complex behavioral processes indicate that risk taking may be increased at moderate BACs for introverts and light drinkers. Moreover, low doses of alcohol have been observed to improve the intellectual performance of heavy drinkers and alcoholics while having the opposite effect on lighter drinkers. Alcohol has been found detrimental to memory, particularly the long-term memory, of heavy drinkers." (pp. 48-49)

The report went on to conclude that "behavior that has been studied is consistently and significantly impaired in virtually all individuals as BACs approach .10." The 1989 update (and this review, as well) found no study that contradicted this conclusion, but that there was important new research on the impairing effects of alcohol at BACs below .10. The 1989 update cited a review by Moskowitz and Robinson (1988) that concluded that performance of tracking and divided attention tasks is degraded at BACs considerably less than .05, and that information processing, perception, and psychomotor skills are impaired at BACs of less than .10, but generally more than .05.

Thus, the focus of recent experimental research on the behavioral effects of alcohol has been on impairment at low BACs. The report by Moskowitz and Fiorentino (2000) mentioned in the prior section of this report reviewed 87 experimental studies of skills performance at low BACs. The authors made an effort to restrict the behaviors of concern to those clearly related to driving, and factors such as motivation, aggression, and emotion were excluded from the review. The results of 550 tests in 12 behavioral categories were complied. The review was concerned with behaviors at BACs of .08 and lower, but some of the studies also contained the results of tests at higher BACs. Commentary on each

behavioral category was largely concerned with the BAC threshold at which impairment was first noticed. The authors reported thresholds as low as .01 for some skills, and as high as .06 for others.

We plotted the percentage of tests showing impairment versus type of test for two groups of BACs, ≤.05 and > .05. The graphs (**Figure 3-1**) indicate that, for the lower BAC group, only four behaviors out of the 12 were impaired in more than half of the tests for a given behavior. The four impaired behaviors were, in descending order of percent impaired: drowsiness (not, as the authors note, a behavior, but a condition), vigilance, divided attention, and visual functions. All of these are clearly related to driving, while some of the others showing a lesser percentage of impairment have a less obvious relationship.

By contrast, for the higher BAC group, all but two of the behaviors (critical flicker fusion and aftereffects) were impaired in more than half of the tests, and two behaviors were impaired (drowsiness and vigilance) in all of the tests. Again, the highest percentages of behaviors impaired were for those most clearly related to driving, while the two behaviors with the lowest percent were the least related to driving.

Other reviews of experimental studies since the 1989 update have also concluded that alcohol can cause significant impairment at low BACs[11]. For example, Ferrara, Zancaner, and Georgetti (1994) reviewed the international literature of the effects of low levels of alcohol on driving ability, and found that most authors had concluded that low alcohol levels (apparently BACs in the .025 - .08 range) can cause significant impairment in psychomotor performance, to the extent that driving safety is compromised.

However, an earlier review voiced different conclusions about the effects of low BACs on behavioral skills. In a 1985 review, Mitchell (1985) concluded that alcohol impairment of driving-related behavioral skills is greatest for those tasks that require cognitive functioning, and that simple perception alone is least affected. He found that impairment of tasks requiring cognitive functioning begins to be evident at BACs above .05 and that there was no evidence that BACs below .05 impair any behavior in most individuals. His review is one of the few that addressed the *amount* of impairment, finding that, for most behavioral skills, the impairment at low BACs is slight, the order of 8-10% in many studies. He concluded that tolerance to central nervous system impairment may develop in regular drinkers, with sensorimotor coordination showing the greatest degree of tolerance, and that divided attention shows relatively little impairment.

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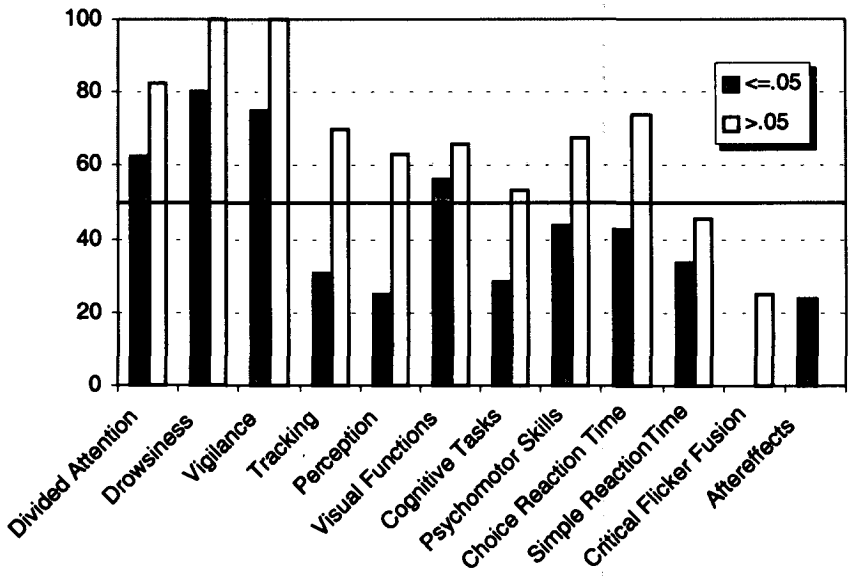
[11] Moskowitz and Fiortino (2000) cite some of these reviews in their report and provide pertinent references.

Figure 3-1: Percentage of Tests Showing Impairment by BAC Group and Type Test



Driving Performance

Laboratory studies such as those discussed above cannot determine exactly how or to what extent the behaviors studied are related to driving, for example, whether a decrement of 10% in a given behavioral task will cause what, if any, decrement in driving performance. Tests of actual driving performance, conducted in on-the-road settings or in driving simulators, offer the promise of more realistic estimates of the effects of alcohol. As noted by Linné, Triggs, and Redman (1999), impairments are typically measured by increased lateral deviation, but other measures are sometimes used as well. The limitations of such tests are well-known, but have been reduced in recent years by technological advances that have made simulators and measurement techniques more sophisticated and more sensitive to alcohol effects.

The review by Moskowitz and Fiorentino discussed above also included literature on driving and flying. Included were 25 studies containing 50 behavioral tests, with over 90% of the tests, both at BACs ≤ .05 and at BAC > .05, showing some degree of impairment. This is in contrast to Mitchell's review of earlier studies which concluded that impairment of actual driving is begins at BACs of .05 to .06, but is small, and then increases more rapidly as the BAC exceeds .10.

Several other simulator studies of alcohol effects have been published since the cutoff year of the review by Moskowitz and Fiorentino, 1997. Interestingly, the most recent of these that we located, (Lenne, Triggs, and Redman, 1999), found reduced performance in maintaining lateral position on a simulated road, and also in secondary reaction time, at BAC $\approx$.05.

SUMMARY AND CONCLUSIONS

The general principles regarding the processing of alcohol by the body remain essentially unchanged from those established many years earlier. Alcohol is absorbed by diffusion, metabolized mainly in the liver, and the small remaining amount is eliminated in urine and expired air.

Alcohol's immediate effects are due to its depressant effect on the brain, and chemical tests of blood drawn from a vein or capillary are the preferred indirect way of estimating alcohol concentration in the brain in live humans. The most common way of estimating the concentration of alcohol in the blood is testing air expired from the lungs.

At the millennium, breath testing has become more precise, more reliable, and more convenient. Also, other techniques are evolving that measure alcohol presence in alternative substances such as saliva (Flores, Spicer, and Frank, 1992) and sweat. Practical self-testing devices have also been developed and are being used in some countries. Improved behavioral tests are also being employed widely to assist police officers in determining alcohol impairment among drivers suspected of a drinking-driving law violation. Subjective estimates of BAC by persons such as police officers and physicians, and the use of methods for calculating one's own BAC, are not accurate enough for use either in research or operationally.

The acute depressant effect of alcohol increases with BAC, and has been measured in terms of its effects on human performance at BACs as low as .03. Alcohol also has been shown to increase one's vulnerability to injury. Studies of the chronic effects of alcohol used over a long period of time indicate that very heavy drinkers have a significantly increased risk of mortality relative to lifetime abstainers. Studies have found not only higher risks for cirrhosis, but also relationships for colorectum, liver, and breast cancers (Corrao, Bagnardi, Zambon et al., 1999), and that low intakes corresponding to daily consumption of two drinks or two glasses of wine can lead to increased risks. By contrast, a protective effect of light to moderate drinking has been found in some instances, and seems well-established for coronary heart disease.

With respect to alcohol's effect on performance related to driving, recent research has focused on low BACs, it having been clearly established in prior research that performance is substantially impaired in virtually everyone at BACs of .10 and higher. Techniques for testing and measurement have improved markedly in recent years, resulting overall in increased sensitivity to degradations

of behaviors due to alcohol as determined both in laboratory experiments and in tests of actual driving performance. As a result, there is evidence that behaviors related to driving are impaired at lower BACs than was previously believed, with increased impairment of many behaviors clearly occurring at BACs in excess of .05. The amount of impairment of these behaviors at lower BACs less than .05, and whether it is associated with increased crash risk, cannot be stated in general terms on the basis of the findings of experimental studies alone, but awaits new evidence from epidemiologic studies. The epidemiologic study by Zador and associates discussed in the prior chapter suggests that risk does not increase for drivers as a whole at very low BACs (less than .02).

4 -DRINKING DRIVERS, PEDESTRIANS, AND BICYCLISTS

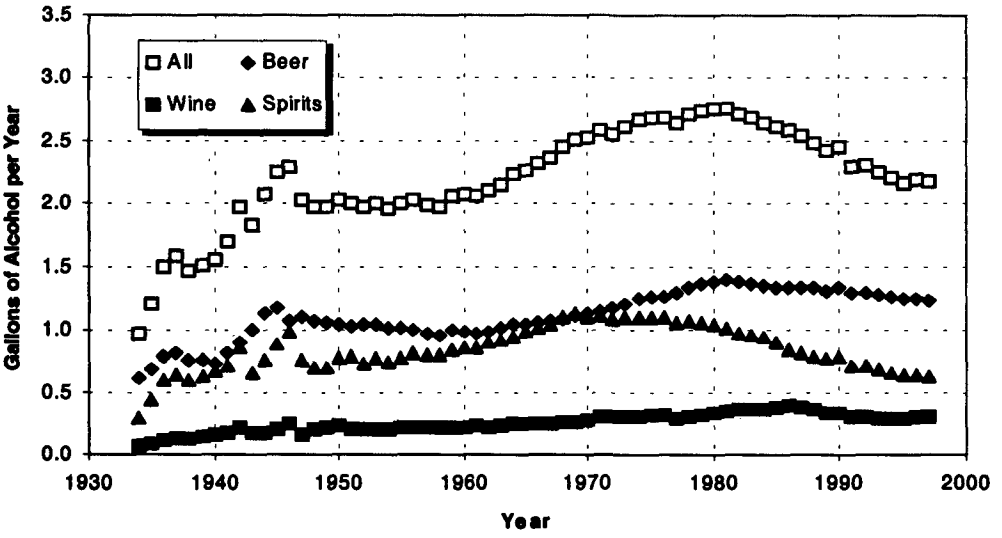
DRINKING AND DRINKING PATTERNS

Although this chapter is primarily concerned with drinking *drivers, pedestrians, and bicyclists*, we also examined some of the literature on drinking by the larger class consisting of *all* persons of drinking age. An overview of pertinent research is presented in this section.

Apparent Consumption

The National Institute on Alcohol Abuse and Alcoholism (NIAAA) has been compiling data on the apparent per capita consumption[12] of ethanol in the U.S. for a number of years. Its latest report (Nephew, Williams, Stinson et al., 1999) shows a long-term decline in total consumption during the period 1981 through 1995, with an indication of a leveling out in 1996 and 1997 (**Figure 4-1**). In 1981, apparent per capita consumption was 2.76 gallons, but decreased 29% to 2.17 gallons in 1995. This decline appears to be due primarily to a decline in the consumption of spirits: the consumption of wine and beer has exhibited much less change.

Figure 4-1: Apparent Per Capita Consumption of Alcohol in the United States, 1935-1997

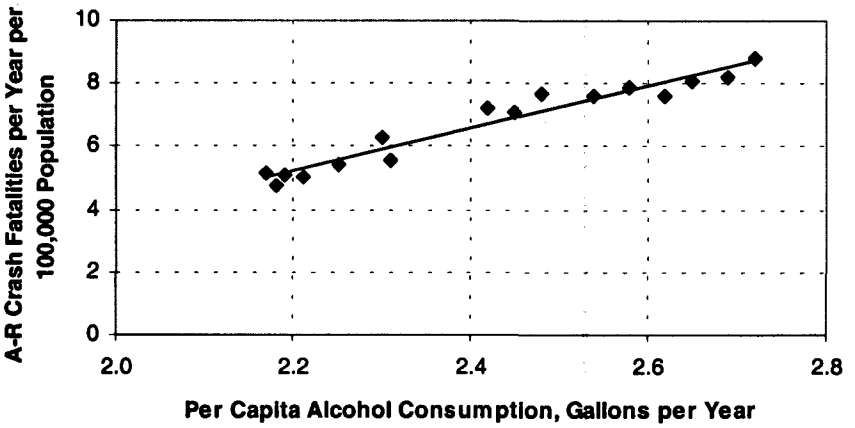


[12] The term "apparent consumption" is used in the literature to indicate gallons of absolute ethanol consumed per person of drinking age. Drinking age is usually assumed by researchers to be less than the minimum legal drinking age. The NIAAA report used a drinking age of 15 for the years prior to 1970, and a drinking age of 14 for 1970 through 1997.

Note that these figures include abstainers in the denominator: per capita consumption capita for the *drinking population* is considerably higher and varies widely by State. The NIAAA report cited above estimates consumption per drinker to be 3.49 gallons for the lowest State (Iowa), and 9.17 gallons for the highest State (the District of Columbia).

There has been considerable controversy in past years about the relationship of alcohol consumption to alcohol-related crashes. That a relationship exists is certainly plausible: if consumption were reduced to zero, all alcohol-related crashes would be eliminated. And, as can be seen in **Figure 4-2** (which combines the data from **Figure 2-1** and **Figure 3-1**), there was a strong correlation between per capita alcohol-related (BAC .10+) crashes and per capita consumption during the 1982-1997 period. However, other factors (e.g., degree of *driving* after drinking) also influenced the crash rate, so the contribution of consumption alone to alcohol-related crashes cannot be determined from such a simple relationship.

Figure 4-2: Alcohol-Related Crash Fatalities per 100,000 Population by per Capita Alcohol Consumption, Driver BAC= .10+, 1982-1997



Several studies in the United States have addressed the question of drinking-driving and consumption in considering the effect of taxes on alcoholic beverages. The seminal study was an econometric analysis by Cook (1981), who also reviewed prior studies of the effect of beverage price on consumption. Using historical data on 39 instances of tax changes during 1961-1975, Cook concluded that *all* highway fatalities could be reduced by increasing the price of distilled liquor and thus decreasing liquor consumption. Our examination of Cook's data indicates a positive correlation between fatal crashes and consumption amounting to a .7% reduction in fatalities for every 1.0% reduction in liquor consumption. However, Cook's regression model did not include other independent variables that might have influenced fatalities.

Skinner (1989) reviewed the Cook study and also performed a separate analysis of differences in 1984 tax rates on distilled liquor, beer, and wine in 31 States. The dependent variable was all highway fatalities per vehicle mile traveled (VMT). Independent variables were: per capita VMT; proportion of urban miles of total VMT; per capita consumption of beer, wine, and distilled liquor; per capita income; per capita homicides; and tax rates per gallon for each beverage type. The effect of consumption on fatalities was not reported, but higher taxes were found not to contribute to lower highway fatalities.

A study by Saffer and Grossman (Saffer and Grossman, 1987) also addressed the problem indirectly in assessing the effect of beer taxes on motor vehicle death rates of young drivers in the 48 contiguous States. The study was reviewed in-depth in Jones and Lacey (1991b). The review found that the study suffered from numerous deficiencies and failed to establish that there is a link between beer taxes and fatality rates. The review concluded that, by not analyzing beer consumption (and beer price) directly, the authors (Saffer and Grossman), took an unwarranted wide leap, bridging the intermediate steps, beer tax/beer price, beer price/beer consumption, and finally, *beer consumption/alcohol-related crashes.*

We found no recent studies of the effect of alcohol consumption on alcohol-related crashes in the United States, but a study by Voas and Tippetts (1999) of the effectiveness of three alcohol safety laws in the United States included per capita beer consumption in its analysis. The study considered a number of factors related to alcohol-related crashes and found that "states with higher beer consumption had more alcohol-related crashes." (p. 12) However, the analyses leading to this conclusion are not described in sufficient detail to assess them here. This study is discussed further in Chapter 5.

Finally, the 1989 update examined two foreign studies which had found alcohol-related crashes to be positively correlated with alcohol consumption (one in Canada and one in Ireland), and found their conclusions about the relationship crashes and consumption to be questionable[13].

Patterns of Consumption

Persons who drink alcohol have been classified by the quantity and frequency of their drinking. Room (2000) recently summarized current developments in characterizing drinking patterns through surveys, concluding that "frequency of drinking at all, and frequency of heavier drinking occasions, are dimensions important both in terms of the social meaning of drinking and of the relation to potential consequences of drinking." A significant percentage of persons of drinking age in the United States are believed to be abstainers who consume no alcohol at all. The actual percentage varies widely among states. Nephew, Williams, Stinson et al. (1999) present data from the Behavioral Risk Factors

[13] Critiques of these two studies were also published by Joksch (1989; 1991).

Surveillance System (BRFSS) on the percentage of abstainers in each State for the period 1986-1997. (The annual BRFSS survey is coordinated by the Centers for Disease Control and Prevention.) In 1997, the percentage of abstainers in the survey ranged from a low of 29.8 percent in Wisconsin to a high of 71.7 percent in Utah. Southern states typically had higher abstinence rates than Northern states, Utah being a notable exception.

Data on abstinence from the 1998 National Household Survey on Drug Abuse (U.S. Department of Health and Human Services, 1999) are generally consistent with State data reported by Nephew and associates, indicating that about 36% of the population of *age 12 or more* were abstinent during the past year.

Persons who drink have been classified in the traffic safety literature as social drinkers and problem drinkers. The 1978 update defined social drinkers as:

> ". . . those whose consumption of alcohol is part of their socially defined interactions with family, friends, neighbors and co-workers. . . . The health and social functioning of the social drinker are not impaired by this pattern of alcohol consumption." (p. 55)

This definition appears to be valid today, but attempts have been made to arrive at a more precise definition of problem drinkers than was available *circa* 1978[14]. As a part of a study conducted in 1990-1993, an expert panel of acknowledged leaders in the field of problem drinking assessment developed a criterion measure for assessing the validity of instruments for the preliminary screening of DWI offenders for alcohol (Lacey, Jones, and Wiliszowski, 1999). The scheme classifies a subject as a problem drinker when that subject exhibits *at least one* of the following characteristics:

- consumes five or more drinks per day on eight or more days each month;
- has experienced five or more adverse consequences of drinking such as job loss, arrests, family or health problems or the like.;
- exhibits three or more symptoms of dependance such as needing to drink more in order to have an effect, withdrawal symptoms or the like; and
- has had treatment for alcohol problems two or more times.

Persons who exhibit *two or more* of the following characteristics are also categorized as problem drinkers:

- consumes five or more drinks per day on from four to seven days per month;
- has experienced three or four adverse consequences of drinking;

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[14] Jacobson (1989) notes the difficulty of arriving at satisfactory definitions of the terms "problem drinker" and "alcoholic" and discusses some of the definitions that had been used.

- exhibits one or two symptoms of alcohol dependance; and
- has had previous treatment for alcohol problems.

The study used these criteria for assessing four screening instruments which were known to be in widespread use and were constructed using sound psychometric procedures. Since the study was mainly concerned with screening DWI offenders, the subjects tested were drawn from two populations of DWI offenders rather than from the general population of drinkers. However, as an additional task, the study validated a combination of the consumption questions from CAGE[15] with CAGE, and with the Alcohol Clinical Index (ACI). These questions were suggested by the expert panel as a possible shorthand way of identifying problem drinkers who were also drivers on a telephone questionnaire NHTSA was developing.

The 1997 survey of drinking and driving reported by Balmforth (1998) used the criterion defined by a version of the combined CAGE / ACI items alluded to above to identify problem drinkers in the general population of drinkers. It was concluded that, by the survey's criterion, 17% of all non-abstainers age 16 or older were problem drinkers. Interestingly, Skinner and Holt (1987), authors of the ACI, estimated that some 20% of the drinking age population in North America were problem drinkers, and that abstainers comprised another 15% (Lacey, Jones, and Wiliszowski, 1999).

Combining the results on abstainers from Nephew and associates presented above, and the results on problem drinkers reported by Balmforth, would result in some 5 - 12% of the U.S. drinking age population (depending on the State) being classified today as problem drinkers.

Two other classifications of drinking patterns are more often used in the general scientific literature dealing with drinking and drinking patterns: *alcohol abuse* and *alcohol dependence*. These classifications have been published in various editions of the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders, usually abbreviated as DSM-x, where x indicates the edition of the Manual. The criterion assessment instrument developed in the report by Lacey and associates (1999) used several items from DSM-IIIR, the revised edition of DSM-III. In general, DSM-III defines the concept of substance abuse as a pattern of pathological use for at least one month that causes impairment of social or occupational functioning, and defines the concept of dependence as involving either alcohol tolerance or withdrawal, and also the impairment of social or occupational functioning. Nathan (1991) and the U.S. Department of Health and Human Services report (1997) discuss the evolution of the DSM criteria, some of the considerations that led to the development of the current DSM-IV criteria, and some of the differences among various versions of the DSM criteria.

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[15] CAGE (an acronym for Cut down, Annoyed, Guilty, Eye-opener) is a screening questionnaire.

The U.S. Department of Health and Human Services (1997) summarized national survey data prior to 1993, indicating that some 6 - 10% of the respondents were alcohol abusers or alcohol-dependent. These percentages are in the same range found in a telephone survey involving a probability sample of 6,250 respondents in Ontario and Quebec (Cochrane, Goering, and Lancee, 1992). The survey instrument included a psychiatric symptom inventory and questions relating to problem drinking that were adapted from the Diagnostic Interview Schedule. This survey found a rate of 7.1% for problem drinking.

A third classification often used for drinkers is "alcoholic," roughly defined as someone who shows major symptoms of alcohol dependence, including impaired control over drinking, alcohol withdrawal symptoms, and obsessive-compulsive drinking style (Skinner and Holt, 1987). The percentage of alcoholics in the drinking age population is not well known, but was estimated by Skinner and Holt at about 5% of the drinking age population in North America. This percentage is quite close to the percentage of heavy drinkers (persons who consumed five or more drinks on the same occasion on at least five different days in the past month) found in the 1998 National Household Survey on Drug Abuse, namely, 5.9%. Further, the U.S. Department of Health and Human Services (1997) summary of pre-1993 survey data indicates that 3 - 6% of the respondents were alcohol-dependent.

Based on the literature we have examined in this review, we conclude that a precise estimate of the percentage distribution of the drinker types discussed above is not possible. Our own rough estimate of the distribution of drinker types in the U.S. is provided in **Table 4-1** below.

Table 4-1: Rough Estimates of the Distribution of Four Commonly Used Drinking Types in the United States at the Millennium

Drinker Type	Percent of Drinking Age Population
Abstainer	35%
Social Drinker	57%
Problem Drinker, Not Alcoholic	4%
Problem Drinker, Alcoholic	4%

The panel convened for the 1981 study of alcohol and public policy (Panel on Alternative Strategies Affecting the Prevention of Alcohol Abuse and Alcoholism, 1981) estimated the alcohol consumption of different drinker types, commenting

that it was remarkable how much of the population was completely abstinent or drank very little. The panel also observed that the heaviest-drinking 5% of the of the population accounted for about 50% of total alcohol consumption, and that the heaviest third accounted for over 95% of the total alcohol consumed.

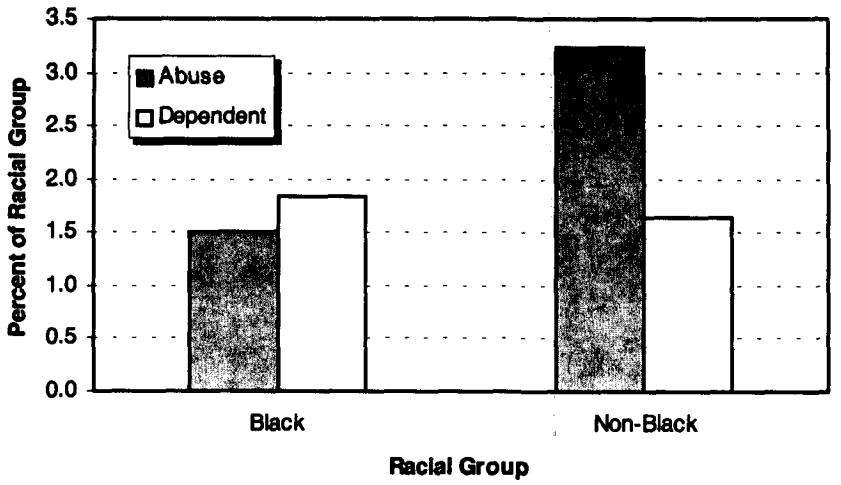
We note that drinking patterns vary widely among different groups of persons. Midanik and Clark (1994) studied the drinking patterns of a number of demographic groups and found that the percentage of males who were current drinkers, weekly drinkers, and drinkers of five or more drinks on at least one occasion at least once a week, were less than the corresponding percentages for women. In addition, the data presented in the study by Midanik and Clark showed that the differences in the percentages between men and women increased with increasing drinking frequency and quantity of drinking. Other studies have found that women are less likely to engage in heavy drinking or to be problem drinkers than are men. The survey reported by Balmforth (1998) found that 74% of problem drinkers were male, and the Canadian survey reported by Cochrane, Goering, and Lancee (1992) found that problem-drinking rates for men are approximately six times greater than for women. Data from the U.S. Department of Health and Human Services report (1997) show that the percentage of males who were alcohol abusers or alcohol dependent was roughly two to three times that of alcohol abusing / dependent females. (The same report gives a lengthy discussion of the drinking patterns of women, concluding, overall, that women drink less than men.)

Age, race, and ethnicity also play a significant role in drinking patterns. With respect to age, data from the1997 survey reported by Balmforth indicate that 21 - 29 year and 30 - 45 year age groups have the highest percentage of problem drinkers (by the survey's definition), at roughly 30% for each group. The 46 - 64 group was next at 18%, followed by the 16 -20 group and the 65+ group at 13% and 9%, respectively. (Note that the minimum legal drinking age in all States is 21 years.)

The data from the 1994 Midanik and Clark study cited above show that the 18 - 29 year age group had the largest percentage of heavy drinkers in 1990 (7%), and the 60+ age group had the lowest (1.5%). The other age groups had percentages in the 3 - 4% range. Data from the 1992 National Longitudinal Alcohol Epidemiologic Survey presented by Grant (1994) show that the 18 - 29 age group also had the highest percentage of alcohol abusers (6.5%), and 65+ age group the lowest (0.3%). The percentages of persons classified as alcohol- dependent followed a similar pattern, showing 3.2% of the18 - 29 age group and 0.2% of the 65+ age group to be alcohol-dependent.

Grant (1994) also tabulated data on alcohol abuse and dependence as a function of race, categorized as either Black or non-Black. The data show that the percent of non-Black alcohol abusers is about twice as high as the percent of Black alcohol abusers, but that the percent of alcohol dependence is about the same for the two groups (**Figure 4-3**).

Figure 4-3: Percent of the Drinking Age Population Who Are Alcohol Abusers or Alcohol Dependent by Racial Group



In a more recent study, Caetano and Clark (1998) examined national trends in alcohol consumption patterns among Whites, Blacks and Hispanics between 1984 and 1995. Data were obtained from two National Alcohol Surveys of U.S. households, the first conducted in 1984 (and used in the above-cited study by Myotonic and Clark), and the second in 1995. The study found that, between 1984 and 1995, the rate of abstention remained stable among Whites but increased among Blacks and Hispanics. It also found that frequent heavy drinking decreased among White men (from 20 percent to 12 percent), but remained stable among Black (15 percent in both surveys) and Hispanic men (17 percent and 18 percent). Frequent heavy drinking was found to have decreased among White women (from 5 percent to 2 percent), but to have remained stable among Black (5 percent in both surveys) and Hispanic women (2 percent and 3 percent). White men and women were two times more likely to be frequent heavy drinkers in 1984 than in 1995. The authors concluded that the reduction in per capita consumption in the U.S. (noted above) is differentially influencing White, Black and Hispanic ethnic groups, and that the stability of rates of frequent heavy drinking places Blacks and Hispanics at a higher risk for problem development than Whites.

The effect of many other demographic variables on drinking patterns is presented in the Myotonic and Clark study, including variables related to socioeconomic status. A recent study by Van Oers, Bongers, Van De Goor et al. (1999) presented results from a survey of 8,000 subjects and noted that lower socioeconomic status (SES) is generally associated with more health problems, and shorter life expectancy. Educational level was used as a surrogate for SES,

and the dependent variables were alcohol consumption, alcohol-related problems, and problem drinking. The study found that educational level and abstinence were inversely related in both sexes, and that excessive drinking was more prevalent among men in the group with the lowest educational level. However, it found no significant relationship between educational level and prevalence of excessive drinking in women. No relationship was found between problem drinking prevalence and educational level in either sex. The authors concluded that: there were differences between educational levels with respect to abstinence, differences with respect to excessive drinking were limited, and prevalence of alcohol-related problems in both sexes are higher in lower educational levels after controlling for differences in drinking behavior.

As a final commentary on the effect of demographic variables on drinking patterns, we note the results of an analysis conducted by Midanik and Clark (1995). The analysis involved separate statistical studies of dependence symptoms and social consequences in which demographic variables were used as controls. After all of the demographic variables (11 in all) were taken into account, only younger age (the 18 - 29 age group) was associated with alcohol problems.

There is evidence that age of drinking onset also may be associated with drinking problems later in life. Hingson, Heeren, Levenson et al. (2001) analyzed data from the National Longitudinal Epidemiology Survey to see whether persons who begin drinking at younger ages are more likely to report drunk driving and alcohol-related crash involvement over their lifetime. The study found that, the earlier the age respondents started drinking, the more likely they were to report driving after drinking too much and being in a motor vehicle crash because of their drinking, even after adjusting for current / ever diagnosis of alcohol dependence and other characteristics and behaviors associated with the age respondents started drinking. Even among persons who were never alcohol dependent, those who began drinking in each age group under 21, relative to those starting at age 21 or older, were more likely to report "ever" and "in the past year" being in a crash after drinking too much. Another study of the same data set revealed that this finding also applied in a general sense to unintentional injuries of any kind (Hingson, Heeren, Jamanka et al., 2001).

The above discussion of alcohol abuse is based largely on survey data. However, another means of identifying alcohol abuse, biochemical test abnormality, is receiving increased emphasis in the literature. Several types of such tests, and their value in clinical settings, are described briefly by Rosalki (1999).

As important as drinking patterns are for explaining alcohol problems and dependency, recent research indicates genetic factors may be of equal or greater importance. In fact, the Tenth Special Report to the U. S. Congress on Alcohol and Health (which just became available as this review was being completed) stated:

> "Perhaps the single greatest influence on the scope and direction of alcohol research has been the finding that a portion of the vulnerability to alcoholism is genetic. Approximately 50-60 percent of the risk for developing alcoholism is genetic."

Studies leading to this conclusion are discussed in the report (U.S. Department of Health and Human Services, 2000b).

Drinking by college students has been the subject of considerable study in recent years and has generated a fairly sizable amount of literature. Much of the literature deals with so-called binge drinking, now generally defined by researchers as five consecutive drinks for male students and four for females. Wechsler, Molnar, Davenport et al. (1999) used data from the 1993 Harvard School of Public Health College Alcohol Study to describe weekly alcohol consumption and its associated problems among a representative national sample of 17,592 students at 140 colleges. A drink was defined as either a 12 ounce can/bottle of beer, a 4 ounce glass of wine, a 12 ounce bottle/can of wine cooler, or a drink containing 1.25 ounces of liquor. Three categories of drinkers were analyzed: non-binge drinkers, infrequent binge drinkers, and frequent binge drinkers. They found that the median number of drinks consumed per week by all students was 0.7 for those who did not binge drink and 3.7 for those who did so infrequently. Frequent binge drinkers drank a median of 14.5 drinks/week. By these researchers' definitions, nationally, 1 in 5 college students was a frequent binge drinker, and binge drinkers consumed 68% of all the alcohol that students reported drinking. Further, binge drinkers accounted for the majority of reported alcohol-related problems.

A later study by Wechsler and Kuo (2000) of 1999 data found that students themselves defined binge drinking as six drinks in a row for men and five for women, one drink higher than that used by researchers. The students estimated that 35% of all students were binge drinkers by their criterion, and binge drinkers were more likely to overestimate the prevalence of binge drinking. Wechsler, Austin, and Schuckit (1998) examined the validity of the "five/four" criterion, finding that 92% of the college students surveyed who reported five or more alcohol-related problems (e.g., drinking and driving, job problems, and alcohol dependence) in the previous year were identified by the five/four measure as binge drinkers. They concluded that "binge drinking on college campuses is normative, and recognizing this problem and confronting it is an appropriate response."

Brown-Pearson (2000) examined the results of a survey of 2,291 students in an Hispanic-serving university in Texas, and reported a number of interesting findings, as follows:

- 31 percent of students reported at least one binge drinking episode in the previous two weeks;
- more males than females were consuming alcohol on the campus;

- off-campus students did not report more binge drinking episodes than on-campus students;
- drinking patterns of Hispanic students were similar to those of White students; and
- overall trends of alcohol use remained relatively stable, and while the perception was that binge drinking had increased slightly, the perception did not match actual reports.

In another study of college students in Texas, the Texas Commission on Alcohol and Drug Abuse (TCADA), in conjunction with the Public Policy Research Institute (PPRI) of Texas A&M University, conducted a telephone survey of substance use and related behaviors among some 2,420 randomly-selected, full-time undergraduate students in Texas aged 18 to 26 (Kerber and Wallisch, 1999). Though the majority of college students did not misuse alcohol, 29% engaged in binge drinking, and 15% were abusing alcohol at the time of the survey. Being male, over the age of 21, Anglo, Hispanic, and having parents with an annual income of over $60,000 increased the risk for binge drinking. Lifestyle characteristics that increased the odds for binge drinking included receiving low grades, being a fraternity or sorority member, and believing that drinking is a very important part of college life. The misuse of alcohol was associated with several other risky behaviors, including driving while intoxicated, risky sex practices, and problem gambling.

The results of a statewide study in California yielded similar results with respect to the prevalence of college binge drinking (Patrick, Covin, Fulop et al., 1997). It found that 37% of students had binged at least once while drinking, that 25% had driven following consumption of alcohol, and that 32% had ridden in a car with someone who had been drinking.

Dowdall, Crawford, and Wechsler (1998) studied data from a survey of 508 students at women's colleges and 9,624 students at coeducational colleges, finding that women at women's colleges binged less frequently, had fewer alcohol-related problems, experienced fewer negative effects of others' drinking, and were less likely to drink and drive. The researchers hypothesized that self-selection factors at women's colleges may contribute to a healthier environment for women.

Clements (1999) delved more deeply into the drinking problems of 306 college students (74.8% female, 25.2% male). The subjects were administered a number of assessment instruments. Of the total sample, 16% reported that they abstained from alcohol. Of the students who consumed alcohol, the men drank significantly larger quantities than the women, and drank more frequently. White students drank more frequently than Hispanic or African American students. A significantly larger proportion of the men (26%), compared with the women (11%), engaged in binge drinking on a typical day of drinking. Almost one quarter of the sample met the DSM-IV criteria for alcohol abuse or dependence

within the past 12 months. The lifetime prevalence for abuse and dependence was an astonishing 35%.

Not all studies have shown such high prevalence of drinking problems among college students. For example, Prince (1999) found that some 9% of 633 students surveyed reported a drinking problem. Seniors reported more problem drinking than any other class. White students reported more problem drinking than the other races, but Hispanic students reported the highest rate of binge drinking.

Data from the 1997 Harvard School of Public Health College Alcohol Study survey also reveal a number of correlates of underage alcohol consumption and related problems (Wechsler, Kuo, Lee et al., 2000). Compared to students aged 21+ years, underage students (< 21 years) engaged in less frequent and less extensive drinking, but consumed more drinks per occasion and had a greater likelihood of drinking in private settings. Correlates of binge drinking overall included residence in a fraternity or sorority, easy access to alcohol, ability to obtain drinks at lower or set prices, and consumption of beer.

Wechsler, Dowdall, Maenner et al. (1998) compared college student binge drinking and related problems in 1993 to those in 1997, again using data from the Harvard School of Public Health College Alcohol Study surveys of students. In 1997, 130 of the original 140 colleges surveyed in 1993 were re-surveyed. The authors found little change in binge drinking. They also found that two out of five students were binge drinkers, that one in five were abstainers, that one in five was a frequent binge drinker, and that four of five residents of fraternities or sororities were binge drinkers. Finally, their data indicated that, among those students who did drink, frequency of drinking, of drunkenness, of drinking to get drunk, and alcohol-related problems, including drinking and driving all increased in 1997 over what they were in 1993.

Finally, Wechsler and associates (2000) compared the results of their most recent (1999) College Alcohol Study by the Harvard School of Public Health with those of the 1993 and 1997 surveys. It was found that 44% of the respondents were binge drinkers in 1999, essentially the same rate as in 1993. Interestingly, both abstention and frequent binge-drinking rates increased significantly, with 19% abstainers and 23% frequent binge drinkers in 1999. Also, binge drinkers still were more likely than other students to experience alcohol-related problems, and students who did not binge drink were at higher risk of the secondhand effects of other students' heavy drinking at those colleges with high binge-drinking rates.

Essentially all of the findings on drinking by college students reviewed here are based on self-reported data, in most instances from surveys completed by the respondents. A program to reduce excessive/binge drinking at the University of North Carolina (UNC), currently being evaluated by NHTSA, measured the *actual* BACs of students who indicated they were either a binge drinker (by the five/four criterion) or a non-binge drinker. Their survey was conducted to support the development of a program approach based on the nature of college student

drinking at UNC, and sought to determine the extent of alcohol use by college students, the amount of drinking-driving by college students, and factors contributing to heavy drinking.

A total of 1,846 randomly selected UNC-Chapel Hill students were interviewed on all nights of the week as the students returned to dorms, fraternity/sorority houses, and off-campus apartments. As a result, BACs were obtained from 1,790 (97%) of the sample, and it was found that only 28% had any measurable alcohol, and only 10% were at .10+. It was also found that:

- 17% of the males and 9% of the females were at .08+;
- 13% of students under age 21 and 13% of students age 21 and over were at .08+; and
- 2% of drivers, and 17% pedestrians /others were at .08+.

The self-reported binge drinkers were 49% of those sampled. About 56% of binge drinkers had a zero BAC at the time of the survey compared to 92% of non-binge drinkers, and 18% of binge drinkers and 1% of non-binge drinkers had .10+. The UNC researchers concluded that:

- students (and others) greatly overestimate the amount of drinking on college campuses;
- these overestimates lead to the erroneous conclusion that frequent and excessive drinking is the social norm on campuses;
- the erroneous belief that "everyone" drinks creates a strong pressure on students to drink; and
- correcting these misperceptions, by communicating the facts about actual drinking norms, should reduce student drinking.

We note again that the research discussed in this section is based largely on self-reported data. The limitations of this kind of data have been discussed elsewhere, including the U.S. Department of Health and Human Services report (1997), and will not be repeated here.

CHARACTERISTICS OF DRINKING DRIVERS

The prior section has discussed some of the characteristics of drinkers in general in the United States. In this section, we examine the characteristics of various groups of *drinking drivers*. Several categories of variables describing the characteristics are discussed, *viz.*:

- Biographical variables, including such variables as age, sex, and ethnicity;
- Drinking variables, such as type of beverage, quantity and frequency of drinking, drinking patterns and alcohol abuse, and drinking locations;

- Drinking-driving variables, including time of day, day of week, type of vehicle driven, number of drinking-driving trips, and variables describing the actual and perceived consequences of drinking-driving; and
- Variables that do not fit neatly into any of the above groupings, including psychosocial variables, and variables describing special groups of drivers such as high-BAC drinking drivers.

The treatment is an extension of Chapter 2, which was concerned with the overall magnitude of the alcohol-crash problem and discussed the problem in broad terms.

For the most part, these variables are discussed one by one in univariate fashion, but interaction effects are noted in some instances. A comprehensive treatment of interaction effects is not possible here because of the time and space that would be required, and the lack of pertinent literature. The same can be said for multivariate analyses.

Several populations of drinking drivers are examined, including:

- Drivers involved in traffic crashes;
- Drivers injured in traffic crashes and treated in hospitals;
- Drivers using the roads but not crashed (i.e., non-crashed drivers);
- Drivers arrested for driving while impaired (DWI):
  - ✓ Drivers convicted of DWI,
  - ✓ Drivers screened for drinking problems and participating in alcohol treatment programs,
  - ✓ Drivers who received various other legal sanctions for DWI;
- Drivers who were subjects in evaluations of drinking-driving programs;
- Drivers who were respondents in surveys of drinking-driving patterns

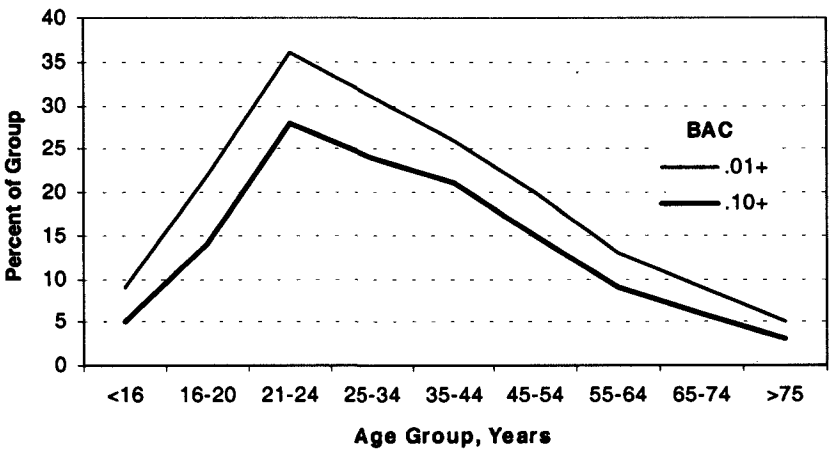
Biographical Variables

Age. Prior state of knowledge updates have found that 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. The 1984 update presented data from NHTSA's Fatal Accident Reporting System (subsequently renamed the Fatality Analysis Reporting System or 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 traveled 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 1989 study reported that the most important development since the 1984 update was that the percentage of crashes involving alcohol had declined during the 1980s, and that the share of young drivers in alcohol-related crashes has been disproportionately reduced. The

findings of the 1998 review with respect to driver age tended to be consistent with those of prior studies discussed in prior state of knowledge updates, with additional information being provided to confirm and augment prior findings.

Nationwide data on driver age as a factor in alcohol-related fatal crashes are available from the latest FARS report at this writing (U.S. Department of Transportation NHTSA, 1999). These data are plotted in **Figure 4-4** and show that the 21-24 year age group had the highest percentage of drivers in alcohol-related fatal crashes, both at .01+ and .10+ (36% and 28%, respectively). The percentages declined steadily from this peak with increasing age, reaching minimums of 3% and 5%, respectively, for the oldest age group, >75 years. Drivers in the under 16 years and 16-20 years age groups (both under the minimum legal drinking age) also had much lower percentages than the 21-24 years age group in both BAC ranges.

Figure 4-4: Drivers in Fatal Crashes by BAC and Age, 1998



These age groups should not be used in computing the share of fatal alcohol-involved crashes as a function of driver age. This is because the age categories in the figure are not of equal size: the categories for ages 25 through 74 contain 10 years each, while the category for ages 16-20 contains five years, and the category for ages 21-24 contains only four years. We used FARS data for 1998 to calculate the drivers of a given age in years with a given BAC (.01+ and .10+) as a percentage of drivers of all ages in that BAC range. We found that for both BACs, this percentage peaks at age 21 (**Figure 4-4**), and drops sharply on either side of the peak.

Figure 4-6: Drivers of a Given Age in Years with or over a Given BAC as a Percentage of Drivers of All Ages with that BAC, Fatal Crashes, 1998

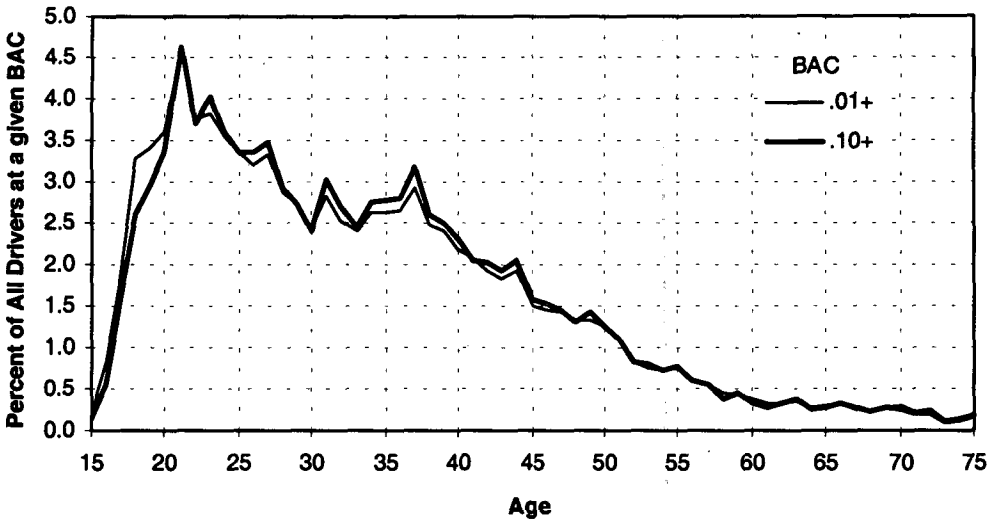
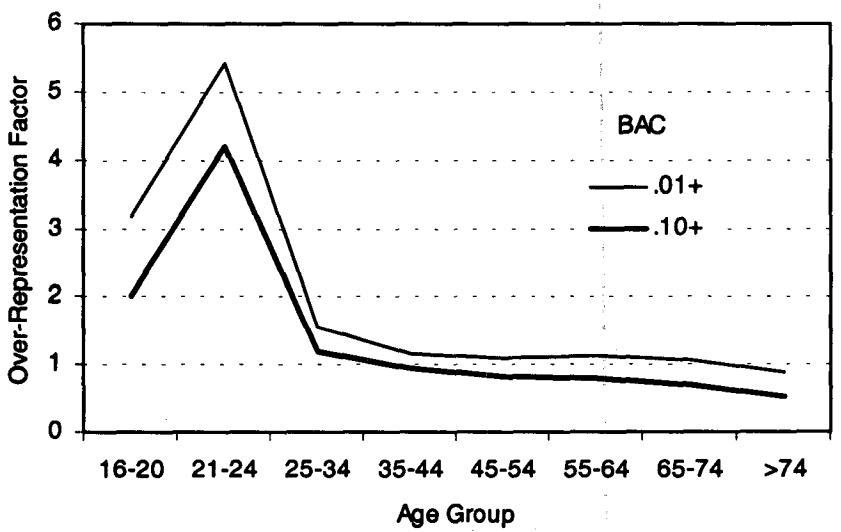


Figure 4-5:Overrepresentation of Various Age Groups of Drivers in Fatal Alcohol-related Fatal Crashes, 1998



In 1998, the 21-24 years age group contained 6.7% of all licensed drivers (U.S. Department of Transportation FHWA, 1999), compared to the 28% of the same age group of .10+ BAC drivers in fatal crashes. This amounts to an over-representation by a factor of 4.2 (28 / 6.7) of this age group in fatal crashes that are clearly alcohol-related. The degree of over-representation of other age groups is shown in **Figure 4-5** for BACs of .01+ and .10+. The sharp peaking of over-representation for the 21-24 years age group is clear. It can also be seen that over-representation is smaller and quite flat for older age groups, but still high for the 16-20 years age group.

NHTSA's General Estimates System (GES) provides data on the age of drivers involved in non-fatal crashes which, in the opinion of the investigating officer, involved alcohol. **Figure 4-7** shows that the 21-24 years age group had the highest percent of drivers in alcohol-involved injury crashes in 1998 (8%), but that the 25-34 age group had the highest percentage in alcohol-related property damage crashes (5%). Both curves decrease on either side of their peak, but the property damage curve has an increase back to its peak value for the 55-64 age group. The 25-34 years age group accounts for the largest percentage of alcohol-involved non-fatal crashes, but this is probably due to unequal category sizes as indicated in our previous discussion of fatal crashes (**Figure 4-8**).

Studies of drivers injured in traffic crashes and admitted to regional trauma centers in the U.S. and Canada provide information on the age distribution of this special group of drivers (Dischinger and Cowley, 1989; Soderstrom, Dischinger, Ho et al., 1990; Vingilis, Stoduto, Macartney-Filgate et al., 1994). The study by Vingilis and associates is especially interesting, comparing the biographical characteristics of 96 alcohol-negative and alcohol-positive drivers who had been seriously injured in traffic crashes in Ontario, Canada in the 1986-1989 time period, and referred to a regional trauma unit. The mean ages of the two groups were about the same (37.1 years for alcohol-negative group versus 35.0 years for the alcohol-positive group), but the age distribution of the alcohol-positive drivers peaked at a higher age (26-35 years) than that of the alcohol-negative group (18-25 years).

Figure 4-7: Drivers in Non-Fatal Alcohol-Involved Crashes by Age Group, 1998

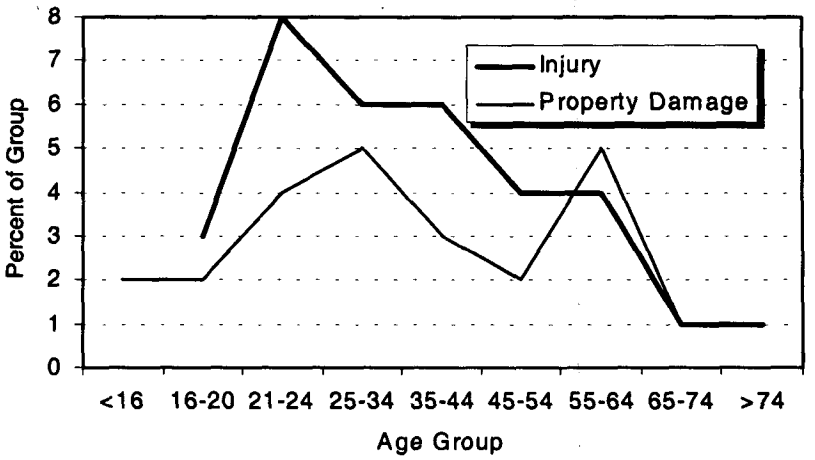
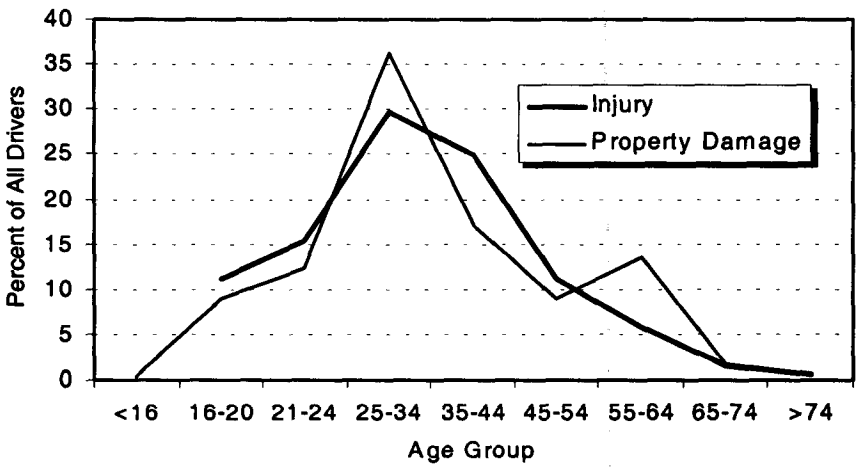


Figure 4-8: Drivers in Given Age Groups as a Percentage of All Drivers in Alcohol-Involved Non-Fatal Crashes, 1998



The 1999 FARS report on 1998 fatal crashes includes *trends* in alcohol-related fatal crashes by age group for the period 1982 through 1998. **Figure 4-9** shows drivers at .10+ as a percentage of all fatal-crash involved drivers versus year for various age groups. The trend is clearly down for all of the groups. **Figure 4-10** depicts the percentage decrease for each of these groups from 1982 to 1998, indicating that the 16-20 years age group and the 65+ years age group had the largest decreases (~50%), and that the 21-44 years age group had the smallest (~25%-30%). Note that the upward trend to the left of the minimum is reversed at the lowest age group, which also contains the smallest number of drivers in fatal crashes (361 in 1998). (There were a total of 56,543 drivers in fatal crashes in 1998, including 882 of unknown age.)

As indicated earlier in this report, roadside surveys have measured the BACs of drivers using the roads, but not involved in crashes. The nationwide surveys have been conducted on weekends and during nighttime hours. The age distributions reported for the latest survey (1996) was limited to four groups, <21 years, 21-34 years, 35-44 years, and >45 years (Voas, Wells, Lestina et al., 2000). The 21-34 and the 35-44 groups had an almost identical percentage of drivers at .10+, 3.8% and 3.7%, respectively. Only 0.3% of the youngest age group (<21 years) were at .10+, and the >45 years age group had 1.7% at .10+.

The percentage of non-crash involved drivers at .10+ shows a downward trend for all four age groups since the first survey in 1973 (**Figure 4-11**). However, only the <21 years age group showed a *statistically significant* decrease ($p < 0.05$) in percentage at .10+ since the 1986 survey, but that decrease was quite large – 88%.

The surveys cited earlier in this report present self-reported data on drinking driving as a function of driver age (Balmforth, 1998; Townsend, Lane, Dewa et al., 1998). The Balmforth report provides percentages of drivers in various age groups who said they had driven within two hours after drinking any alcohol in the past 30 days, and Townsend and associates give a breakdown of the total number of drivers by age who said they had driven within two hours in the past year after drinking any alcohol. The percentages are shown in **Figure 4-12.**

Figure 4-9: Drivers in Fatal Crashes at a BAC of .10+ as a Percentage of All Drivers in Fatal Crashes by Age, 1982-1998

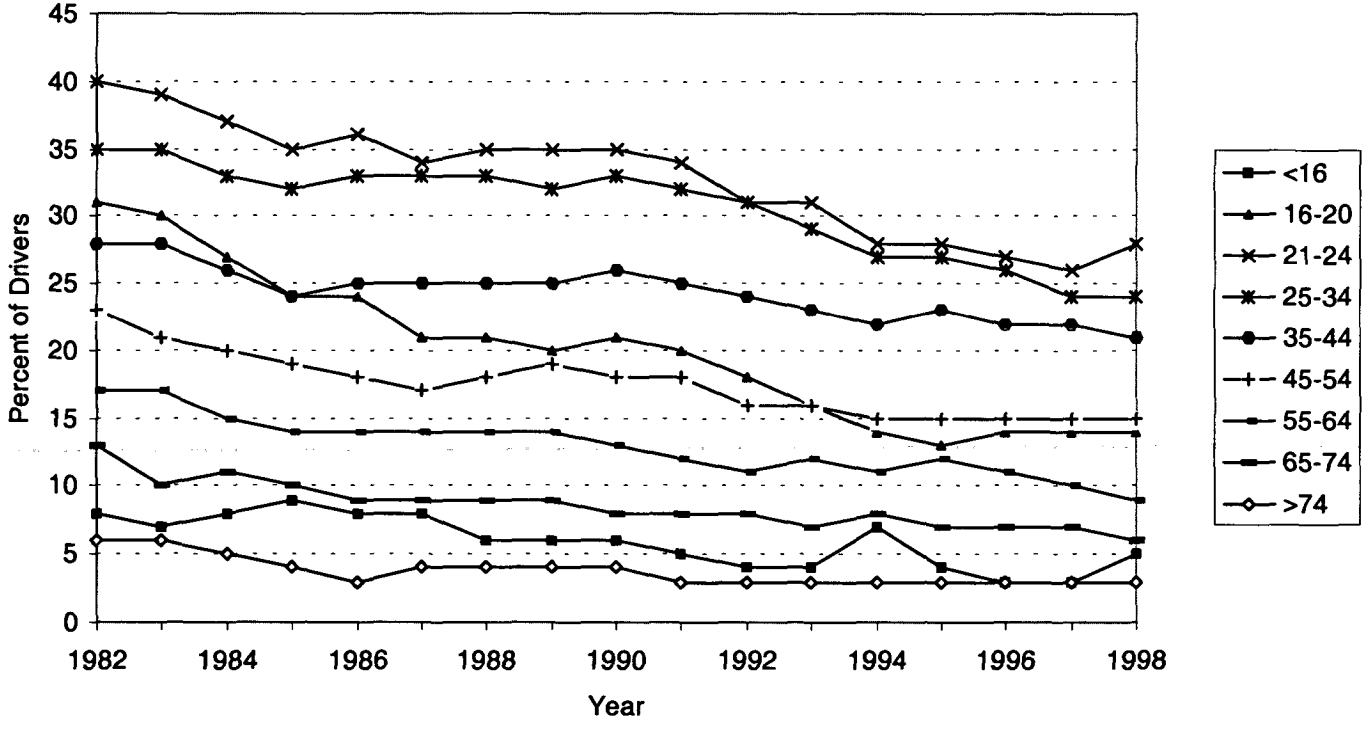


Figure 4-10: Percent Decrease From 1982 to 1998 in Percent of Drivers with BACs of .10+ in Fatal Crashes by Age Group

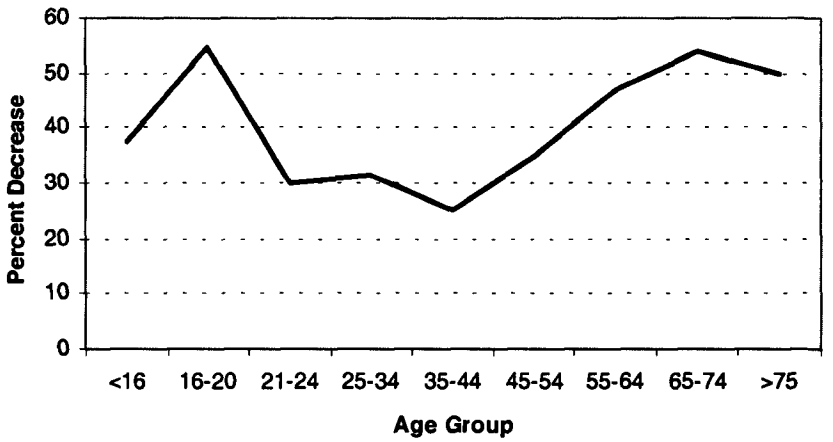


Figure 4-11: Non-Crashed Drivers with a BAC of .10+ as a Percentage of All Non-Crashed Drivers by Age, Nationwide Roadside Surveys 1973-1996

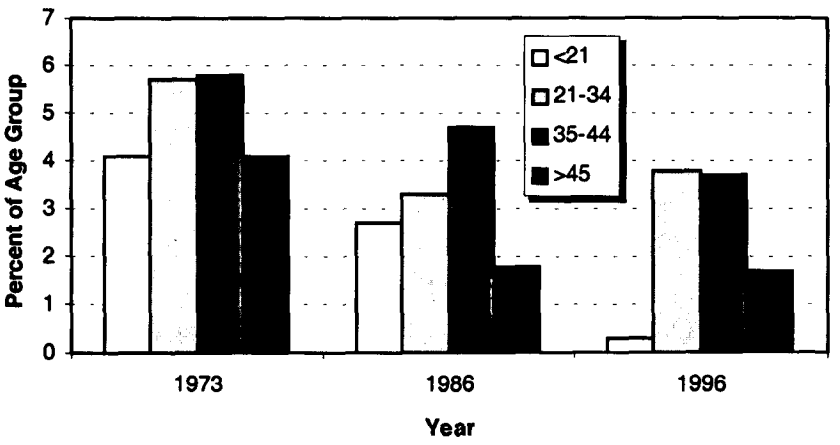
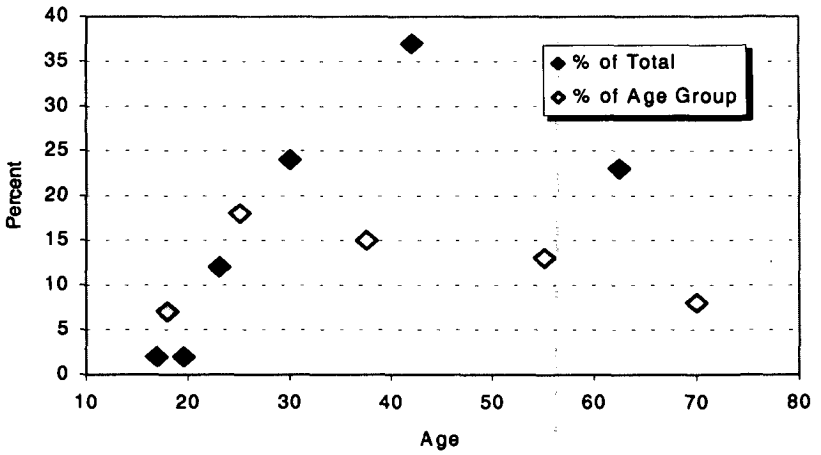


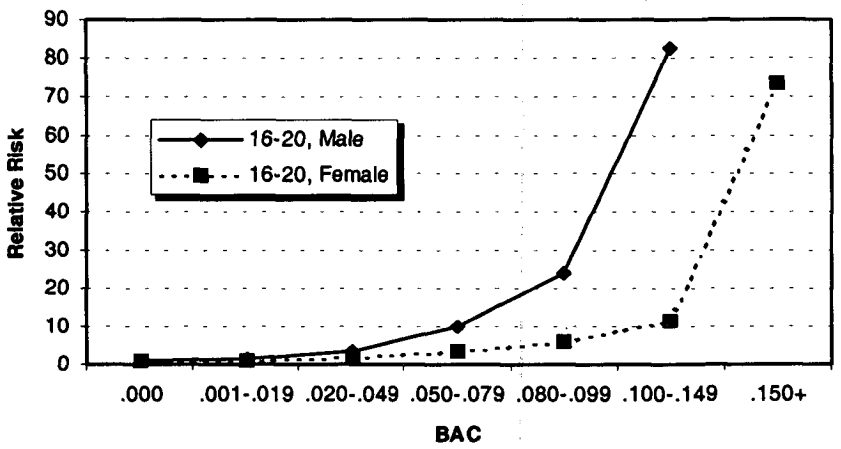
Figure 4-12: Age Effects on Driving Within Two Hours After Drinking Any Alcohol, Data From Two National Surveys



The figure shows that the 25 years age group is most likely to drive after drinking within two hours, and that the youngest and the oldest drivers are the least likely. However, the 45 years age group had the highest percentage of all persons who said they drove within two hours after drinking.

Zador and associates (2000) considered the effect of driver age in their analysis of fatal crash risk, but provided relative risk curves only for three age groups, by driver sex. The age groups were 16-20, 21-34, and 35+ years. The relative risk curves for the 16-20 years group are shown in **Figure 4-13**. The curves for the other two age groups are the same as the curve for 16-20 years females, except at .001-.010 BAC. At .001-.010 BAC the relative risk of the 21-

Figure 4-13: Relative Risk of A Fatal Crash for Males and Females Age 16-20, Data from Zador and associates (2000)



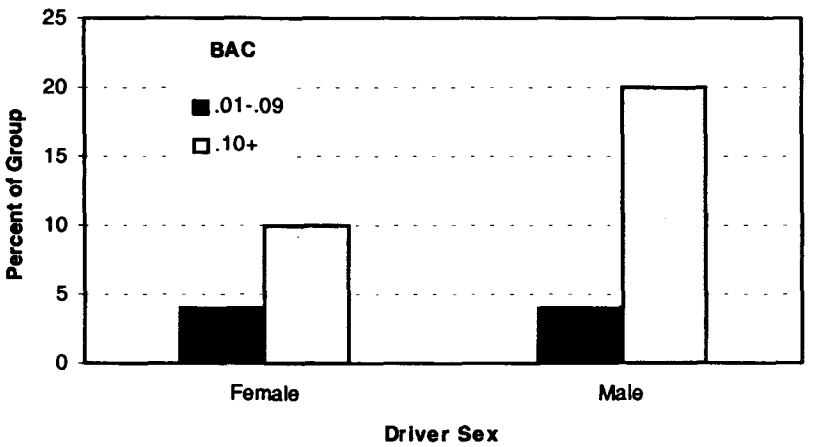
34 and 35+ years age groups for both sexes drops to .18, compared to 1.22 for the females of age 16-20 years.

Waller (1998) reviewed research on the effects of alcohol and aging on driving performance and found that, after about age 55, crash risk per mile driven begins to increase, and continues to increase with age at an accelerating rate until it may exceed that of young beginning drivers for drivers in their eighties. Alcohol was found to further increase the crash risk of older drivers.

Sex. Prior state of knowledge updates have found that drinking-drivers are predominately male, but that female drivers nevertheless comprise a significant percentage of drivers in alcohol-related crashes. Further, recent updates have found that the role of female drivers in alcohol-related crashes is increasing.

FARS data for 1998 show that 20% of males involved in fatal crashes had a BAC of .10+, compared to 10% of females (**Figure 4-14**). However, the percentages for males and females were about the same (4%) at lower BACs.

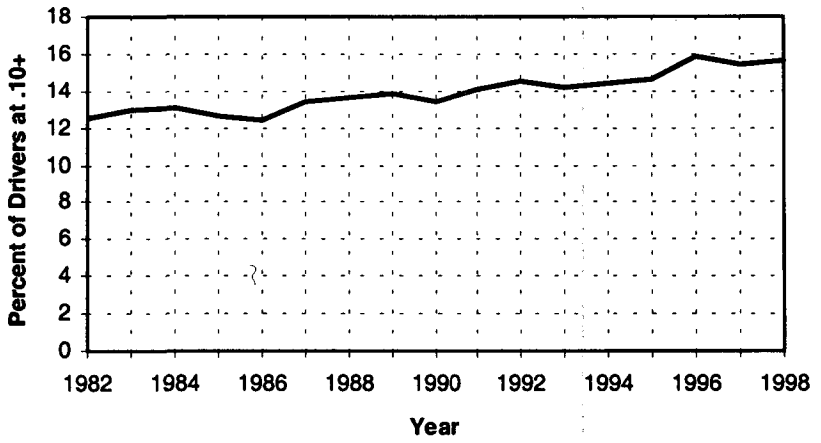
Figure 4-14: Drivers in Fatal Crashes by BAC and Sex, 1998



Males drivers constitute a much larger portion of the alcohol-crash problem than female drivers[16]. In 1998, about 84% of the drivers at .10+ in fatal crashes were male, but the percentage of female drivers continues to increase slowly, from 13% in 1982 to 16% in 1998 (**Figure 4-15**).

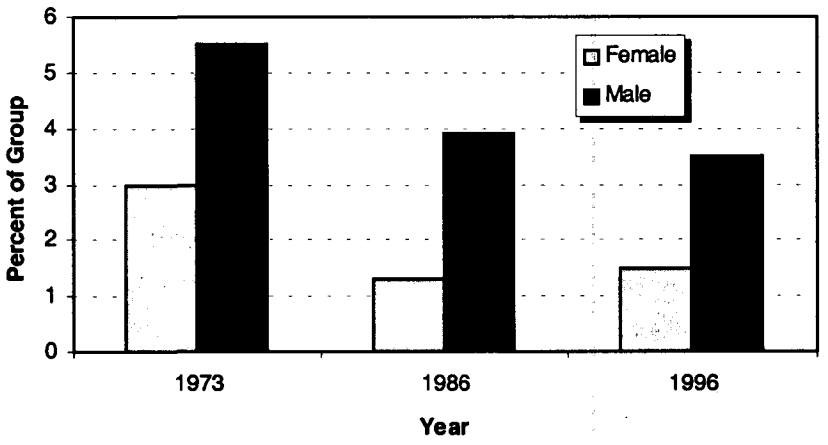
[16] Data on non-fatal alcohol-related crashes as a function of driver sex were not presented in the 1999 FARS report.

Figure 4-15: Female Drivers as a Percent of All Drivers in Fatal Crashes at BAC=.10+, 1982-1998



Roadside survey data indicate that the percentage of male non-crashed drivers at .10+ has declined since the first survey in 1973, but that the decline decreased since 1986 **Figure 4-16**. The percentage of female drivers at .10+ declined by about 50% between the first two surveys, but then increased slightly in 1996.

Figure 4-16: Non-Crashed Drivers with a BAC of .10+ as a Percentage of All Non-Crashed Drivers by Driver Sex, Nationwide Roadside Surveys 1973-1996



The survey data reported by Balmforth indicate that 36% of the males and 13% of females had driven within two hours after drinking in the past year. Data from the survey reported by Townsend and associates show that 68% of those

who driven within two hours after drinking in the past year were male, compared to 32% who were female.

Prior state of knowledge updates have indicated that females may have a higher alcohol-related crash relative risk than males, but the recent analysis of FARS data and roadside survey data by Zador and associates shows no such effect for drivers of age 21 years and higher. In fact, their data show that young males (i.e., age 16-20 years) have a higher relative risk than young females at all BACs (See **Figure 4-13**).

Race and Ethnicity. The 1998 update observed that the role of race in the alcohol-crash problem has rarely been addressed in prior research, noting that the 1978 update found some suggestion of a race effect, but could not separate the effect of race from the effect of socio-economic status. Indeed, it has been argued that race / ethnicity is not a valid attribute for describing most human behaviors, since it implies some kind of inborn genetic characteristic rather than a human condition or life event such as education, employment status, income, and drinking patterns. Nevertheless, racial and ethnic groups have been found to differ with respect to many variables that describe their condition, and race / ethnicity are widely used as independent variables in the scientific literature on many disciplines.

FARS does not contain data on driver race and ethnicity, but some States include race as a variable in their crash files. We examined one such State's crash files (Florida) to calculate the number of crash-involved drivers in various racial groups as a percentage of all had-been-drinking (HBD) crash-involved drivers for the period 1993-1998. We found that: drivers classified as "White" accounted for about 80% of the HBD drivers, "Black" drivers for about 10%, "Hispanic" drivers for about 9%, and "Other" drivers for about 1%. These percentages have varied slightly over the period reported, with the percentage of Whites decreasing slowly from 82% to 78%, and the percentages for the non-White groups increasing slowly (**Figure 4-17**). The Hispanic group showed the largest increase, from 7% in 1993 to 10% in 1998.

Whites also had the largest percentage of HBD drivers in crashes of any group, followed by Hispanics, Blacks, and others in that order (**Figure 4-18**). The percentages declined for all groups over the 1993-1998 period, with Hispanics showing the largest decrease over the period.

Figure 4-17: Had-Been-Drinking Drivers as a Percentage of All Drivers in Given Racial / Ethnic Groups in Crashes in Florida, 1993-1998

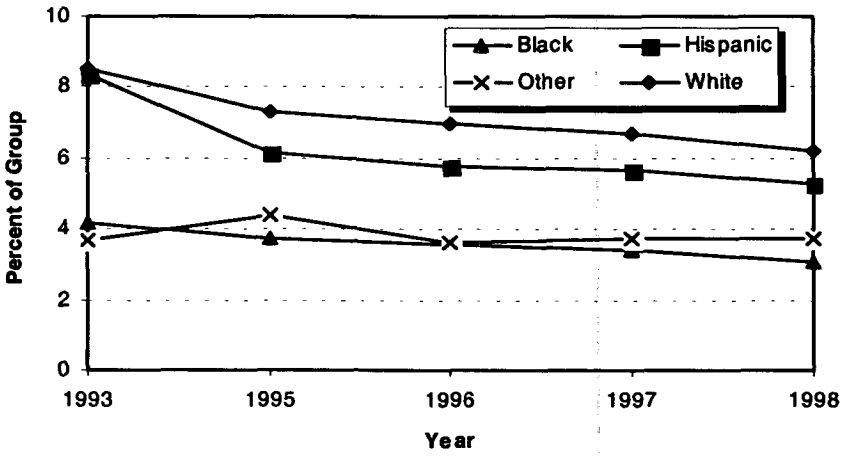
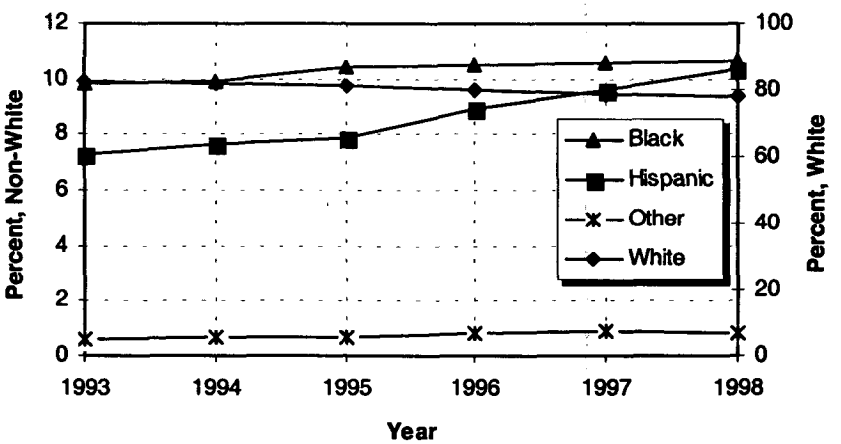


Figure 4-18: Drivers in Various Racial / Ethnic Groups as a Percentage of All Had-Been-Drinking Drivers in Crashes in Florida, 1993 -1998



Further insights on the role of alcohol in crashes have been gained by matching FARS data with death certificate data collected by the National Center for Health Statistics. Voas and associates (2000) recently compiled such data for the period 1990-1994, finding that "Caucasian Americans" accounted for about 72% of alcohol-related fatalities, "African Americans" for about 12%, various Hispanics groups for about 13%, and other ethnic groups (including Native Americans) for about 3%. Note that an alcohol-related fatality was one that occurred in a crash in which a driver, pedestrian, or cyclist had a BAC of .01+. These percentages are quite close to those for the HBD *drivers only* in Florida, with the exception of the percentage of "Other" ethnic groups (**Table 4-2**). Native Americans have been found to be highly over-represented in pedestrian crashes (discussed later in this report), which may help account for the larger percent of other ethnic groups in the study by Voas and associates.

Table 4-2: Racial / Ethnic Composition of Two Alcohol-Related Crash Populations

Population	Racial / Ethnic Group, % of Population			
	White / Caucasian American	Black / African American	Hispanic / Hispanic Sub-Groups	Other
Florida, HBD Drivers in All Crashes	80	10	9	1
FARS / NCHS, Fatalities in Crashes Involving a .01+ Driver, Pedestrian, or Cyclist	72	12	13	3

The study by Voas and Associates also examined *fatality rates* of different ethnic groups and sub-groups, finding that Native Americans had the highest rates (68%), and that Asian-Pacific Islander Americans had the lowest (28%). The rates for Caucasian Americans and African Americans were nearly the same (~45%). Among Hispanics, Mexican Americans had the highest rates (55%), and Cuban Americans the lowest (37%). Males had higher driver fatality rates than females for all ethnic groups, with smallest differences occurring for Native Americans and Cuban Americans. The 21-40 years age group had the highest alcohol-related driver fatality rates for all ethnic groups, 80% for Native Americans and 70% for Mexican Americans.

Roadside surveys and other surveys provide some recent information on the racial / ethnic characteristics of drivers not necessarily involved in crashes. The 1996 nationwide roadside survey of non-crash involved drivers (Voas, Wells, Lestina et al., 2000) found that about 9% of African Americans had a BAC of .05+ and that about 4% were at .10+. For Hispanics, the percentages were 15%

and 8%, respectively. Further, the percentages for African Americans declined from the two prior surveys, while the percentages for Hispanics increased.

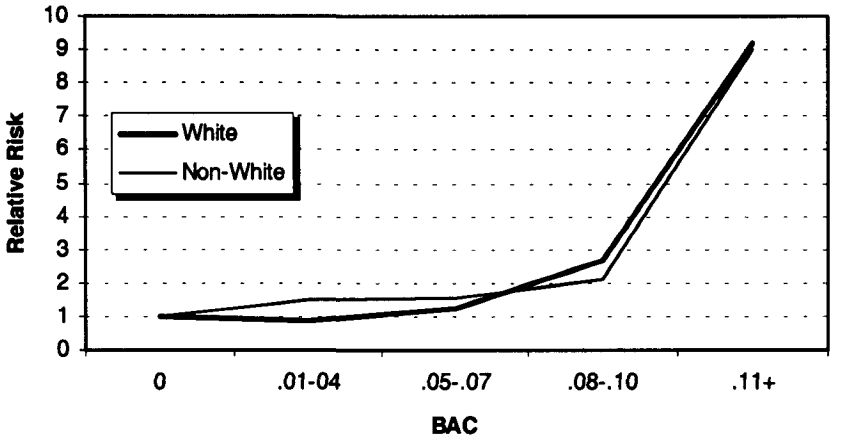
The percentages for Whites were not presented, but the odds of a BAC of .05+ for African Americans and for Hispanics relative to the odds for Whites were computed using a logistic regression model that controlled for age, sex, weekend day, and time period (late or early). The results show that, in 1996, the odds for African Americans were about the same as the odds for Whites, but the odds for Hispanics were 1.7 times the odds for Whites. Also, the odds ratio for African Americans / Whites decreased compared to the first two surveys, while the odds ratio for Hispanics / Whites increased.

Quite different results for Blacks and Hispanics compared to Whites were obtained in the 1996 survey reported by Townsend, Lane, Dewa et al. (1998). Here, the measure was "drove within two hours after use of alcohol alone in the past year." The odds ratios were 0.5 and 0.6 for African Americans / Whites and Hispanics / Whites, respectively. We computed these odds ratios directly from the data in the report (Table 3a) which did not control for the effects of other variables such as age and sex.

The survey reported by Balmforth (1998) did not present any results for different ethnic groups. However, a recent study of results from NHTSA's 1997 survey (the same survey summarized by Balmforth), pooled with the results of two prior surveys conducted in 1993 and 1995, examined the ethnicity factor in some depth (Royal, 2000). Again, the primary measure for drinking-driving was "drove within two hours after use of alcohol alone in the past year." The self-reported prevalence for drinking-driving was 28% for Whites, 21% for American Indians / Eskimos, 17% for Hispanics, 16% for Blacks, and 13% for Asians. Also reported was the percentage of crash-involved drivers who had consumed alcohol within two hours prior to the crash. The figure was 3% for White, non-Hispanic drivers, 7% for Black non-Hispanics, and 8% for Hispanics.

No recent studies of the effect of race or ethnicity on the alcohol-crash relative risk were found in this review. However, raw data from the Grand Rapids study (Borkenstein, Crowther, Shumate et al., 1964) suggest that there is little difference in the relative risk of Whites and non-Whites for crashes of all severities (**Figure 4-19**). The calculated relative risks do not control for any other variables that may have affected relative risk.

Figure 4-19: Relative Risk of a Crash by Race at Given BACs - Grand Rapids Study



Other Biographical Variables. Other biographical characteristics of drinking-drivers that have been studied include marital status, employment status, education, and annual income. Little new knowledge has been gained in recent years on the role of these and other biographical variables in drinking-drivers alcohol-crash involvement, amount of drinking driving, or alcohol crash risk. The 1998 update observed:

> "The 1978 update provided considerable data on the effects of other biographical variables on alcohol-crash risk and incidence, but little new data on this subject were reported in the 1984 and 1989 updates." (p. 19)

However, the 1998 update cited a study of seriously injured drivers in Ontario, Canada (Vingilis, Stoduto, Macartney-Filgate et al., 1994) which revealed large differences between *employed and unemployed* drivers with respect to BAC level -- 20% of employed drivers were alcohol-positive versus 67% of unemployed drivers. This difference is highly significant despite the small sample sizes involved in the study. The 1996 household survey reported by Townsend and associates (1998) found the opposite to be true for persons who "drove within two hours after use of alcohol alone in the past year." Here, 29% of employed drivers reported driving under these conditions, compared to only 21% of unemployed persons.

The Ontario data also indicated significant differences among groups of seriously injured drivers differentiated by *income*, with the under $15,000 per year group and the $30,000-$65,000 per year group having the lowest percentage of alcohol-positive drivers (about 10%), and the $15,000-$30,000 group having the

highest percentage of alcohol-positive drivers (about 44%). This finding was interesting in light of the findings of earlier roadside survey research reported in the 1978 update which showed that percentage of low income on-the-road drivers increased steadily with increasing BAC. Again, the 1996 household survey indicated a different relationship, with self-reported drinking-driving increasing steadily with income, from 11% at incomes of less than $10,000 to 64% at incomes of $75,000 per year.

With respect to *education*, research reported in prior updates indicated that drivers with a relatively small number of years of formal education were over-represented, both among higher-BAC crash-involved drivers and among higher-BAC drivers who had not crashed. The 1986 National Roadside Breathtesting Survey (Lund and Wolfe, 1989) reinforces the result for non-crash involved drivers, with 4.1% of the drivers with no more than a high school education having a BAC .10+ compared to 2.2% of drivers with a bachelor's degree or more. By contrast, the 1996 household survey found that drinking-driving increased steadily with formal education, from 11% for persons with less than a high school education to 35% for college graduates.

We note that the above household survey results were for persons who reported driving within two hours after *any* drinking, and so may be biased in favor of persons who drank very little before driving. This suggests totally different relationships with the various biographical than for persons who drank more before driving.

FARS contains no information on biographical variables other than age and sex, nor do state databases on crashes of all types. The report on the 1996 roadside survey also contained no data on "other biographical variables."

Drinking Variables

Literature on drinking variables associated with drinking drivers has most often been concerned with alcoholic beverage preference, quantity and frequency of drinking, prevalence of drinking problems, and drinking location. Many of the studies have dealt with subjects who had been convicted of DWI and referred for alcohol-problem assessment or alcohol-problem treatment.

With respect to *alcoholic beverage preference*, studies dating back to the 1960s consistently have shown beer to be favored by a wide margin (Jones and Joscelyn, 1978; Jones and Lacey, 1989; Jones and Lacey, 1998a). Also, prior updates suggest that the *drinking location* preceding illegal drinking-driving was most frequently bars or taverns and other person's homes. The 1998 update noted a study of New York State DWIs by Wieczorek, Miller, and Nochajski (1992b) that found that subjects who drank at more than one location engaged in DWI more often than did subjects who drank at only one location. The multiple-location DWIs had an average of 4.00 self-reported drunk driving events in the past 30 days compared to 2.46 for the single-location DWIs ($p = 0.0009$). In

addition, the multi-location drinkers drove almost twice as far prior to their arrest (an average of 11.5 miles for multi-location versus 6.7 miles for single-location, $p<0.0001$), thereby exposing other drivers and their passengers to a greater crash risk. These two groups also differed significantly on a number of drinking variables, with the multi-location drinkers indicating patterns of heavier drinking and stronger evidence of alcohol problems and alcohol dependency.

The 1998 update also cited a study of Vermont university students by Musty and Perrine (1990) that found that some 70% of those *under* the legal drinking age reported drinking most frequently at private locations (for example, home, other person's homes, and clubs), and that about 75% of students *above* the legal drinking age reported drinking at public bars and restaurants.

Another study cited in 1998 update (Lang and Stockwell, 1991) examined the effect of type of drinking location on crash involvement in Australia. This study involved subjects in Perth, Australia who had been arrested for DWI, either as a result of being involved in a crash (n=257) or having failed a roadside sobriety test (n=1 ,909). Two types of drinking locations were considered in the study, "unlicensed" locations (for example, private residences or public places such as parks) and "licensed" locations. The study found that the prior drinking location of the drivers whose DWI arrest occurred after a crash was more likely to be an unlicensed location than it was for drivers whose DWI arrest occurred after some other event or activity such as speeding or reckless driving ($p=0.001$). Thirteen percent of the drivers who drank in an unlicensed location were arrested after a crash compared to 8% of the drivers who drank in a licensed location. Note that these figures reflect the conditional probability of an arrest given a crash, not the unconditional probability of crash.

Since the 1998 update, additional literature has appeared considering the interaction of drinking location, beverage type, and other factors, including biographical factors. Especially noteworthy is a study by Gruenewald and associates (2000). The study sought to determine whether the association of beer drinking with drinking and driving is due to cultural norms or is an artifact arising from the demographic profile of beer drinkers (young and male), the drinking patterns of this sub-population (frequent and heavy), and the venues in which they prefer to drink (bars and restaurants). The data were obtained from a carefully designed telephone survey in six U.S. communities involving a test sample that included 2,275 drinkers, 985 of whom had driven after drinking.

The study found that frequent consumers were more likely to drink outside the home, preferred beer and spirits to wine, and were more likely than others to drink and drive. Most important, *beverage preferences were not directly associated with drinking and driving*. Beer drinkers, however, were from the sub-population most likely to drink and drive, heavier drinking younger men, who prefer ro drink at bars and restaurants. The results suggested that the association of beer consumption with drinking-driving arises from the circumstances in which the sub-population of beer drinkers more commonly find themselves (as a result of their

efforts to maximize, within economic constraints, the social and amenity value of drinking), as opposed to any culturally induced disposition beer drinkers may have to drink and drive.

Three recent studies in New Mexico have examined the the role of drinking location in drinking-driving. In the first study, Chang, Lapham , and Barton (1996) compiled the sociodemographic characteristics of 5,154 mostly male DWI offenders) referred for alcohol-related assessment. They found that some groups showed a higher rate of DWI convictions, compared to the adult county population, that is: young, single male; Hispanic and Mexican National; and divorced/separated/widowed (increasing with age). They also found that older, educated or employed offenders reported drinking more in bars or lounges, while younger offenders were more likely to drink in private parties. Further, Hispanic and Mexican National men showed equal likelihood of drinking with friends and relatives in bars or lounges, whereas non-Hispanic White males reported drinking more with friends. Native Americans were associated with higher blood alcohol concentrations (BAC), and with alcohol-related problems.

Lapham, Skipper, Chang et al. (1998) estimated the distance driven between drinking and arrest locations among 3,107 New Mexico offenders convicted of DWI and determined whether the drinking location, the driver's appearance (factors such as race, age, gender), or age of the vehicle accounted for any differences in the estimated distance driven. Among those who were not arrested in the immediate vicinity, the number of miles driven ranged from 0.5 to 18.2, with a mean of 3.4 miles (median= 2.6). Further, persons who drank in a high or medium-high arrest intensity area, those with BACs of .20+, and those drinking at bars, restaurants, or private parties, drove fewer miles compared to other offenders. The authors also found that factors such as age, gender, and vehicle age were unrelated to how far drunk drivers travel before their arrests.

In the third study of New Mexico DWIs, Lewis, Lapham, and Skipper (1998) examined alcohol purchase locations of convicted drunk drivers to determine the characteristics and arrest circumstances of offenders who bought alcohol at a drive-up liquor window compared with those who obtained alcohol elsewhere. The study results revealed that drive-up windows were the preferred place of purchase of package liquor by offenders who bought the alcohol that they drank prior to arrest. The odds of being Hispanic ($p<0.0001$), a high-risk problem drinker ($p<0.01$), and drinking in the vehicle prior to arrest ($p<0.01$) were significantly higher for drive-up window users than for offenders who purchased package liquor elsewhere. The authors concluded that a statistically significant relationship exists between the use of drive-up windows and "certain high-risk drinking behaviors."

Jones-Webb, Toomey, Short et al. (1997) examined relationships among perceived alcohol availability, drinking location, alcohol consumption, and drinking problems. Their subjects were 3,372 adolescent drinkers, ages 16-18, who participated in the authors' Communities Mobilizing for Change on Alcohol

Project baseline survey (See page 132). The authors found that perceived alcohol availability was significantly associated with higher levels of alcohol consumption for males. Drinking in a public location, such as a bar, restaurant, or party, was marginally associated with higher levels of alcohol consumption for females.

Greenfield and Rogers (1999) examined effects of measurement on risk curve analysis in an application involving prediction of frequency and indicator measurements of drunk driving with beverage-specific alcohol consumption and risk perception measures. Again, self-reported data were used, this time from a 1995 household survey in which the responses of 1,260 adult drivers who reported any drinking in the prior year were selected for analysis. Relationships between drinking pattern, beverage choice, perception of risks and drinking before driving, and frequency of drunk driving, were investigated. Self-reported drunk driving (occurrence) was measured by a question assessing driving after drinking enough to be in trouble if stopped by the police within the prior 12 months, and those affirming this (n = 191) were asked how many times they did so.

It was found that, after controlling for demographics, heavy beer consumption ($p < .01$) more than heavy wine (not significant) or liquor / spirits ($p < .05$) intake was strongly predictive of risk perception. A significant interaction was found between heavy beer consumption and perceived risk ($p < .001$) in predicting reported frequency of drunk driving. The authors concluded that individuals' underestimation of beer's intoxicating effects, compared to other alcoholic beverage types, helps explain beer's over-representation in drinking-driving violation reports.

The same authors (Rogers and Greenfield, 1999) generalized their findings on beer drinking to "hazardous drinking" in general, which they defined as occasions in which five or more drinks were consumed in a day. Their data came from a survey involving 2,817 respondents who had consumed at least one drink in the previous year. The results showed that, in the U.S., beer accounts for the bulk of alcohol consumed by the heaviest drinkers and that beer also accounts for a disproportionate share of hazardous drinking. Logistic regression analysis revealed that drinkers who consumed beer in a hazardous fashion at least monthly are more likely to be young, male, and unmarried and less likely to be Black than are other drinkers. Hazardous beer consumption was found to be more predictive of alcohol-related problems than hazardous consumption of wine or spirits.

A wide range of epidemiologic and clinical studies have clearly indicated the over-involvement of persons with *drinking problems* in drinking and driving incidents, including alcohol-related traffic crashes as well as arrests and convictions for DWI. Many of these studies are reviewed in prior updates.

Several recent studies have examined the relationship between BAC at arrest and alcohol problems. Lapham, Chang, Skipper et al. (2000) studied the association between arrest blood alcohol concentration (BAC) and alcohol use disorders among convicted drunk driving offenders in New Mexico. Subjects were interviewed using the Diagnostic Interview Schedule, discussed in Chapter 2. If the

age at onset of alcohol disorders was the same as or younger than the age at screening, the person was classified as having alcohol abuse or dependence at the time of screening. Arrest BAC ranged from .01 to .45 (mean = .156). Alcohol dependence at screening was found for 58% of offenders with BAC <.15, 66% of offenders with BAC .15 to .19, and 72% of offenders with BACs of .20 or above ($p<.001$). The overall accuracy of BAC of .15 or higher and .20 and higher as a screening test for alcohol dependence ranged from .45 to .64. The authors concluded that, although arrest BAC is associated with alcohol use disorders, it provides limited utility as an objective indicator of alcohol dependence.

Bergman, Hubicka, Laurell et al. (2000) assessed 1,600 Swedish drivers suspected of DUI, and a control group of 785 drivers not suspected of DUI using the Alcohol Use Disorders Identification Test (AUDIT) instrument. The authors found that hazardous or harmful alcohol use according to the AUDIT was four times as common among the male, and ten times among the female, suspected DUIs, as compared to the control drivers. Further, more than half (58%) of the suspected DUIs had such drinking problems and 18% had severe problems. Also, almost half (46%) of the suspects with a BAC below the Swedish illegal limit of .02 had such problems. This lead the authors to conclude that BAC level has low sensitivity and specificity as a means for identifying drinking problems in suspected DUIs.

Wieczorek, Miller, and Nochajski (1992a) had arrived at similar conclusions after examining the relationship between BAC at arrest and a number of variables related to drinking patterns and alcohol abuse or dependence[17]. Their sample consisted of 235 persons convicted of DWI and referred to a drinking driver treatment program in Erie County, New York. BACs at arrest were available for all of these subjects, and only those with a BAC greater than .05 were included in the study. Data were collected through face-to-face interviews, clinical evaluations, and the complete Mortimer-Filkins test. None of the results indicated any significant relationship between BAC at arrest and diagnoses of alcohol problems. Significance levels were 0.40 for all but one of the tabulated analyses, the clinical analysis ($p>0.10$), which indicated that the high-BAC group (BAC $\geq$ .15) had slightly fewer non-critical alcohol problems.

However, Lucker and Gold (1995) obtained different results in a study of the association between breath alcohol concentration (BAC) at arrest and problem drinking for a sample of 1,283 male DWI offenders in the U.S. Army. The results indicated a moderate but statistically significant association between BAC at arrest and DSM-III diagnosis. BAC's ability to indicate problem drinking was also compared with the diagnostic ability of three well-known, paper-and-pencil instruments designed for that purpose. BAC performed as well in identifying problems with alcohol as did the MAST, the MacAndrew Scale of the MMPI, and the Vaillant.

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[17] Reviewed in Jones and Lacey (1998a).

Hutchinson (2000) conducted in depth interviews with a sample of 48 male convicted drink drivers, all drinking 50+ units per week. An analysis of their drinking patterns and styles showed that there is a wide range of drinking patterns and styles and no consistency. He found that drinking patterns vary over the years, from occasional to daily drinking, and are altered by major lifestyle changes. Likewise drinking styles had no consistency but there was a concentration on separating drinking from work-related activities. The quantity consumed on any or each drinking occasion bore no relation to either pattern or style of drinking. The author concluded that the only controlling device is the concept of "alcoholic," and that there is no safe or sensible limits as such.

Driving Variables

The driving variables associated with drinking drivers most often examined in the literature have been the time of day and day of the week of drinking-driving, types of vehicles driven, number of drinking driving trips per unit time, and enforcement actions experienced as a result of their drinking driving.

Research overwhelmingly supports the intuitively obvious conclusion that drinking driving and alcohol-related crashes occur most often when most people engage in recreational drinking – during the nighttime and on weekends. FARS data for 1998 (U.S. Department of Transportation NHTSA, 1999) provide further confirmation of alcohol-related (BAC > .01) crashes as a predominately nighttime-weekend phenomenon. **Figure 4-20** shows that the midnight to 3 a.m. period had the highest percentage of alcohol-related fatal crashes (76%), and that the three-hour periods immediately before and after the midnight to 3 a.m. period also had high percentages (62% and 69%, respectively). By contrast, the morning and early afternoon hours of 6 a.m. to 3 p.m. had the lowest percentages (in the 11% to 15% range), with the percentage starting to rise again in the late afternoon to early evening periods (24% to 45%).

The late nighttime to early morning hours also contained the largest percentages of all alcohol-related fatal crashes (**Figure 4-21**). Nearly 80% of all alcohol-related fatal crashes occurred during the 6 p.m. to 6 a.m. period.

With respect to day of the week, the FARS report of 1998 data also contains information on the percentage of fatally injured drivers in alcohol-related fatal crashes by time of day (daytime or nighttime), day of week (weekday or weekend day), driver age (<21 years or 21+ years), and number of vehicles involved in the crash. The data for single-vehicle crashes are plotted in **Figure 4-22** and show that the highest percentages for both age groups occur during nighttime-weekend hours -- 77% for 21+ years drivers and 57% for <21 years drivers. These percentages fall to 22% and 7%, respectively, during daytime-weekday hours.

Figure 4-20: Percent of Fatal Crashes That Were Alcohol-Related by Time Period, FARS Data for 1998

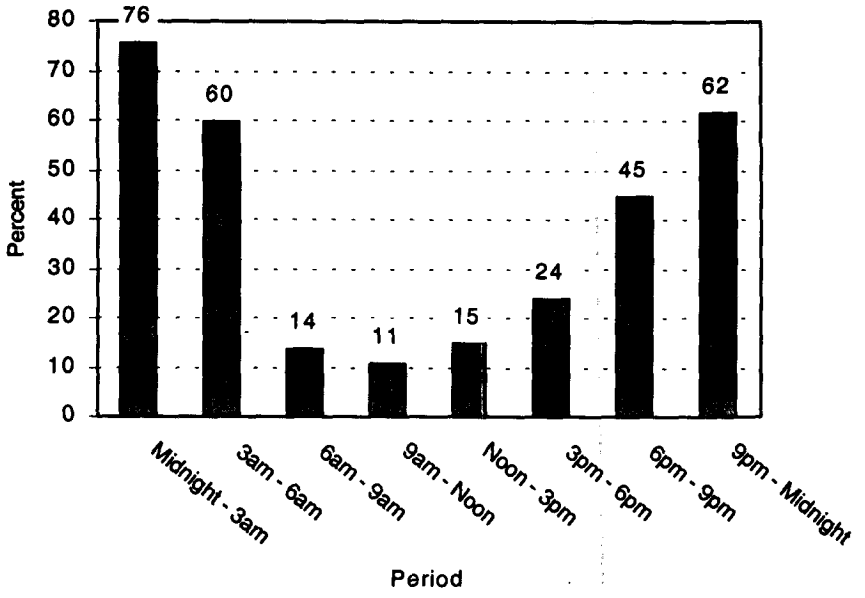


Figure 4-21: Alcohol-Related Fatal Crashes in Given Time Periods as a Percent of All Alcohol-Related Fatal Crashes, FARS Data for 1998

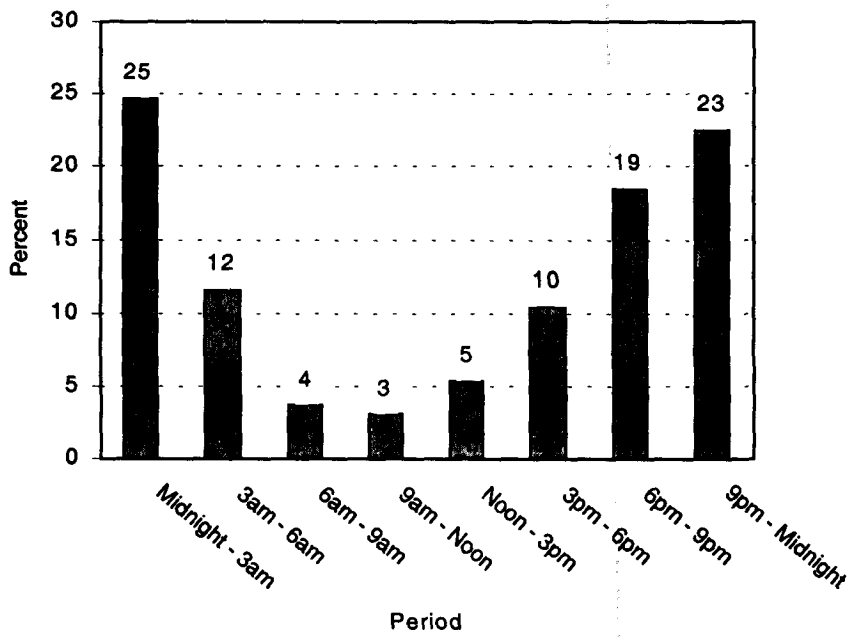


Figure 4-22: Percent of Fatally Injured Drivers in Single-Vehicle, Alcohol-Related Crashes by Driver Age, Time of Day, and Day of Week, FARS Data for 1998

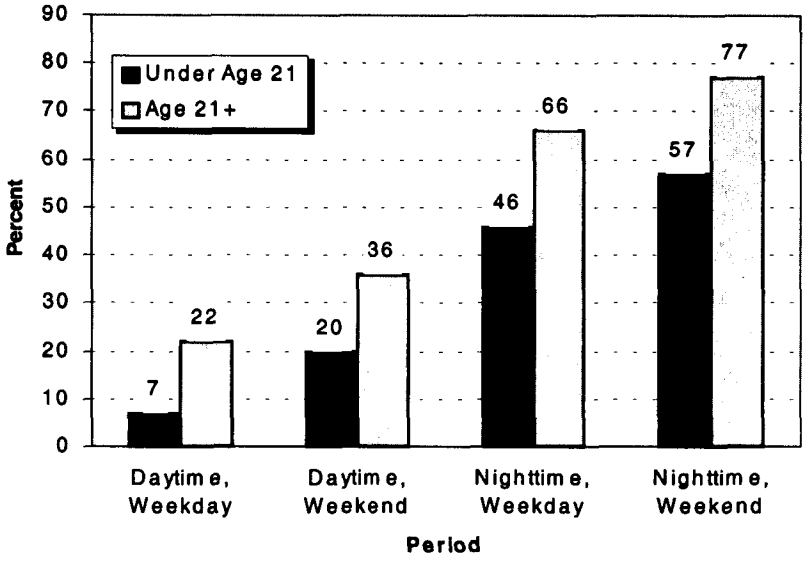
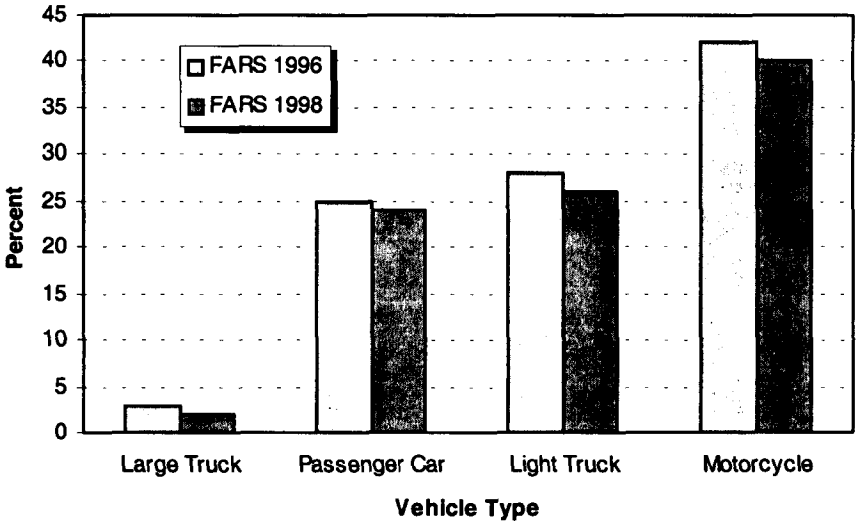


Figure 4-23: Percentage of Alcohol-Positive Drivers in Fatal Crashes by Vehicle Type, FARS Data for 1996 and 1998



Wilson and Chen (2000) developed a model for predicting the BAC of nighttime drivers, identifying several biographical variables (age, sex, and educational level) and situational variables (coming from a bar, and a group of passengers of the same sex as the driver) that differentiate nighttime drivers on the basis of their BAC. However, the model left much of the variance unexplained and had a high rate of false positives.

The 1998 update observed that prior updates had not found much useful information on the effect of *vehicle type* on the alcohol-crash problem, but presented 1996 FARS data on the types of vehicles that were involved in fatal crashes. The data showed that drivers of motorcycles most often had been drinking (42% alcohol-positive and 30% $\geq$.10), and drivers of large trucks least often had been drinking (3% alcohol-positive and 1% >.10). Drivers of light trucks were slightly higher than passenger cars for both measures (28% alcohol-positive and 22% $\geq$ .10). Later data for alcohol-positive drivers in 1998 are shown in **Figure 4-23** and indicate small reductions since 1996 for all of the vehicle types shown.

Using FARS data for 1992, Preusser, Williams, and Ulmer (1995) developed a program for generating computerized "crash reports" for crashes that were fatal to a motorcycle driver. The reports were then analyzed to define types of motorcycle crashes. Five such types accounted for 86% of the crashes: ran-off-road (41%), ran traffic control (18%), oncoming or head-on (11%), and motorcyclist down (7%). Alcohol and excessive speed were commonly associated with motorcycle crash involvement.

A paper by Sun, Kahn, and Swan (1997) reported a test of the hypothesis that a motorcyclist is more likely to be compromised by alcohol than the driver of an automobile. During 1992, they measured the BACs of 40 male drivers of motorcycles and 411 drivers (68% male) of four-wheeled vehicles who were admitted to a university hospital trauma center. They also measured the Glascow Coma Scale (GCS), Revised Trauma Score (RTS), and Injury Severity Score (ISS) for each patient. The mean age was 32 years for the motorcyclists and 35 years for the automobile drivers. Among the motorcyclists, 94 percent wore helmets, and among the automobile drivers, 26 used seat belts. The authors found that one-third of the motorcyclists had a positive BAC, averaging .12, whereas a positive BAC was found in 35 percent of the automobile drivers, averaging .18. The difference in BAC between the two groups was statistically significant ($p < 0.05$), and no significant differences in drug use were found between the two groups. The authors concluded that among comparable accident victims, motorcycle drivers have lower blood alcohol concentrations than do drivers of automobiles.

Several Australian researchers have studied the role of alcohol in motorcycle crashes. Holubowycz and Mclean (1995) interviewed a sample of 302 male drivers and motorcycle riders admitted to the Royal Adelaide Hospital in Adelaide, South Australia between June 1985 and April 1987. They found that with one exception, the likelihood of having a BAC $\geq$ .08 did not differ with demo-

graphic profile. Also, as BAC increased, there was a significant increase in: various indices of quantity and frequency of drinking; beer being the preferred beverage; percentages drinking alone, in a hotel, in a vehicle and for various less socially acceptable reasons; frequency of drink-driving; likelihood of previous drink-driving suspension; and, more liberal attitudes towards drink-driving. About 25% of those with a BAC of at least .15 were believed to experiencing alcohol-related problems prior to the crash, compared with only a very small proportion of those with lower BACs. Pre-crash drinking was found to be most commonly involved drinking in a hotel, drinking with friends and drinking beer, with no significant differences between BAC groups. The authors concluded that the results suggested that usual drinking and drink-driving patterns, as well as attitudes to drink- driving, become more extreme as the BAC of male crash-involved drivers and riders increases.

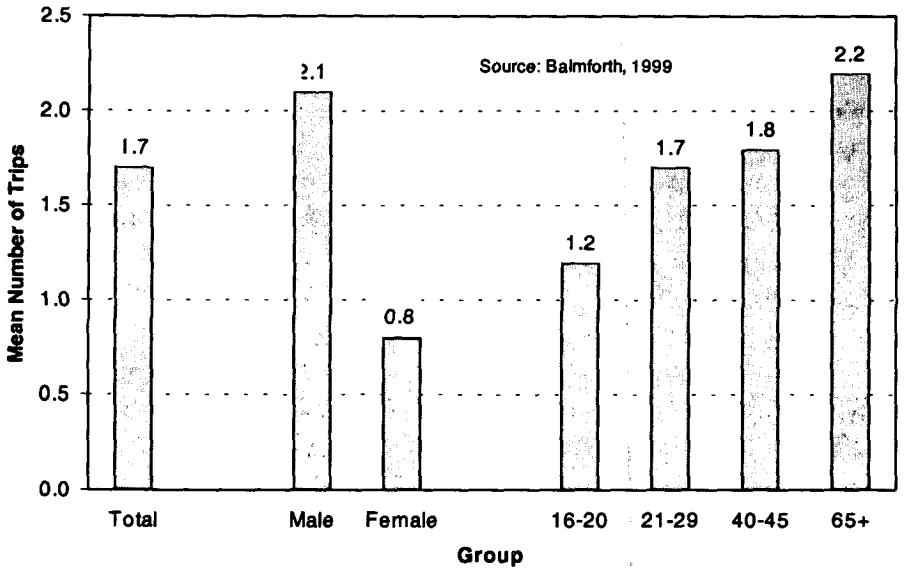
Haworth (2000) conducted an interesting case-control study of injured motorcyclists and passengers in Melbourne, Australia using data from 222 crashes and from 1,200 motorcyclists riding through the crash sites at the same time of day and week. He found that a BAC greater than zero was associated with a five-fold increase in the odds of crashing compared to having a BAC of zero. A BAC greater than .05 was associated with about a 40-fold increase in risk. Haworth also found that nighttime crashes were more likely to involve alcohol.

The report on the 1997 National Survey of Drinking and Driving (Balmforth, 1998) contains data on the mean number of drinking-driving trips by drivers who drove within two hours after drinking during (1) the past 30 days and (2) the past year. The data are presented by driver gender and age group and are shown for trips in the last 30 days in **Figure 4-24**. The mean number of trips for all drinker-drivers (n=964) was 1.7, but the number for males was nearly three times that for females (2.1 versus 0.8). With respect to driver age, drivers in the three middle age groups averaged about 1.7 trips, but the lowest age group had a lower number of trips (1.2), and the highest age group averaged more trips (2.2).

Although this chapter is primarily concerned with drinking *users of the U.S. Highway Transportation System*, we also examined some of the literature on drinking by the larger class consisting of all persons of drinking age. Our main interest was alcohol beverage consumption and its relationship to traffic crashes.

Drivers who have been subject to *law enforcement actions* have been subject to considerable scrutiny by researchers. This is particularly true for drivers who have been convicted of DWI or some related offense such as breath-test refusal. Two obvious reasons are: (1) such drivers clearly have engaged in hazardous drinking-driving behavior and (2) they comprise a convenient group for study as a result of the conditions of their conviction, including assessment of alcohol problems and follow-up during probation.

Figure 4-24: Mean Number of Drinking-Driving Trips in Past 30 Days by Driver Age and Sex



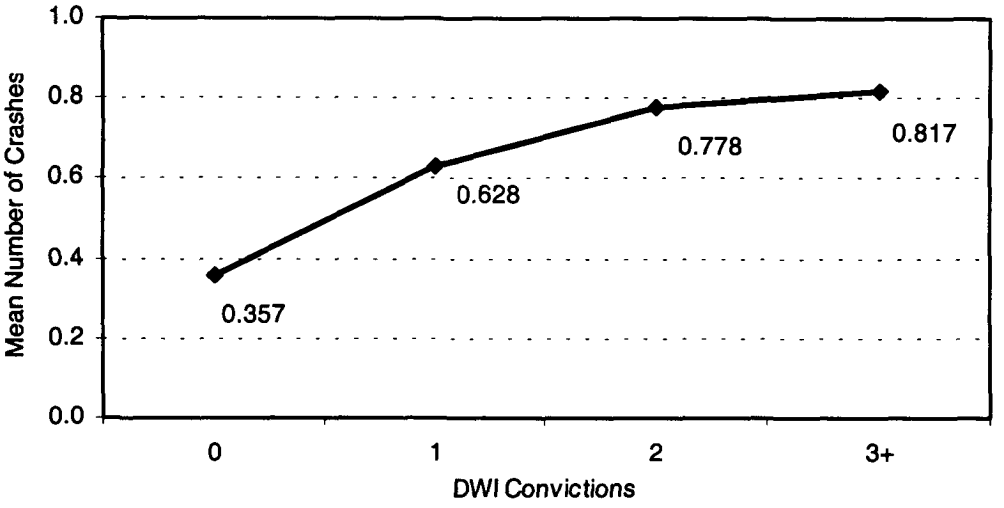
Much the material examined in our recent review of the scientific literature on repeat DWI offenders (Jones and Lacey, 2000) also dealt with DWI offenders who were not repeat offenders. We reported that FARS data combined with data from the U.S. Department of Justice indicated that drivers with one or more DWIs are over-represented among fatal-crash involved drivers, but that the degree of over-representation had declined from 1.8 in 1988 to 1.4 in 1997. It was estimated that in 1997, roughly 2.2% of all fatal crashes (810) involved a driver with one or more DWI convictions.

However, an analysis of Minnesota data by Ross, Simon, and Cleary et al. (1995) indicates a much higher percentage of repeat DWI offenders in fatal crashes in that state. These researchers defined an administrative license revocation as a prior alcohol-related driving incident, and found that such drivers had an involvement rate of 34% in fatal crashes. The reason for this large discrepancy could be at least in part that the FARS definition of a prior offense is a court conviction, rather than an administrative action. Judicial processes provide more opportunities for a non-conviction (plea bargaining to a lesser offense, for example) than administrative processes, and court records are often less accurate than the records of an administrative agency.

The repeat offenders review cited two studies in California that also involved large data bases. In the first, Peck and Helander (1999) (Peck and Helander, 1999) examined how the mean number of traffic crashes during 1985-1991 in

California varied as a function of DWI convictions in the same period. The data are re-plotted below (**Figure 4-25**).

Figure 4-25: Mean Number of Traffic Crashes in California in 1985-1991 by Number of DWI Convictions in the Same Period



Drivers who had no DWI convictions in that period had the least number of crashes, and the largest incremental increase in crashes was from no convictions to one conviction (.357 to .628, 76% increase). By contrast, very little percentage increase in crashes occurred for drivers with convictions in the 2-3+ range (5% increase).

In the second California study, Tashima and Helander (1998) reported that out of 17,189 alcohol-involved fatal or injury crashes, 42.5% involved drivers with no DWI priors or alcohol-reckless convictions, and that only about 17% of crashes involved drivers who had been convicted of one or more DWIs occurring prior to the crash. Further, an even smaller percentage (8%) of the 810 alcohol-involved *fatal* crashes involved drivers who had been convicted of one or more DWIs occurring prior to the crash. The report also included data that showed a steady, linear increase with priors for alcohol-related crashes of about 20% per prior, but a *decrease* with priors for crashes of all types. Fatal/serious injury crashes remained about the same as a function of priors.

The repeat offenders report concluded that available data from the literature indicate a higher alcohol-crash involvement among repeat offenders than among drivers with no priors or just one prior, but that exactly how much higher nation-wide cannot be said with any degree of confidence. The report also concluded that the involvement of repeat offenders in *crashes of all types* may actually be less than that of first offenders, possibly because sober repeat offenders may drive more carefully than sober first offenders, or may not drive at all because their

license was suspended. Finally, the report found that, in terms of sheer number of crashes of all types, both serious and non-serious, persons with no priors at all appear to show the highest involvement in total crashes and in alcohol-related crashes of all degrees of severity.

Perrine, Naud, and von Eye (2000) examined the relationships over time between quantity of alcohol consumed and self-rated intoxication level while driving. The authors used an automated touch-tone, interactive, voice response (IVR) system to collect their data in Vermont which were reported daily over a two-year period. Data collected dealt with questions such as type and amount of alcoholic beverage consumed, drinking location, day of week and time of day of drinking, and perceived level of intoxication. In-depth case studies of two the 33 subjects were discussed in the paper, confirming results from prior roadside surveys in Vermont that bar drinking "becomes once again a major focus of concern regarding drinking and driving." The paper showed that very detailed data regarding drinking and driving patterns can be obtained by the authors' innovative approach.

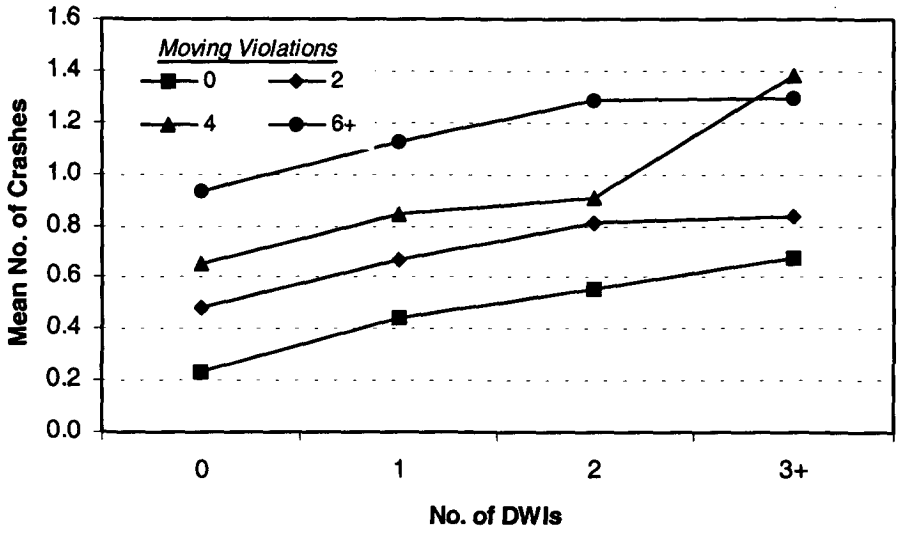
Our 1998 update observed that prior updates had indicated that drinking drivers had substantially more enforcement actions (including DWI) against them than did other drivers. Several studies published since the 1989 update were reviewed and their findings reported, as follows:

- Wilson (1992) - The DWI group had an average of 3.7 driving while impaired incidents during the past 30 days, compared with 1.4 for the control group.
- Wieczorek, Miller, and Nochajski (1992a) - A study group of DWIs had 2.5 to 4.0 DWI incidents during the past 30 days.
- Wieczorek, Mirand, and Callahan (1994) - 23% of of a study group of DWIs referred to a treatment program had driven while drunk at least once during the past year, and 15% drank and then drove at least once during the past 30 days.
- Wieczorek, Miller, and Nochajski (1989) - A group of 461 drivers referred to an alcohol-treatment program in New York State had an average of about two prior DWI arrests on their records.
- Wells-Parker and associates (1991) - Of 3,339 DWIs assigned to a DWI treatment program in State of Mississippi, 27% of the males and 12% of the females had a prior arrest for DWI. Also, 16% of the males and 6% of the females had two or more DWIs on their record.

Our own recent review of the scientific literature on repeat DWI offenders (Jones and Lacey, 2000) cited a number of later studies of DWIs, many of which contained data on first offenders as well as repeat offenders. For example, Peck and Helander (1999) cited above provided California data on the mean number of

crashes of all types in a seven-year period as a function DWI convictions and moving traffic violations in the same period. The data are plotted in **Figure 4-26.**

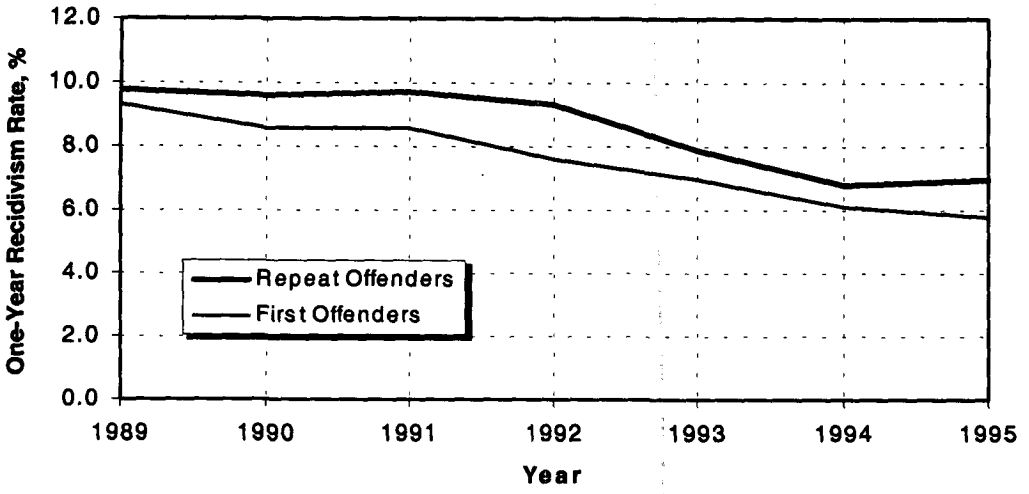
Figure 4-26: Mean Number of Traffic Crashes in California in 1985-1991 by Number of DWI Convictions and Number of Moving Violations in the Same Period



The figure shows that, in general, the number of crashes increased with number of DWIs and also with number of moving violations such that, for example, drivers with one DWI and four moving violations had about twice as many crashes as drivers with one DWI and no moving violations.

In the same paper, Peck and Helander presented an interesting summary of the recidivism of first offenders and repeat offenders in California, showing among other things how recidivism rates have varied over time. Their data (**Figure 4-27**) indicate that the one-year recidivism rates for repeat offenders and first offenders alike decreased in the 1989-1995 period, from nearly 10% to 7% for repeat offenders, and from about 9% to 6% for first offenders. Peck and Helander also listed a number of correlates of recidivism of DWIs in general, and showed how the predicted recidivism of repeat offenders varies with arrest BAC and number of priors.

Figure 4-27: Recidivism Trends In California, 1989-1995



In another study of repeat offenders, Jones, Wiliszowski, and Lacey (1996) examined the effect of prior DWI convictions on the DWI recidivism of 506 repeat DWI offenders assigned to an intensive supervision probation program in Milwaukee County, Wisconsin during 1992 - 1994. It was found that the more priors a subject had, the higher that subject's recidivism at any given time. For example, 28.3% of treatment-group subjects with four priors were predicted to recidivate after one year, compared to 7.8% of such subjects with two priors. A similar relationship between priors and recidivism was found in a study of an individualized sanctioning program in Rockdale County, Georgia (Jones and Lacey, 1998b). Here, the recidivism rate was found to increase by about 8% for each prior DWI.

The biographical and other characteristics of DWIs have been investigated in a number of studies. Many of these have been reviewed in prior updates, the latest being our review of the literature on repeat offenders. There, we presented a table of characteristics of repeat offenders, which we re-produce here for convenience (**Table 4-3**). The table is pertinent to DWI offenders in general, in light of the finding of multivariate studies that indicate that repeat offenders do not appear to differ much from first offenders (Arstein-Kerslake and Peck, 1985). The study by Arstein-Kerslake and Peck found no first-offender group that was distinguishable from a repeat-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." Marowitz (1998) provides more support for this notion, concluding that "first [DUI] offenders with high BAC levels and prior 2-year traffic convictions are at as high a risk of recidivating as many repeat offenders."

Table 4-3: Summary of Attributes of Repeat Offenders

Variable	Value
Sex	Predominately male, typically over 90%
Age	Usually (~75%) under 40, mean around 35
Race	White
Income	Low
Marital Status	Unmarried
Education	HS or less
Employment	Non-White collar
BAC	.18+ at arrest; higher in fatal crashes
Prior DWIs	Typically 2 or 3, higher for some in treatment programs
Prior Other Traffic Infractions	Several
Prior Criminal Offenses	Yes, more than first offenders, include serious crimes against persons
Alcohol Problems	Often have problems, alcohol dependency common
Personality & Psycho-social Problems	Yes, probably more common and severe than those of first offenders
Drinking Locations	Multiple locations favoring bars; at home; parties. Often plan to drive after drinking
Final destinations	Home
Beverage	Mostly beer, often distilled spirits
Recidivism	~10%+ per year, increasing with number of prior DWIs
Implied Consent	More than 50% are BAC test refusers
Sentences	Traditional, treatment often
Reasons for DWI	Thought he/she was fit to drive
Perceived Detection	Low for first offenders, increases with priors

Source: (Jones and Lacey, 2000)

In the narrative accompanying the table, we stated that:

> "What is known from the recent literature about repeat offenders is summarized in [**Table 4-3**]. There are few surprises. Repeat offenders are nearly always male, and are typically under age 40, White, low income, unmarried, not college educated, and employed in non-White collar occupations. Their BAC at arrest is typically slightly higher than that of first offenders; they often have alcohol problems; and they commonly suffer from alcohol addiction.
>
> They prefer to drink beer and distilled spirits in bars at multiple locations, thus increasing the probability of their driving while impaired. Because they are such experienced drinkers, they very often believe they are quite capable of driving after drinking and do so knowing that they may be arrested for DWI. Personality and psychosocial problems are common among this group.
>
> By definition, they have prior DWI offenses, usually two or three, but those who have been assigned to treatment programs often have more. But they also have a record of other, often non-major, traffic infractions, an attribute that has been found to be a very powerful predictor of DWI recidivism. In addition, they usually have a record of criminal offenses that include serious crimes against persons as well as against property. When stopped for suspicion of drunk driving, they often refuse to submit to a chemical test for alcohol. When convicted of DWI, they are given traditional sanctions (jail and license suspension), but are also often required to participate in alcohol treatment programs." (Pages 19-20)

Three other recent studies also contain information on the characteristics of DWIs. The study by Chang, Lapham, and Barton (1996) cited above present a detailed compilation of the sociodemographic characteristics of 5,154 mostly male DWI offenders referred for alcohol-related assessment.

Siegal, Falck, Carlson et al. (2000) studied the sociodemographic and psychiatric characteristics of 126 "hardcore" DWI offenders incarcerated in Ohio prisons in 1998-1999. Again, detailed compilations are presented, with the authors concluding that virtually all of the sample could be described as alcohol dependent, that almost two-thirds manifest a concurrent substance abuse disorder, and that the rates of psychiatric illness were many times that which could be found in a general population sample. Educational achievement was low with only a single subject reporting any college experience and 43% indicating less than a high school education. In addition to their multiple arrests / convictions for alcohol and / or drug-related vehicular offenses, 61% of the sample reported arrests for disorderly conduct / public intoxication. The substance abuse problems were found to be long standing: the average age of the sample was nearly 36 years, and the age of the first alcohol dependency symptoms was about 21 years of age, with relatively few subjects having been exposed to identification and early intervention for their alcoholism or substance abuse.

Finally, Siegal and associates found that their hardcore population was, in fact, not a homogeneous group but three distinct groups each exhibiting specific clinical needs:

- Contemporary Alcohol Dependent -- similar to problem drinking populations at chemical dependency treatment facilities. (They often have histories of other psychiatric and/or behavioral disorders, but no antisocial personality disorders.);
- Antisocial Poly-Substance Dependent-- a deeply troubled group, all of whom are alcohol dependent, 90% meet diagnostic criteria for substance abuse or dependence, 75% have a history of psychiatric illness, and all carry the diagnosis of antisocial personality disorder; and
- Dually Diagnosed Alcohol Dependent -- somewhat older than the other two groups with no members with significant histories of drug abuse/dependence (beyond alcohol) or antisocial personality disorder.

The third study (Wieczorek, Callahan, and Nochajski, 2000) used the Alcohol Use Inventory (AUI) to identify subgroups of persistent drinking drivers (n=363), where persistent drinking drivers were defined as individuals with at least two drinking and driving convictions. The analysis suggested groupings of persistent drinking drivers based on overall severity of alcohol problems. Interestingly, there were few differences among the groups with respect to demographic factors, the only significant difference being employment status – full time employment was much less common among the groups with more severe alcohol problems. By contrast, the groups differed significantly on nearly all of the driving or drinking-driving measures, with traffic violations, alcohol-related crashes, and total DWIs higher among the more severe groups. The higher severity groups also reported more alcohol consumption, with the more severe groups reporting over 20 drinks prior to arrest, and a showing a history of multiple treatment experiences. The higher severity groups also showed more significant psychiatric pathology on ten measurement scales, with the level of psychiatric problems reaching clinical levels.

Motivations for Drinking-Driving. Another class of literature on drinking drivers has dealt with the reasons why persons drink and drive. Wiliszowski, Murphy, Jones et al. (1996) addressed the question directly by asking repeat DWI offenders why they continue to drink and drive after being convicted of DWI. Most of the subjects gave multiple reasons for driving after drinking, the most frequent being that the person thought he or she was "OK to drive." (**Table 4-3**)

Subjects were also asked if they ever planned not to drink or to drink only a certain amount of alcohol when they knew they would be driving afterward. Twenty-two percent indicated that they planned to drink when they knew that they would be driving afterward, and this percentage increased with increasing number

of prior DWIs: six percent of those with one prior planned to drink; 18% of those with two priors planned to drink; and 31% of those with three or more priors planned to drink.

Table 4-4: Reasons Given for Driving After Drinking by Repeat Offenders

Reasons For Driving After Drinking	% of Responses
Thought he/she was OK to drive	32.2
Just did not think about it	21.0
Lacks control over him/herself after drinking	18.6
No one available to drive for him/her	14.4
Would be OK if careful (to avoid accident/arrest)	13.8

When asked what they thought the likelihood of police detection was before their first offense, almost 44% said they just had not thought about the possibility of being detected and arrested by police before that first offense. The percentage dropped for subsequent offenses to 16.8% with twice as many males giving this response as females.

Finally, the responses indicated that the majority of persons interviewed thought they were intoxicated at the time of an arrest, and more individuals thought they were intoxicated for first and second offenses than for third or higher offenses, but the difference was not statistically significant at the .05 level.

In a study in Pomerania (Germany), Bornewasser and Glitsch (2000) studied the decision making processes of 185 DWIs compared to those of a group of 145 drivers who had never been detected for drunk driving. Each subject was asked to imagine a standard scenario when they had a low BAC (< .05), and one when they had a high BAC (> .11). Descriptive analysis showed that a decision process took place, that the number of both inhibiting and impelling beliefs was reduced at high BACs, and that there was a lack of inhibiting beliefs in the group of DWIs. The DWIs had a strong and significant tendency to neglect social norms and had lower perceived risks of detection and crashing.

Burns and Fiorentino (2000) examined the relationships of drinkers' ratings of their own intoxication and driving impairment in an alcohol experiment with 48 men and women, ages 21-54 years, who were light, moderate and heavy drinkers. The subjects rated their degree of intoxication at BACs of .000 to .125. The authors found that heavy drinkers rated their intoxication levels lower than either moderate or light drinkers, a finding that was said to reflect their acquired tolerance to alcohol effects. Heavy-drinking men generally had lower intoxication

ratings than women, but driving ratings between heavy-drinking men and women did not differ.

In a study of drinking practices and attitudes of pub patrons in Israel, Shinar (1995) found a pattern of "alarming ignorance of the effects of drinking, total disregard for the risks of driving when under the influence of alcohol, but coupled with relatively conservative amounts of alcohol consumption." This was seen as particularly troubling, given a trend toward increasing alcohol consumption by Israeli youth.

Turrisi and Jaccard (1991) used psychological theories of judgement and decision making in analyzing drunk driving decisions. Four groups of individuals were examined (a) those having multiple convictions for drunk driving, (b) those having one conviction for drunk driving, (c) those never having been convicted of drunk driving, but who admit to having driven while intoxicated, and (d) those who drive, but claim to not have driven while intoxicated. Cognitions examined included perceived drunkenness relative to legally allowable blood alcohol levels for driving, perceived probabilities for being stopped and arrested and being involved in an automobile accident if driving drunk, and drunk driving tendencies.

Three major findings are of interest. First, there were a number of misinterpretations in the use of "external cues" (number of drinks and time between drinks) of the effects of impairment. These misinterpretations existed across all groups tested, and also applied to the probability of being in a crash after drinking. Second, "situational cues" (weather and driving distance) did not modify judgements about the probability of a crash / arrest. Third, persons who drove after drinking but had not been caught were less cautious about drinking driving than were persons who had been caught. This was true even for persons who knew they were over the illegal limit.

Thurman, Jackson, and Zhao (1993) used factorial surveys to examine the drunk-driving judgments of a national probability sample of 528 non-abstaining adults. They found that key components in decisions to drink and drive included the extent of the driver's behavioral impairment, the availability of drunk-driving alternatives, weather conditions, the number of miles that have to be driven after drinking, the legal consequences of drunk driving (in terms of jail sentences and license revocations), the community response to drunk driving, where drinking occurs, fines that might be issued, the use of traffic roadblocks, and the driver's familiarity with roads that must be driven after a drinking event. Their analyses also indicated that the influence of these factors varied across levels of drinking-driving experience, suggesting that those persons most experienced with drunk driving tend to rate legal sanctions as more important in judgments to drink and drive than those persons who typically refrain from drunk driving.

A study of United Kingdom drivers examined the relationship between subjective perceptions of safe driving and legal driving consumption limits and other factors important in the decision to drive after drinking (Albery and Guppy, 1995). Responses from over 900 drivers established that those who perceived

safe consumption levels to be greater than those required to break the law indicated reduced moral commitment to present and possible future countermeasures. These drivers also had previous experience of being breath tested (but not charged with a drink-driving offence), reported comparatively lower estimates of their chances of apprehension and accident involvement when over the illegal limit, showed higher consumption levels on a driving trip and greater self-reported driving while impaired by alcohol. The implications of the findings for the development and delivery of measures to counter drink-driving are discussed.

A recent study involving Albery and Guppy (Guppy, Clay, and Albery, 2000) investigated the self-reported frequency of driving when over the illegal limit of more than 1,400 British drivers. Dependent variables were biographical variables, driver self-perceptions, risk perceptions and reported risk-taking experiences. The respondents were 800 drivers randomly sampled from a national database of licensed drivers, 250 culpable crash-involved drivers identified through police records, and a further 400 drivers sampled locally to the accident group. Just over 20% of the variability in drink-driving frequency was predicted by their model. Higher drink-driving frequency was significantly associated with younger male drivers, those driving fewer miles per week, and those with previous crashes. In addition to the biographical variables, lower drinking-driving risk perceptions and self-perceptions of carelessness and irritability were significantly associated with more frequent drinking-driving.

CHARACTERISTICS OF DRINKING PEDESTRIANS AND BICYCLISTS

Prior updates have found a very limited amount of scientific literature on the characteristics of drinking pedestrians and bicyclists. The 1998 update presented 1996 FARS data on the age distribution of intoxicated pedestrians (BAC=.10+) who were killed in traffic crashes, and observed that the distribution was quite similar to that of intoxicated drivers. Trend data on alcohol-related fatally-injured pedestrians by age were also presented, showing very little change in the distribution over time.

The most recent FARS report available for this review (U.S. Department of Transportation NHTSA, 1999) did not provide breakdowns by age group or by sex. We used the FARS database for 1998 available on a CD-ROM to develop some basic information for this report. **Figure 4-28** shows that males are about twice as likely as females to have a BAC of .10+ (35% versus 17%). With respect to age, pedestrian fatalities in the 21-44 age groups were the most likely to be alcohol-related, with a fall-off at both sides of the peak age (**Figure 4-29**).

Figure 4-28: Alcohol-Related Pedestrian Fatalities as a Percentage of All Pedestrian Fatalities by BAC and Sex, FARS Data For 1998

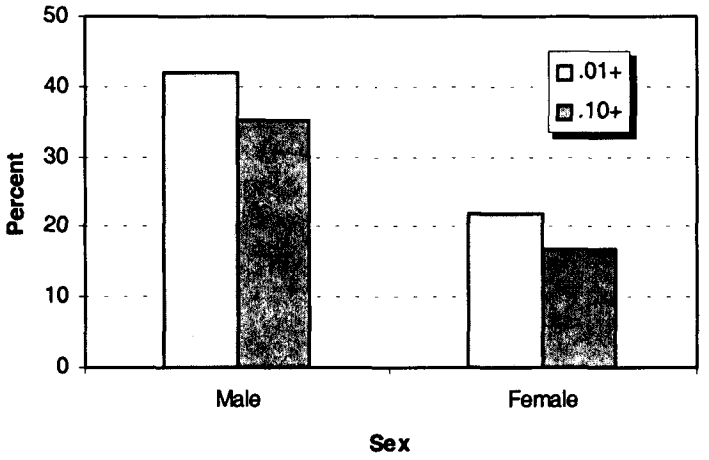


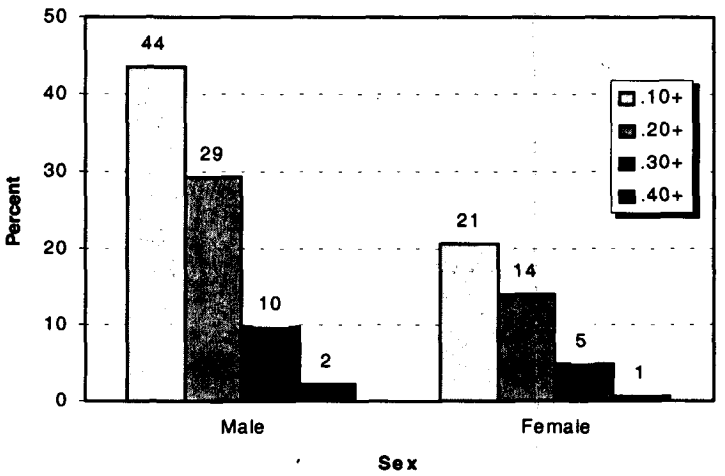
Figure 4-29:Alcohol-Related Pedestrian Fatalities as a Percentage of All Pedestrian Fatalities by BAC and Age, FARS Data For 1998

These two graphs used data generated by applying NHTSA's imputation method for estimating BACs where no measurements were made (Klein, 1986). The method provides for only two levels of BAC, .01+ and .10+. In a landmark

study of the role of alcohol in pedestrian crashes in New Orleans, Blomberg and associates (1979) found that, not only were typical alcohol-impaired pedestrians predominately male and in the mid-age range, but that they also had very high BACs. To get an idea of the percentage of fatally-injured pedestrians at higher BACs in 1998, we once again examined the actual data in 15 states that have high percentages of BAC measurements and have been studied in past examinations of the alcohol-crash problem.

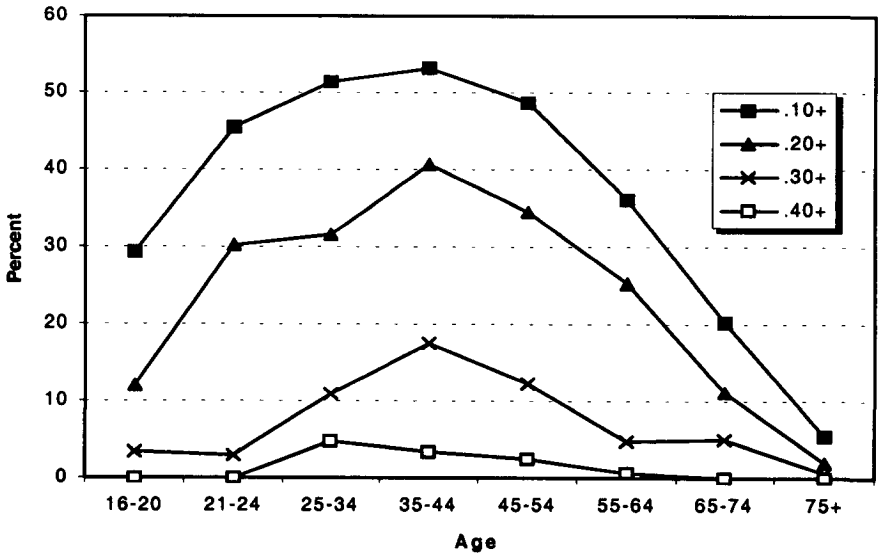
The results with respect to the sex of pedestrians are shown in **Figure 4-30.** Nearly 30% of the males were at .20+, and 10% were at .30+. The percentage for males was about twice as high as that for females at any given BAC level. With respect to age, the percentages peaked for the 35-44 age group at all BAC levels except .40+, which peaked for the 25-34 age group (**Figure 4-31**). An astonishing 41% of fatally injured pedestrians of age 35-44 had a BAC of .20+, and 18% were at .30+.

Figure 4-30: Alcohol-Related Pedestrian Fatalities as a Percentage of All Pedestrian Fatalities At High BACs by Sex in 15 States, FARS Data For 1998



Leaf and Preusser (1997) reviewed the pedestrian-alcohol problem and analyzed FARS data for the years 1983 through 1994. The records of 53,904 pedestrian victims whose BACs (67% of all cases) were measured were used in their analysis of the overall pedestrian-alcohol problem. Since race is not coded in FARS, the FARS data were matched against data in the Centers for Disease Control's Multiple Cause of Death (MCOD) file for the years 1987-1989. As a result, race data on 16,957 fatally injured pedestrians of age 15 years or higher were obtained.

Figure 4-31: Alcohol-Related Pedestrian Fatalities as a Percentage of All Pedestrian Fatalities At High BACs by Age in 15 States, FARS Data For 1998



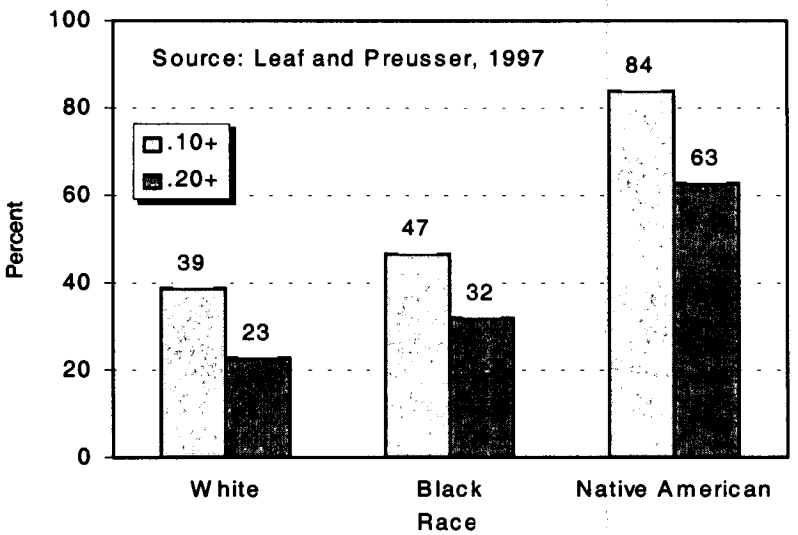
The results for two high BACs, .10+ and .20+, are especially interesting here. For males, 48% had BACs of .10+ and 30% had BACs of .20+. For females, these percentages were 25% and 15%, respectively. These two sets of percentages are quite close to those we obtained for the 15 states in 1998.

There were distinct differences in the age-sex distributions for the racial groups coded in the MCOD file. Overall, Whites (including White Hispanics) had the lowest percentages, and Blacks were moderately higher. Native Americans were the highest, with 84% at .10+ and an astonishing 63% at .20+ (**Figure 4-32**). Asians and Pacific Islanders (not shown) were very few in number (n=266) and had extremely low incidences of high BACs.

With respect to sex, males were twice as likely as females to have BACs of .10% or higher (47 percent vs. 24 percent). Whites (including Hispanics), male and female, had BACs of .10+ less frequently than Blacks (41 percent vs. 47 percent). Native American males were about twice as likely to have high BAC levels as other males (86% vs. 43%); Native American females were three times as likely to have BAC levels of .10+ as other females (75% vs. 23%). Data for six sites that had information on Hispanics showed that Hispanic males had greater alcohol involvement than did White males (52% of Hispanic male victims had BACs of .10+ vs. 46% of White males), but that Hispanic females had much lower involvement (17% for Hispanic females at .10+ vs. 27% for White fe-

males). Again, Blacks had somewhat higher proportions of BACs at .10+ than did Whites.

Figure 4-32: Alcohol-related Pedestrian Fatalities as a Percentage of All Pedestrian Fatalities at High BACs by Race, Data from FARS and MCOD, 1987-1989



With respect to age, about 90% of males between 15 and 34 had BACs of .10+, with values dropping only slightly for older Native Americans. Nearly three-fourths (73%) of males 25-34 had a BAC of .20+ or higher; and more than half of Native American males had a BAC of .20+ in every age category. Native American females (based on a small number of cases) showed similar high alcohol involvement. For them, maximum involvement was for ages 25-34, but levels of involvement stayed very high from ages 15 through 54 and possibly beyond. Over all ages, three-fourths of Native American females had a BAC of .10+, and more than half (54 percent) had a BAC of .20+.

For Whites, Blacks, and Hispanics, levels of alcohol involvement were lower, although still very high, and generally similar. Highest BAC values were shown for males ages 25-54, where three out of five had BACs of .10+, and two out of five had BACs of .20+. Close behind were males ages 21-24, who had nearly the same level of involvement at BACs of .10+, but somewhat lower numbers at BACs of .20+. Males ages 15-20 had lower, but still large, levels of alcohol involvement: 38% had BACs of .10+, but only about one in eight (12-15%) had BACs of .20 or higher. Male pedestrians ages 55 and older had still lower levels of alcohol involvement: One-fourth had BACs of .10+, and a relatively high one-sixth had BACs of .20+.

Females showed similar distributions of BAC levels across ages, but the peak was narrower (reached only in the 25-34 age category); dropped off more sharply for younger and older women, and never quite reached the levels shown for males. Black females showed the greatest levels of alcohol involvement, followed by White females, followed by Hispanic females.

The above discussion of age-sex-race interactions is taken from Leaf and Preusser (1997), pages 22, 23, and 25.

Leaf and Preusser also examined the role of several driving-related variables in crashes involving three high-risk racial groups and made comparisons with their White counterparts. The combined FARS / MCOD file for 1987-1989 was used in developing the comparisons. We summarized data from their tabulations in **Table 4-5**, which indicates the groups and the variables considered, and whether there was any significant or meaningful difference in the percentage of high-BAC crashes between each high-risk group and its White counterpart for a given variable.

Table 4-5: Differences in the Percentage of High-BAC Pedestrian Crashes among High-Risk Racial Groups and Their White Counterparts for Several Driving-Related Variables

Variable	Contrast		
	Black Adults Vs. White Adults	**Hispanic Males Vs. White Males**	**Native American (NA) Adults Vs. White Adults**
Time of Day / Day of Week	No Difference	Hispanic higher on weekday nights and weekend days	No Difference
Light	Black higher during daylight	No Difference	NA higher during dark, unlighted
Weather	No Difference	No Difference	No Difference
Road Condition	No Difference	Hispanic more on dry pavements	No Difference
Road Class	Black higher on local streets, less on arterials	Hispanic higher on local streets, less on rural connectors	NA higher on local streets, rural connectors; lower on arterials
Speed Limit	Black higher at lower speed limits	Hispanic higher at lower speed limits	NA higher at higher speed limits
Location	No Difference	No Difference	No Difference
Pedestrian Behavior	Black higher for walk in roadway	Hispanic higher for improper crossing	NA higher for walk in roadway
No. Vehicles	No Difference	No Difference	No Difference

It is seen that none of the contrasts showed any difference with respect to *weather, location, and number of involved vehicles*. However, all of the contrasts showed a difference with respect to *road class, speed limit, and pedestrian behavior*. For *road class*, all of the racial groups had higher percentages than their White counterparts on local streets, and Native Americans had a higher percentage on rural connectors. For *speed limit*, Blacks and Hispanics had a higher percentage at lower speed limits, and Native Americans had a higher percentage at higher speed limits. For *pedestrian behavior*, Blacks and Native Americans had a higher percentage of walk-in-roadway crashes, while Hispanics had a higher percentage of improper-crossing crashes. Finally, two variables were associated with differences for one or two contrasts. For *time of day / day of week*, Hispanics had higher percentages on weekday nights and weekend days, while for *light*, Blacks had a higher percentage during daylight, and Native Americans had a higher percentage during dark, unlighted conditions.

As indicated on page 59, Voas and associates (2000) recently complied information on race and ethnicity obtained by matching FARS data with death certificate data collected by the National Center for Health Statistics. The data covered the period 1990-1994, and includes some information on pedestrians in fatal crashes for that more recent period. More racial / ethnic categories are included than in the study by Leaf and Preusser, with data again confirming very high alcohol involvement for Native Americans (74%) and very low involvement for Asian-Pacific Islanders (10%). Blacks, Mexican Americans, and Other Hispanic Americans had slightly higher involvement rates than Caucasian Americans, which were followed by Central and South Americans, Puerto Ricans, and Cubans in that order.

In assembling background data for their development of a countermeasure program for alcohol-involved pedestrian crashes, Blomberg and Cleven (2000) performed extensive case studies of 20 fatally-injured pedestrians with high BACs. From the case studies, they developed a detailed profile of the crash victims. The profiles included personal and residence items, alcohol/drug items, pedestrian habits items, and crash items, totaling 39 items altogether. Profiles on pedestrians who were not victims were also constructed. The authors summarized the results of the case studies, and findings from police crash reports, as follows:

> "It is estimated that alcohol use on the part of the pedestrian is involved in approximately 40% of the age 14+ pedestrian crashes in Baltimore. The pedestrian alcohol problem in the city is therefore similar to that in other large cities in the United States.
>
> As in other cities, the problem in Baltimore is largely experienced by a middle-aged male who is walking in dark clothing on weekend nights.
>
> The HBD [had been drinking] pedestrian who gets involved in a crash has a very high BAC--usually more than twice the legal limit for driving.

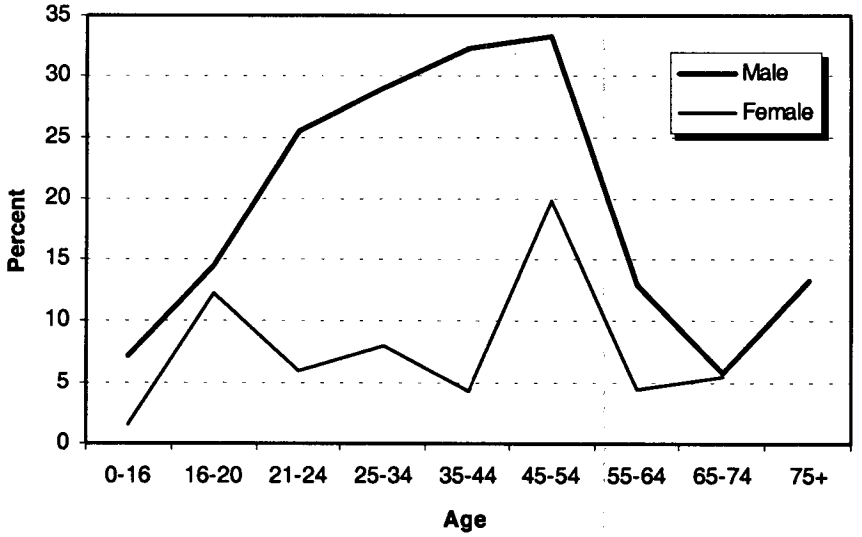
> The pedestrian alcohol problem in Baltimore occurs largely in the center of the city and on a few major city corridors.
>
> Most crashes occur near the victim's home and when the victim is making a relatively short trip (for example, to go to a nearby store for food or cigarettes).
>
> High BAC victims and non-victims who regularly drink to excess come in contact with people who could intervene and possibly prevent a pedestrian crash. In addition to relatives and friends, these include liquor sellers and servers, social service representatives, the police and others.
>
> Both [non-fatally injured] victims and non-victims feel crashes could be avoided if pedestrians drank in moderation and paid better attention to safe pedestrian behavior. They also feel that driver behavior could be improved (particularly driver speeds and knowledge of the cues of an impaired pedestrian), and that engineering improvements (e.g., improved lighting, installation of traffic and pedestrian signals) could make the city's streets safer. The lack of knowledge by the general public of the pedestrian alcohol problem was also noted." (p. 15)

No other recent comprehensive studies of the characteristics of alcohol-impaired pedestrians in the U.S. were located in our search of the literature. However, two state studies in the U.S. should be noted, the first in Arizona using combined FARS / MCOD files (Campos-Outcalt, Prybylski, Watkins et al., 1997), and the second in Florida (Miles-Doan, 1996). The Arizona study contrasted the prevalence of "American Indians" and "non-Indians" in alcohol-related crashes and had findings that were generally consistent with those of Leaf and Preusser. The Florida study found that alcohol impairment, indicators of crash severity, and rural location were correlated with each other and also with the likelihood of serious injury or death. The Florida study also found that, controlling for several environmental, crash, and pedestrian characteristics, being under the influence of alcohol increased the odds of dying over those of a non-fatal injury by a factor of five.

There is evidence that many of the characteristics of alcohol-impaired pedestrians in the U.S. are present among alcohol-impaired pedestrians in some other countries. For example, Holubowycz (1995) found similar age-sex-BAC interactions in South Australia to those in the U.S., although the Australian percentages were somewhat lower than U.S. percentages at the higher BACs.

We found no new studies of pedestrian alcohol-crash risk (as defined in Chapter 2). The study in New Orleans by Blomberg and associates (1979) had found that relative risk of pedestrian crash of any severity increases with BAC, and becomes very high at BACs in excess of .20. (How high depends on the non-crashed group used for comparison, with the most precipitous rise occurring when the crashed and non-crashed groups were matched for age and sex.)

Figure 4-33: Percentage of Fatally Injured Bicyclists at BAC=.10+ by Age and Sex, Data from FARS, 1998



The literature on the characteristics of *alcohol-impaired bicyclists* is much sparser than that for pedestrians. Again, the latest available FARS report (U.S. Department of Transportation NHTSA, 1999) did not provide breakdowns by age group or by sex, and so we used the FARS database for 1998 available on a CD-ROM to develop information on age and sex for bicyclists. We used NHTSA's imputation method for estimating the BACs of subjects whose BACs were not tested.

We found that 20% of fatally injured male bicyclists had a BAC of .10+, compared to only 8% for females. Impairment (BAC =.10+) peaked for the 45-54 age group for both males (33%) and females (20%), dropping rapidly at higher ages. At ages less than 45, the percentage for males decreased slowly until age 20, and then dropped rapidly. For females, the decrease at ages less than 45 was immediate, increasing again at age 16-20 (**Figure 4-33**).

In their study comparing fatal and nonfatal bicycling injuries in Maryland, Li and associates (1996) reviewed some of the major studies of the role of alcohol in bicycle crashes prior to 1996. Cited was a study of FARS data for the years 1987-1991 by Li and Baker (1994) which found that 23% of the fatally injured bicyclists aged 15 or older whose BACs were tested had a BAC of .10+. Studies indicating that some 8%-15% of injured bicyclists were alcohol-positive were also cited in the study.

The 1996 study by Li and associates included only 63 fatalities, 52 males and 11 females. Twenty-five percent of the males had a BAC of .10+, compared to 9% of the females. The sample size of bicyclists whose injuries were not fatal

was much larger, with a total of 214 males and 39 females. Of the males, 13% were at .10+, compared to 7% of the females. With respect to age distribution, the sample size for fatalities was too small to arrive at any meaningful conclusions, but the distribution for the larger sample of non-fatalities was quite smooth, peaking at about 20% at 30-39 years and was nearly that for ages 20-39 and 40-49. There was a rapid fall-off at the high and low ends of the age spectrum. Li and associates also found that helmet use was far less frequent among fatally or seriously injured bicyclists at .10+ than at lower BACs (6% vs. 31%).

SUMMARY AND CONCLUSIONS

Overall, per capita consumption of alcohol in the U.S. has decreased nearly 30% since 1981, with most of the decrease occurring in the consumption of spirits. And while consumption is strongly correlated with fatal alcohol-related traffic crashes since 1981, it still remains to be shown that, all other possible contributing factors considered, a causal relationship exists between per capita consumption and crashes.

The research shows that most persons of drinking age may be classified as social drinkers, and that more than a third drink no alcohol at all. Problem drinkers and alcoholics together account for less than 10% of the drinking age population. Note that these figures are for the U.S. as a whole; the percentages vary widely by geographic location.

The age 21 to 45 group has the highest prevalence of problem drinking and alcohol-dependency, and the 65+ group the lowest. The 18-29 subgroup has been identified as having a particularly high risk of alcohol dependency and adverse consequences of drinking. In general, women drink less than men and are less likely to have alcohol problems or to be alcohol-dependent.

Race and ethnicity have also been found to play a role in drinking patterns. For example, males identified as "non-Black" have about twice the prevalence of alcohol abusers as males identified as "Black." However, while heavy drinking is believed to be decreasing among Whites, it seems to be remaining stable among Blacks and Hispanics, implying a possible larger share of future drinking-related problems for the latter two groups.

Recent research clearly establishes that there is a drinking problem on college campuses, but there is some question as to the magnitude of that problem. Much research has focused on so-called binge drinking. Estimates of the prevalence of binge drinkers are based on self-reported data, and range from 26% to 49% of all students. And while one study describes binge drinking as normative, these studies suggest that it is not. Nevertheless, binge drinkers account for a disproportionate share of drinking problems among college students, with one study finding that 92% of students with drinking problems were binge drinkers. Estimates of the percentage of binge drinkers with drinking problems ranging from 9% to 26%. Other studies suggest that the prevalence of binge drinking has

been relatively stable over the past several years, but that the *perception* of the prevalence is increasing.

With respect to the alcohol-crash problem, research continues to show that young drivers are more often involved in alcohol-related crashes than any other comparable age group. Alcohol-crash involvement rates, share of the alcohol-crash problem, and alcohol-crash risk all reach their peaks for young drivers, with the largest share of the fatal-crash problem occurring at age 21.

As noted in past updates, a large proportion of the alcohol-crash problem involves young White males. In 1998, 84% of fatal-crash involved drivers with BACs of .10+ were male, and more than 70% were White. However, certain racial / ethnic subgroups have higher involvement *rates* than other subgroups. Of these, American Indians have the highest rate, and Asian / Pacific Islanders the lowest.

The impact of other biographical variables on drinking and driving is less understood. Crash data suggest that:

- drivers who are unemployed are much more likely to be alcohol-positive than those who are employed;
- drivers in the mid-income range have the highest prevalence of alcohol use, and drivers in the high-income range and the low-income range have the lowest; and
- drivers with the least formal education have the highest prevalence of alcohol use, and drivers with the most formal education have the lowest.

It is interesting that self-reported data collected in household surveys have arrived at very different conclusions with respect to employment, income, and education using a different criterion for drinking driving: "drove within two hours after drinking [any amount] in the past 30 days [or year]." A possible explanation for this difference is that the household surveys may be biased in favor of persons who drank very little before driving, suggesting totally different relationships with the various biographical variables than for persons who drank more before driving.

Many studies have found that beer is the preferred beverage of drinking drivers. One study found that frequent consumers were more likely to drink outside the home, preferred beer and spirits to wine, and were more likely than others to drink and drive. These individuals were more likely to underestimate the effects of beer and "hazardous" drinking. The authors of the study suggested that the association of beer consumption with drinking-driving arises from the circumstances in which beer drinkers are often found, rather than some other disposition beer drinkers may have to drink and drive.

A number of other studies have examined the role of drinking location in drinking-driving, finding that heavier drinkers prefer to drink at bars and other persons's homes, and at multiple locations requiring longer driving distances.

Younger drivers have been found to prefer drinking at private parties, while older, more educated drivers prefer bars and taverns. Those frequenting "drive-up windows" for acquiring alcoholic beverages have been found more often to have drinking problems and to engage in high-risk behaviors.

It has often been suggested that the high BACs frequently found in drivers arrested for DWI are indicative of a drinking problem, and therefore that high-BAC drivers in crashes are also problem drinkers. Three well-designed recent studies have found that a high BAC at arrest is not in itself indicative of a drinking problem, sending a cautionary note to those concluding without other evidence that heavy drinkers are also problem drinkers. By contrast, a study of a special group of DWI arrestees - male DWI offenders in the U.S. Army - found a significant association between BAC at arrest and drinking problems.

Studies continue to show that drinking-driving is primarily a nighttime, weekend phenomenon. Household surveys indicate that male drivers make three times as many trips within two hours after drinking any amount of alcohol than do females. Using this measure, such drinking drivers as a whole made 1.7 drinking-driving trips in the past 30 days, with the oldest drivers making the most trips and the youngest drivers making the fewest. Motorcycles have the highest rate of alcohol-related fatal crashes, followed by light trucks, passenger cars, and large trucks in that order.

Drivers who have previously been arrested for DWI continue to be the subjects of a large number of alcohol-safety research studies. This is interesting, since FARS data suggest that only a few percent of fatal crashes involve drivers who have recent convictions of DWI. One research issue that has frequently been addressed is the role of number of prior DWI convictions in crashes. Studies in California have found that only 8% of drivers in fatal crashes had one or more DWI offenses on their driver record. However, studies in Minnesota suggest a much higher percentage. In California, crashes of all types actually decreased with number of priors, and in terms of sheer number of alcohol-related crashes, persons with no priors had the highest rate of involvement.

The characteristics of repeat offender DWIs and first offender DWIs have in general been found to be quite similar in many respects, but DWIs with large numbers of priors have been found more often to have long-standing problems of alcohol dependency, and to differ on the severity of their alcohol problems rather than on their demographics. A history of participation in multiple treatment programs is common for these individuals, as well as diagnoses of psychiatric pathology.

A smaller body of literature has addressed the factors that influence one's decision to drive after drinking. Decision theory holds that a rational person will try to maximize the expected gain resulting from a decision, and there is some evidence that drivers attempt to do this in an informal way. Research suggests that experiencing a prior negative event (such as an arrest or a crash) has a positive effect, tending to make a driver less inclined to drive after drinking or to

drive more cautiously after drinking. Factors that have a negative effect include a lack of knowledge of the impairing effects of alcohol or a misinterpretation of the cues of impairment, a reduction of inhibitions at higher BACs, a lowered perception of alcohol-crash risk, and a neglect of social norms after drinking. Research suggests that it is not just the impairing effects of alcohol that favors a decision to drive after drinking; some drivers plan to drink knowing they will drive afterward.

We note that past updates reported the findings of several studies that found drinking-driving to be just one of a series of problem behaviors exhibited by certain groups of individuals. This line of research appeared quite promising at the time, but we found no recent studies of this nature in our search of the literature for this update.

The scientific literature on the characteristics of *alcohol-impaired pedestrians and bicyclists* is far less extensive than that for drivers. What exists indicates that the alcohol-crash problem for pedestrians is, at it is for drivers, predominately a male problem. Very high BACs are common for pedestrians in alcohol-related fatal crashes, especially for those in the 35-44 age group (which is estimated to have 41% at .10+ and 18% at .20+). Alcohol-impaired bicyclists in fatal crashes are also more likely to be male, with the highest percentage of bicyclists at .10+ occurring for those in the 45-54 age group, an older peak age group than that for either drivers or pedestrians.

Locations of pedestrian alcohol-related crashes as a whole are most likely to be near the victim's home or a short distance from the starting point of the trip. Recent research on race and ethnicity indicates that Native Americans have the highest prevalence of alcohol-related pedestrian crashes, roughly three times that of Caucasians at .20+. Blacks and non-Black Hispanics fall somewhere between these two extremes.

Several situational variables (such as road class and speed limit) have been found to distinguish White alcohol-impaired pedestrians in crashes from those of other racial / ethnic groups. In-depth studies of such situational variables are rare in the larger body of literature on drinking-*driving*: a recent study in New Zealand by Bailey and Bailey (2000) found that such situational factors as adverse weather, the driver falling asleep, and involvement of a truck are important in alcohol-related crashes and observed that some of these factors may be more readily addressed with remedial measures than the alcohol factor.

5 - DEALING WITH THE ALCOHOL-CRASH PROBLEM

GENERAL NATURE OF ALCOHOL-CRASH COUNTERMEASURES

Conceptual Frameworks

The most widely used framework for analyzing alcohol-crash countermeasures is the two-dimensional matrix first proposed by Haddon and Brenner in the 1960s for traffic-crash countermeasures in general (Haddon, 1968). The framework is etiologically based, specifying three major crash-related factors along one dimension, and three major phases of traffic crashes along the other dimension (**Figure 5-1**). Countermeasures are analyzed and generated by the types of causes they address as defined by the nine cells of the matrix. The framework was an outgrowth of an earlier characterization of traffic crashes as a public health problem which was to be addressed by actions directed at the driver (host), the vehicle (agent), and the highway (environment) (Gordon, 1949).

Figure 5-1: The Haddon-Brenner Framework for Analyzing Traffic-Crash Countermeasures

Factor	Phase: Pre-Crash	Crash	Post-Crash
Human			
Vehicle & Equipment			
Environment			

Joscelyn and Jones (1981) observed that the Haddon-Brenner framework was too simplistic to justify its place as the dominant framework for analyzing highway safety problems and for generating solutions. They argued that the framework's focus on the crash problem alone is too narrow and that many events not immediately associated with a traffic crash can influence crash causation. Specifically, they noted, the framework does not explicitly include societal aspects, implying that the traffic crash problem will be dealt with by some undefined external forces produced by systems not represented in the framework.

Joscelyn and Jones proposed a new framework relating the loss-generating elements of highway transportation to the elements of society that attempt to control those losses. Specifically, their framework represents a process to control

the disutility in the Highway Transportation System, a process in which disutility is monitored by society, and actions to reduce disutility are taken by risk management systems (such as the traffic law system) created for that purpose. By such a process disutility is maintained at a level that society (public and private *organizations* as well as individuals) will tolerate. Clearly, the absolute level of disutility maintained by the process at any point in time is dependent not only upon the capabilities of the risk management systems that generate the forces to control risk, but also upon societal pressures on those systems to reduce risk. Viewed in this context, the role of accurate and timely information about risk and risk management in highway safety is obvious.

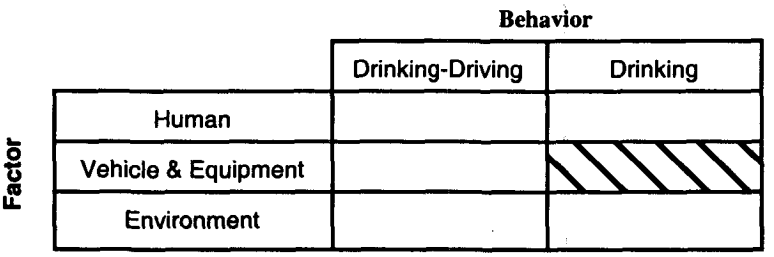
Both frameworks have their advantages, the Haddon-Brenner framework being easy to understand and visualize, and the Joscelyn-Jones risk management framework incorporating elements that deal with crashes, in addition to elements that influence the etiology of the crashes themselves. We will use both frameworks in discussing the nature and effects of alcohol-crash countermeasures in this chapter.

Targets

Possible targets of alcohol-crash countermeasures exist in each of the nine cells of the Haddon-Brenner matrix, from human factors in the pre-crash phase to environmental factors in the post-crash phase. However, countermeasures designed explicitly for alcohol-related crashes are inherently more suited to the pre-crash phase, particularly if the pre-crash phase is extended far enough in advance of the crash to where perceptions of risk and risk-management actions are formed. This implies a policy of crash-prevention for alcohol-crash countermeasures, not only by preventing drinking-driving, but also by preventing crashes resulting from drinking-driving.

All three classes of factors (human, vehicular, and environmental) are potential targets for pre-crash alcohol countermeasures. However, another distinction must be made as to whether drinking or drinking-driving is the targeted behavior. This leads to the creation of another matrix devoted only to the pre-crash phase (**Figure 5-2**).

Figure 5-2: Matrix of Target Types for Pre-Crash Alcohol Countermeasures



Here, there are only six cells, containing such countermeasures as:

Countermeasure Class	Example
Human / Drinking-Driving	DWI legal-system deterrence and incapacitation countermeasures such as jail and license revocation
Human / Drinking	Countermeasures aimed at alcohol availability and consumption such as server liability laws
Vehicle & Equipment / Drinking-Driving	Alcohol interlocks
Vehicle & Equipment / Drinking	None Known
Environment / Drinking-Driving	Highway edge markings
Environment / Drinking	Control of drinking locations

The cells in **Figure 5-2** categorize countermeasure targets at the most general level of detail. Classifications at any reasonable level of detail can be defined for each cell by combining sets of drinking-driver characteristics such as those discussed in Chapter 4. Note that a similar typology can be developed for pedestrians and bicyclists as well as drivers.

Driver-Oriented Countermeasure Actions

After the target of a countermeasure has been defined, the actions against that targets must be taken. Joscelyn and Jones (1981) defined two general categories of driver-oriented actions:

- Specific risk-management actions - those designed to reduce risk among persons who have been identified as drinking drivers and have been exposed to actions to reduce the probability of future drinking-driving; and
- General risk-management countermeasures - those designed to reduce risk among persons who are only potential drinking drivers.

These categories are an extension of the concept of specific and general deterrence, where specific deterrence imposes penalties on those who have been caught engaging in a proscribed behavior, and general deterrence creates a threat of punishment for those who have not necessarily been caught engaging in a such a behavior. The concept of *incapacitation* has often been used in conjunction with deterrence-based approaches. If achieved, incapacitation reduces alcohol-

crash risk by removing one's ability, means, or authorization to drive at all, through such means as physical confinement, confiscation of one's vehicle, or removal of one's driving license. In theory, incapacitation establishes a deterrent threat as well as prevention of driving during the period of incapacitation.

Finally, a third type of pre-crash action can also be conceived, an action to reduce the probability of a crash after drinking-driving has occurred. However, we found no evaluated countermeasures with this objective. As will be seen later in this chapter, a large percentage of evaluated alcohol-crash countermeasures have been aimed at deterring drinking-drinking driving through the threat of unpleasant consequences, incapacitating drivers, or both.

Policies and Programs

We found no evidence of a multi-agency national policy for dealing with the alcohol-crash problem. The policy of the National Highway Traffic Safety Administration (NHTSA) seems to stress the direct control of drinking-driving (rather than drinking) with little emphasis on environmental factors (U.S. Department of Transportation NHTSA, 1998) which are the domain of the Federal Highway Administration (FHWA). The National Institutes of Health (NIH) seem most concerned with drinking-oriented countermeasures that stress human factors, while the National Institute of Justice (NIJ) focuses on DWI deterrence. Cooperative agreements exist between NHTSA and NIH, and between NHTSA and NIJ, on some alcohol-countermeasure research and evaluation programs.

There is also evidence of increased interest in partnership arrangements between federal governmental agencies and various local government and private-sector organizations. For example, NHTSA began a "Partners in Progress" program in 1997 that worked with state and local agencies, and their private-sector partners, to develop innovative solutions to the alcohol-crash problem. NHTSA is currently exploring ways of increasing cooperation among public-sector and private-sector organizations.

Evaluations

In this update we are most interested in alcohol-crash countermeasures that have been evaluated by their effectiveness in reducing alcohol-crash risk. Such evaluations are called "impact evaluations" in the literature, in contrast to evaluations that measure effectiveness only in terms of increased activity or improved processing. The number, variety, and quality of impact evaluations have increased dramatically since the 1968 state of knowledge review. We found 107 references to "drinking drivers" in the library of The University of Michigan Transportation Research Institute (UMTRI) prior to 1968, most of which addressed the experimental and epidemiologic aspects of the alcohol-crash problem. Since 1968, the UMTRI library has added more than 3,000 documents on this

subject, many of which report the results of impact evaluations of alcohol-crash countermeasures.

Designs. There is an extensive literature on the evaluation of societal programs, a review of which would be far beyond the scope of this update. Some of this literature deals explicitly with the evaluation of highway safety countermeasures, and generally reflects concepts in use today in evaluating alcohol-crash countermeasures (Griffin III, Powers, and Mullen, 1975; Hall and O'Day, 1971; Streff, 1991; U.S. Department of Transportation NHTSA, 1981; Vilardo, Davis, Jones et al., 1977).

A central requirement in evaluating any given countermeasure is to account for factors other than the countermeasure that might affect the outcome. Such factors are termed a threat to the internal validity of the evaluation (Campbell and Stanley, 1963). Threats to *external* validity (situational factors that may prevent generalizing the results of the countermeasure to other settings) are also present, but, usually, internal validity is the primary goal.

The *treatment-and-control* design attempts to get internal validity by comparing the experience of different groups of people. Such comparisons are appealing because they are relatively simple in concept. They tend to be more valid if they are used to compare groups of people, one to which a countermeasure is applied (the treatment group), and one to which it is not applied. In the simplest case, the groups are of the same size and are studied for the same period.

One common way of establishing the suitability of a control group is to use a *before-and-after* × *treatment-and-control* design. If the basic approach is to compare the treatment group before and after the intervention, then the control group is used for making a corresponding comparison. Typically, in this approach, it is assumed that extraneous factors affect treatment and control groups in the same way, and a relation (usually proportional) is assumed between the measure in the treatment group and the control group. Then, one uses the change in the control group to adjust the change in the treatment group for the influence of extraneous factors.

Time series designs are a conceptual extension of before-and-after comparisons. Here, not just two periods, before and after, but a number (usually 40 or more) of periods are used. Nearly always, a large percentage of the periods are in the "before" phase, and usually several are in the "during" phase of the countermeasure. Such a series of data can be analyzed more thoroughly, and effects of confounding factors estimated and eliminated.

There are basically two approaches to time series analyses. One uses only the time series of the measure of effectiveness (or "criterion variable") studied, and the other also uses other data, either as "control" or as "explanatory" variables. In the first approach, an internal structure is determined for series of the measure of effectiveness. In the second approach, additional time series are used.

Another, even more basic, evaluation design requirement that is often neglected or not provided in evaluation studies is a detailed description of the nature of the countermeasure and what it is intended to accomplish. Such a description should:

- define the ultimate objectives of the countermeasure;
- define and describe countermeasure activities;
- specify the resource requirements for performing those activities;
- relate input to the countermeasure to its output; and
- describe the operational environment or setting of the countermeasure.

The relationship between the *input* to the countermeasure and the *output* of the countermeasure is especially critical. The relationships between system input and system output have been described as a "chain of action" in the evaluation literature (Vilardo, Davis, Jones et al., 1977). This literature speaks of various levels of objectives which are related in a hierarchical fashion to the countermeasure's ultimate highway safety objective. For example, countermeasure resources (such as money for police overtime) are related to countermeasure performance (such as more patrol activity and more citations for DWI) which is related to immediate objectives (such as fewer DWI violations) which are related to ultimate objectives (such as fewer alcohol-related crashes involving a fatality or serious injury).

A final aspect of these descriptive preliminaries to the evaluation is describing the *operational environment* of the countermeasure. Such information is important for identifying possible confounding events or activities that might have affected the impact of the countermeasure on its target. It is also important for comparing the results of the countermeasure as implemented in this jurisdiction with those of similar countermeasures that have been or may be implemented in other jurisdictions.

Limitations. As suggested above, countermeasure evaluations are inherently limited by one's ability to filter out the effects of other factors. The better the confounding effects of non-countermeasure factors can be controlled for, the more convincing the evaluation. True experimental designs of the type used in the laboratory are not possible; instead, quasi-experimental designs have to be used for these "natural experiments."

A potential problem that can severely limit the credibility of an evaluation is the use of an inappropriate criterion variable for measuring the impact of the countermeasure. Alcohol-crash countermeasures following the general risk-management strategy aim to reduce the number of crashes that are likely to have involved alcohol as a causal factor. An objective way is needed for identifying such crashes from available data. At present, driver BAC is the best objective measure of alcohol-related crashes, but it will usually only be available for fatal

crashes, and only for the fatally injured drivers. In such cases, a BAC of .10+ can reasonably be expected to be associated with alcohol as a causal factor. Evaluations in jurisdictions having a small number of fatal crashes will have to rely on surrogates based on other attributes that have been found to be closely correlated with BAC. One such surrogate that often has been used is nighttime single-vehicle injury crashes. Subjective measures such as crashes in which a driver is judged by the police officer investigating the crash as "had been drinking" have also been used, but may give spurious results because of non-crash related factors that may have influenced the officer's opinion (e.g., heightened awareness of the alcohol-crash problem stemming from a highly-publicized crash).

Another basic limitation is the quality of the data used in the evaluation. The most commonly used data on traffic crashes are collected by police agencies in the course of investigating crashes. When using such data, a number of points need to be watched to make sure that the data are compatible over time, or across agencies. Examples of such potential problems are:

- change in reporting requirements;
- inclusion or exclusion of operator reports;
- criteria for inclusion of crashes on private property;
- possible differences between reporting and inclusion in data files;
- differences in reporting practices between agencies; e.g., police in large cities often do not investigate minor property damage crashes, but give priority to restoring traffic flow;
- changes in definition of death, for example, from "one year from the date of the accident" to "30 days from the date of the accident;" and
- changes in the definitions of injury severity classes.

Similar problems can occur in other types of archival data, including driver records data of prior violations and crashes.

Surveys that have collected information from (or about) individuals are often used as a data source in evaluations of alcohol-crash countermeasures. Such data are used for such purposes as determining the awareness of some group of a countermeasure or of a message related to a countermeasure, and obtaining self-reports of the respondents' driving behavior which is to be affected by the countermeasure. In rare cases, all members of a population are surveyed, for example, all persons arrested for DWI in the study area during a certain time period, or all licensed drivers in an area may receive a questionnaire by mail. Usually, however, only a sample of the population is contacted, and one extrapolates from the sample to the entire target population.

Survey data present their own set of problems, ranging from improperly phrased questions that bias the responses, to the selection of a survey sample theat does not represent the population from which information is sought (e.g., male drivers of age 21-34 years). Such problems are discussed at length in textbooks

on survey research. A more fundamental concern is the very nature of the data collected, which is self-reported. Respondents may not remember their behavior or events that may have influenced their behavior, may not wish to report incriminating or embarrassing behavior, or may slant their responses to please the surveyor or to comply with perceived social norms.

A third class of data that are sometimes used in evaluating alcohol-crash countermeasures are obtained through *field observations*. The BAC of non-crash involved drivers is one common type of such data. Determination of BAC requires that a driver be stopped and tested using either an "active" or a "passive" testing device. Data may be collected at a parking lot, near a restaurant, bar, etc., where drivers can be contacted, or from drivers stopped in traffic.

While quite high response rates have been achieved with such roadside surveys (over 90% in some instances), a variety of problems can occur in making field observations. Problems can include poor selection of times and locations of observations, lack of training of observers, lack of quality control procedures, and poorly designed forms and protocols. These problems can result in data that do not accurately reflect the BACs of the drivers targeted by the countermeasure being evaluated, or the BACs of some comparison group of drivers.

Summary

This section has discussed the general nature of evaluations of alcohol-crash countermeasures to provide background and a framework for the more detailed review of the literature to follow. Two conceptual frameworks for analyzing alcohol-crash countermeasures were discussed, and ways of classifying countermeasures programs were suggested. The general requirements for designing an evaluation were examined briefly, along with some of the problems and limitations of traffic-crash evaluations.

Our review deals almost entirely with countermeasures whose impact on the alcohol-crash problem has been evaluated. It incorporates the above considerations and is structured at the top level along the lines they suggest, *viz.*:

- Countermeasures aimed directly at preventing drinking driving; and
- Countermeasures aimed at preventing excessive drinking by drivers or potential drivers.

A third class of countermeasure, containing those that would attempt to prevent crashes after the occurrence of drinking driving, is discussed briefly. Countermeasures for alcohol-related crashes involving pedestrians and bicyclists are discussed separately.

COUNTERMEASURES TO PREVENT DRIVING AFTER DRINKING

Deter and Incapacitate Drinking-Drivers

The Traffic Law System. As indicated above, these countermeasures involve the Traffic Law System (TLS) as the primary risk-management system. This review is concerned with a particular type of traffic-crash risk, that which is created by alcohol-impaired drivers. At the highest level, the formal functions of a DWI enforcement system are law generation, law enforcement, adjudication, and sanctioning, defined broadly by Joscelyn and Jones (1981) as follows:

Law Generation

- Define the target risk precisely;
- Prohibit behavior that creates risk (i.e., driving with a BAC exceeding specified limits);
- Provide for the operation of the DWI enforcement system through procedural guidelines, creating necessary entities, and funding them.

Law Enforcement

- Detect and apprehend violators for further system action; and
- Manipulate human behavior to prevent violations.

Adjudication

- Determine if risk-taking occurred for individuals apprehended by Enforcement;
- Determine the validity of risk prohibitions by Law Generation; and
- Provide fundamental fairness essential for system operation.

Sanctioning

- Provide the ultimate system response to ensure that the sanctioned individual will not engage in risk-taking in the future (specific deterrence); and
- Provide a pattern of responses to individual risk-taking that influences all potential risk-takers to refrain from such actions (general deterrence).

Besides the traditional functions listed above, a fifth, less formal, function is concerned with the dissemination of information among the components of the system and to potential DWI violators, among others.

Interestingly, few researchers have questioned the underlying hypothesis of deterrence as applied to the alcohol-crash problem. However, one study (Evans, Neville, and Graham, 1991) used state-level data over the 1975-1986 period to "test the predictions of deterrence theory" with respect to anti-drunk driving policies and legislation during the years 1982-1986. An econometric regression-analysis approach was used with various alcohol-related and non-alcohol mea-

sures as dependent variables, and 0-1 variables for the year during which a given law (ten laws were included) was in effect.

Evans and associates found no conclusive evidence that any *specific* form of punitive legislation had a measurable effect on motor vehicle fatalities nationwide, but that there was evidence that multiple laws designed to increase the certainty of punishment (e.g., sobriety checkpoints and preliminary breath tests) had a synergistic deterrent effect. They also concluded that mandatory seat belt use laws and beer taxes may be more effective at reducing drunk driving fatalities than policies aimed at general deterrence. We note that this study dealt only with the legislative component of the TLS, rather than all components (e.g., enforcement and public information) that are hypothesized as being necessary to create deterrence. Nevertheless, the study provides some evidence that passage of *multiple* laws, accompanied by some unspecified further TLS actions by non-legislative components, can deter drinking-driving.

As noted in Chapter 1 of this review, Wagenaar, Zobeck, Williams et al. (1995) attempted a meta-analysis of TLS-based alcohol-crash countermeasures reported during 1960-1991. They found 125 studies containing separate empirical evaluations of the effects of 12 alcohol-crash countermeasures. They found that all of the DWI control efforts were associated with reductions in drink-driving and traffic crashes. They estimated that overall, the mean reductions achieved by such countermeasures in the U.S. reported in the recent literature (i.e., 1980-1991) ranged from 8% to 17%. The authors observed that "DWI control literature is limited by the preponderance of weak study designs and reports that often fail to include basic data required for meta-analysis." (p. 307)

Prior NHTSA-sponsored reviews have classified deterrence and incapacitation countermeasures for drinking drivers by the TLS function most predominant in executing the countermeasure, and our review below follows the same approach. One such prior review was sponsored NHTSA and was conducted by Jones and Lacey in 1991. It deals with scientific impact evaluations conducted in the 1980-1989 time period, and material from that review is discussed briefly here to provide perspective for the evaluations conducted since 1989. A bibliography of the studies examined in the 1991 review is contained in Volume I of the review report (Jones and Lacey, 1991a), and reviews of individual studies are collected in Volume II (Jones and Lacey, 1991b). As indicated earlier in this report, under this contract, we conducted a special review of the recent scientific literature about drivers who have been convicted more than once of DWI and that has been published as a separate report (Jones and Lacey, 2000). Many of the evaluations reviewed also dealt with first offenders. Such evaluations are re-examined here below with respect to their findings on first, as well as repeat, offenders.

Legislative Countermeasures. While all TLS countermeasures have their origin in laws that authorize them, some exist without any explicit, formal program of enforcement, adjudication, and sanctioning. In their meta-analysis,

Wagenaar and associates (1995) estimated that such laws were associated with mean reductions in "alcohol-impaired driving and crashes" of 3% to 14% in the U.S., depending on the length of the post-intervention period examined in the evaluations. (The reductions were 9% to 14% for post-intervention periods in the 13-48 months range).

Administrative License Revocation Laws. Several such legislative countermeasures have been evaluated in recent years, including *administrative license revocation (ALR) laws* (also called *administrative per se* laws) in the past ten years. Laws calling for administrative license revocation have become widely used in the U.S., existing at this writing in 40 states and the District of Columbia (NHTSA State Legislative Fact Sheet - Administrative License Revocation). The term "administrative license revocation" (ALR) as used here refers to the revocation of an impaired driver's drivers license by an administrative agency (such as a state department of motor vehicles) rather than by a judicial agency. In general, such laws permit a driver's license to be revoked (or suspended) on the basis of failing or refusing to submit to a BAC test. The laws provide that the driver's license shall be revoked within a prescribed time period, based upon a report submitted to the administrative agency by a police officer. Most ALR laws require the police officer to take the offender's license at the time of arrest and to provide the offender with a temporary license which also serves as a notice of revocation and provides information regarding the offender's right to an administrative hearing or review.

McArthur and Kraus (1999) reviewed three evaluations of ALR laws in several states and concluded that the laws were effective in reducing recidivism in some states, but not in others. All three evaluations were termed "dual retrospective cohort studies" in which recidivism rates under the ALR law was compared to recidivism rates not under the ALR law. The first study (Stewart, Gruenewald, and Parker, 1992) found the law did not reduce recidivism in two states, but did reduce it (by about 30% to 40%) in another state. The second study (Lacey, Stewart, Marchetti et al., 1990) found a recidivism reduction of about 37% up to 30 months after the license action, but no reduction at 36 months. The most recent of the three evaluations (Rogers, 1997) examined the odds of recidivating within one year after license action, finding that the ratio of the odds under the ALR condition to the odds under the no-ALR condition was 0.73. Note that the there were differences in the definition of recidivism among the three studies, with Stewart and associates and Rogers using re-conviction as the "failure," and Lacey and associates using re-arrest.

Voas and associates (1998) evaluated the effect of ALR on the recidivism of multiple offenders. They examined the driving records of 45,788 drivers who were convicted of driving under the influence (DUI) in Ohio between July 1, 1990 and August 30, 1995. Several analyses were performed, the most pertinent of which to this review was an analysis of the DUI recidivism of two cohorts of drivers, the first cohort convicted before the ALR law, and the second convicted

after the ALR law. The analysis showed that one year after their arrest, about 19% of the before group had recidivated, compared to only about 5% of the after group. However, as the authors indicate, not all of this large reduction in recidivism can be attributed to ALR, since new legislation strengthening and extending the vehicle impoundment and immobilization occurred at the same time as the ALR law.

In an earlier study, Beirness, Simpson, and Mayhew (1997) evaluated both the general deterrence effect and the specific deterrence effect of ALR combined with another sanction (discussed in detail below), vehicle seizure and impoundment (VSI), but did not differentiate between first offenders and repeat offenders. Both programs had been implemented in Manitoba, Canada in 1985. They found that the combined sanctions decreased: drinking-driving fatalities by 12%, nighttime single-vehicle crashes by 26%, repeat DWI offenses within four years by 44%, and traffic crashes among DWI offenders in the 97 days following a DWI offense by 69%.

Voas and Tippetts (1999) also examined the general deterrent effect of ALR in their recent national study. Data from their report indicate that ALR laws reduced alcohol-related fatal crashes in the United States by about 30% over the period 1982-1997. The authors noted that "this long-term trend is not the product of a single law, but the result of the growing impact of several laws over time plus the affect of some factors not included in the model tested, such as the increasing use of sobriety checkpoints and the media's attention to the drinking-and-driving problem."

Two other types of such laws that have been the subject of recent evaluations are of interest in this review, .08 BAC legal-limit laws, and zero tolerance laws for youth.

.08 Laws. In the United States, .10 BAC illegal limit laws were the rule *circa.* 1980 until the states of Oregon and Maine adopted .08 BAC as their illegal limit in the early 1980s. Since then, 23 states, the District of Columbia and Puerto Rico have adopted new laws setting .08 as the limit, and many more are likely to follow due to recent Federal legislation imposing financial penalties on those who fail to do so. The Federal legislation was supported by several evaluations indicating the lowered illegal limit could reduce alcohol-related crashes.

A report by Research and Evaluation Associates (1991) studied the immediate effects of the passage of a .08 law in California which went into effect in January 1990, followed by implementation of administrative license revocation six months later. Both initiatives received extensive media attention during legislative debate and at implementation. Time series analyses of FARS data revealed a 12% reduction in alcohol related fatalities associated with the implementation of the .08 law. However, the authors were unable to separate out the relative effects of the two laws, so the true magnitude of the effect of .08 remains under debate.

In 1995, the California Division of Motor Vehicle published an evaluation of the law with a longer term (four year) follow-up. They, too, found reductions in

alcohol related fatal crashes, and also in serious injury crashes and late night crashes. However, again, because of the temporal proximity of the implementation of the two laws, they were unable to discern the specific effects of the .08 law.

In a preliminary study of FARS data of the first five states adopting .08, Johnson and Fell (1995) reported reductions ranging from 4% to 40% in four of the five states studied.

Hingson, Heeren, and Winter (1996) studied the effects of lowering the BAC limit from .10 to .08 in California, Maine, Oregon, Utah and Washington. They used a design incorporating comparison states which kept their BAC illegal limit at .10. Most of the comparison states were in the same region as their respective .08 states; however in the case of California, Texas was selected, presumably because of its size. The authors reported a 16% reduction in crashes with a fatally injured driver at .08 or higher associated with passage of an .08 law. They also observed similar reductions for high BAC drivers. As with the California studies cited above, these conclusions must be tempered because some of the states also adopted other laws such as ALR during the study period.

Another analysis of a more recent FARS file for the same five target states by Scopatz (1998) used different comparison states that those selected by Hingson and associates as well as the original set. He reported reductions ranging from 4% to 14% (none statistically significant) in drivers in crashes at or above .08 in the .08 states relative to his comparison states and argued that this demonstrated the influence the choice of comparison states could have on studies of this design.

The six states adopting .08 laws in 1993 and 1994 were studied by Hingson, Heeren, and Winter (2000) using techniques similar to those employed in their earlier study and expanding on them. They used meta-analytic techniques to combine the results of single state pair analyses comparing reductions in the proportions of both fatal crashes involving a driver with a BAC of .01 or above and fatal crashes involving a driver at .10 or above. Examining all six .08 states relative to their comparison states, they found a statistically significant 6% reduction in the proportion of fatal crashes with drivers at or above .10 BAC. When they limited the analysis to those four states which had had an ALR law in effect for three or more years before implementation of the .08 law, they also observed a 6% reduction attributable to the .08 law. The analyses of crashes with drivers with a BAC of .01 or above showed a 5% relative decline both for all six .08 states and the four that had longstanding ALR laws.

North Carolina implemented an .08 law on October 1, 1993, long after having implemented other legislation traditionally thought to be effective, such as ALR. Foss, Stewart, and Reinfurt (1998) conducted time series analyses on a number of measures of alcohol-related crashes to assess the effect of the new .08 law. Additionally, they conducted a series of before-and-after comparisons with control states similar to those conducted by Hingson and associates cited above. North Carolina had been experiencing a long term trend of declines on those measures

since the early 1980s when significant legislative measures in this area were implemented. These authors did not discern a statistically significant effect coincident with the implementation of the .08 law, but merely a continuation of the downward trend.

As indicated above, Voas and Tippets (1999) conducted a global analysis of FARS data for all 50 states in an effort to discern the effects of ALR, .10 per se, and .08 per se laws. Examining data from 1982 through 1997, they used weighted least squares regression models to test for the effects on both low BAC and high BAC drivers in fatal crashes coincident with the adoption of each of these categories of laws. They reported reductions attributable to .08 laws on the order of 8% on both measures. However, the authors also cautioned that "the attribution of savings to any single law should be made with caution since each new law builds to some extent on existing legislation and on other ongoing trends and activities." (p. iv).

A time series study of fatal crashes in eleven states which had adopted .08 by Apsler, Harding, and Klein (1999) found significant reductions in alcohol-related fatalities in seven of the eleven coincident with the introduction of .08. In five of those states, the reduction was attributed to the introduction of .08 alone, though it is important to note that they all had ALR laws in effect. In the other two states showing reductions, ALR and .08 laws were implemented in close succession.

In 1999, the General Accounting Office conducted a review of available evidence on the effectiveness of .08 laws including reviewing relevant studies and interviewing researchers and traffic safety professionals (McCain, Hollings, Shuster et al., 1999). The authors concluded that "the evidence does not conclusively establish that .08 BAC laws by themselves result in reductions in the number and severity of crashes involving alcohol." and that "A .08 BAC law can be an important component of a state's overall highway safety program, but a .08 BAC law alone is not a 'silver bullet.' Highway safety research shows that the best countermeasure against drunk driving is a combination of laws, sustained public education, and vigorous enforcement." (pg 23)

Voas, Taylor, Baker, et al. (2000) studied the effects of the passage and implementation on an .08 law in Illinois in July 1997. In this preliminary study, they examined not only the effect of the law on alcohol-related crashes but on the Traffic Law System. Though the total number of DUI arrests increased by 10.8%, they reported no adverse consequences on the operation of the courts and sanctioning agencies. The proportion of arrestees with BACs of .08 and .09 increased, and the average BAC of DUI arrestees Statewide decreased from .18 to .16. BAC test refusal rates were unchanged. Using interrupted time series analyses, they observed a significant reduction of 13.7% in the proportion alcohol-positive drivers in fatal crashes compared to a non-significant 2.5% increase on the same measure in five adjacent comparison states. A follow-up analysis of the effects of the Illinois .08 law incorporating 1999 FARS data, indicated that the effect persisted (Voas, Tippetts, and Taylor, 2001). The revised estimate of the effect

attributable to the .08 law was a 12.3% reduction in alcohol-involved drivers in fatal crashes.

Finally, the Centers for Disease Control (CDC) and their Task Force on Community Preventative Services more recently conducted a systematic review of studies addressing the efficacy of .08 laws (Centers for Disease Control, 2001). It found that "these laws are effective in reducing alcohol-related motor vehicle crash fatalities." This resulted in a "strong recommendation" that states adopt such laws. The CDC review estimated that the median decrease in alcohol-related motor vehicle fatalities following implementation of such laws was 7%. A recent review by Dee (2001) arrived at similar conclusions, estimating that nationwide adoption of .08 BAC laws would "generate substantial gains, reducing the annual count of traffic fatalities by at least 1,200."

Zero Tolerance Laws. By the 1980's, the legal minimum drinking age for alcohol consumption had been raised to 21 in all 50 United States; however, in a large fraction of those states, the legal BAC limit for persons under 21 remained at .08 or .10, the same as for adults. What have become to be known as zero tolerance laws attempt to bring the drinking driving laws in concert with the drinking laws by making it an offense for persons under 21 to drive with alcohol in their system. Currently, all 50 states now have laws for youth prohibiting driving at a BAC over .00, .01, or .02, depending on the state. The traffic safety impact of such laws (often referred to as "zero tolerance laws") has also been the subject of several studies.

In an early study of zero tolerance laws, Blomberg (1992) conducted time series analyses of Maryland crash data statewide and in six experimental counties in conjunction with implementation of a .02 zero tolerance law and publicizing its existence. The dependent variable was crash involved drivers under 21 judged "had been drinking" (HBD) by the investigating officer. He found an approximate 11% reduction in HBD crashes statewide associated with implementation of the law. For the smaller subset of six experimental counties where PI&E efforts were mounted, the initial reduction observed was 21%, with a further reduction of 30% subsequent to the PI&E effort which emphasized the sanctions associated with violating the law.

Hingson, Heeren, Howland et al. (1991) examined nighttime fatal crashes in four states which passed zero tolerance laws before 1989. They studied adolescent and adult nighttime fatal crashes in four study states and four nearby comparison states. In the study states they observed a 34% post-law decline in nighttime fatal crashes for those under 21 compared to a 7% reduction for adults. Interestingly, in the comparison states the comparable figures were 26% and 9%. They reported that the states adopting the zero tolerance laws had significantly greater relative reductions, adolescents to adults, than the comparison states. Using a similar method for twelve states adopting low BAC laws for youth, Hingson, Heeren, and Winter (1994) reported that in low BAC law states, a 16% reduction in single vehicle nighttime crashes for youth relative to a 5% decrease in adults

occurred. The comparable figures for the comparison states were a 1% increase for youth and a 6% decrease for adults. They also reported that states with .00 BAC levels fared better that states that had .02 or .04-.06 levels for youth.

California implemented its zero tolerance law in 1994. The law created an offense which was an administrative violation. It allowed police officers to test with a preliminary breath tester at the roadside those youthful drivers they suspected of driving after drinking. If the driver refused or had a BAC over .01 the officer could then seize the license and issue a citation which permitted driving for 30 day (to allow a hearing request) after which time a license suspension would be administratively imposed by the DMV. The law was crafted to make enforcement relatively easy and avoid the need to take youthful offenders into legal custody. Voas, Lange, and Tippetts (1998) examined its effect in terms of level of enforcement, perceived risk of arrest among young drivers and effect on fatal crashes. Data used in the evaluation included driver records, random digit dial telephone surveys, interviews with underage drivers in weekend roadside surveys and the FARS file.

The roadside surveys indicated that before July 1993, 10-20% of youth thought the limit was .01 or less and in the six months before the law went into effect that level increased to 50-60%. The telephone survey taken just before the law went into effect indicated approximately 53% thought the level was zero and two years later about 56% thought so. The authors concluded that there was no evidence the law was better understood two years after it went into effect. However, over half of the affectable population were aware of the zero tolerance provision when it was in effect. The authors found little change in the rate of alcohol-related charges for drivers under 21 but rather found a replacement of the more serious DUI charge with zero tolerance violations. Over half of such violations in the post law period were for the less serious zero tolerance offense. Telephone survey questions on perceived risk of arrest showed little change from the immediate pre-law survey to the survey two years later.

Time series of fatal alcohol-related crashes for young drivers were analyzed for California and four comparison states. California adult alcohol-related crashes were also examined as a comparison. A 20.9% reduction on this measure for California youth was observed compared to a 4.1% reduction for adults and an 11.6% reduction for youth in the comparison states. These differences were not statistically significant. The authors suggest that better publicity about the law and stronger enforcement would have resulted in "more substantial results."

To study the effect of zero tolerance laws in all 50 states, Voas, Tippetts, and Fell (1999) conducted a pooled cross-sectional time-series analysis of fatal crashes involving youthful drivers using FARS data from 1982 through 1997. Using this technique they attempted to account for differences among the states in background factors such as urbanization, number of licensed drivers, vehicle miles traveled, characteristics of the vehicle fleet and the like. They also attempted to factor in changes in demographic factors within states, alcohol consumption and

effects of other related laws. The overall analysis indicated a reduction in the proportion of underage drinking drivers in crashes of 24.4% attributable to zero tolerance laws. The authors do caution that in an analysis such as this, other factors related to the outcome may have been left out. An example might be that there may have been greater normative changes about drinking and driving which may have effected youth more than adults. Nonetheless, they conclude that zero tolerance laws are having a beneficial effect.

Lacey, Jones, and Wiliszowski (2000) examined the effects of zero tolerance laws in four states, two of which (Maine and Oregon) had had the law in effect since the early 1980's and had recently modified them in an attempt to make them more effective. The two other (Florida and Texas) had only recently enacted such laws. This study examined issues surrounding how the laws were implemented in the four states and the extent to which implementation of the laws has had an effect on alcohol-related crashes as measured by Nighttime Single Vehicle Injury (NSVI) crashes of youth.

In all four states, the administrative license suspension procedures for zero tolerance violations seemed to be running smoothly. Most states integrated the zero tolerance license suspension process into existing administrative license suspension procedures for the adult DWI offense. Youth seemed to request hearings to contest suspensions and request hardship licenses less often than did adults.

In Florida and Texas, enforcement of the zero tolerance law was low but gradually rising. In both of those states, efforts were made from the outset to ease the paperwork burden for officers taking zero tolerance enforcement action. However, as in California above, this initially did not result in an increase in alcohol related arrests for youth.

In Maine and Oregon, which had longstanding zero tolerance laws, the volume of enforcement actions for zero tolerance violations approximated the rate for adult DWI. It was observed that a number of zero tolerance violations were at BAC levels above the legal threshold for adults. However, there was no evidence on the basis of volume that zero tolerance violations were being used instead of DWI for youth as had been observed in California.

Most officers indicated that a permissible level of .00 was preferable to .02 in that it sent a clear message to youth that no consumption of alcohol was legally compatible with driving. This observation is in concert with the findings of Hingson above.

In the states which had longstanding zero tolerance laws, Oregon and Maine, and where police were generally familiar with basic enforcement procedures for the law, recent changes in the law were associated with further reductions in a proxy of alcohol-related crashes. In Maine, where the permissible BAC level was reduced from .02 to .00, a reduction in nighttime single vehicle injury (NSVI) crashes for youth on the order of 36% was observed. In Oregon, where a change in the age for the .00 limit was made from 18 years to 21 years, a NSVI reduction

of 40% was observed. In the two states where the basic law was more recently adopted, a much smaller reduction was observed in Florida (5%), and no reduction was observed in Texas.

Hingson, Heeren, and Winter (1998) evaluated a Maine law lowering the legal BAC limit from .10 to .05 for persons convicted of DWI. The authors used a before-and-after × treatment-and-control design. They calculated changes in the proportions of fatal crashes involving drivers with prior DWI convictions from the six-year period before enactment of the law to the six-year period following enactment of the law, and compared Maine with the other New England states. They found that in Maine, the proportion of fatal crashes involving drivers with recorded prior DWI convictions declined 25 percent following passage of the .05 DWI law, while the proportion rose in the rest of New England during the same years. The proportion of fatal crashes involving drivers with recorded prior DWI convictions and illegal alcohol levels also declined significantly in Maine, as did the proportion of fatal crashes involving fatally injured drivers with recorded prior DWI convictions and illegal alcohol levels. Most of the latter decline was due to a decline in alcohol-related fatalities of previously convicted drivers with very high BACs, of .15 percent or higher, at the time of the fatal crash. Each of these declines in Maine was significant relative to the rest of New England.

Enforcement Countermeasures. The 1991 review by Jones and Lacey concluded that countermeasures that have stressed enforcement can have a significant traffic safety deterrent impact, particularly when used in combination with a strong public information and education (PI&E) component. It noted that some of the stronger studies of the effects of enforcement coupled with public information campaigns found reductions in the number of nighttime crashes ranging from 10 to 30%. However, some other strong studies found only small or "possible," but not significant, effects. Wagenaar, Zobeck, Williams et al. (1995) estimated the average percent reduction in evaluations of U.S. countermeasures classified as "enforcement" (which included sanctions as well as enforcement) to be in the 6% to 12% range, again, depending on the post intervention period examined.

Enforcement strategies employing the concept of sobriety checkpoints appear to have been successful in Australia and France, and earlier research in the U.S. suggested they had been an important factor in some DWI programs that combined enforcement with enforcement-strategy specific PI&E. A new examination of 14 of the better evaluations of random alcohol screening (including sobriety checkpoints) since 1983 concluded that random screening was effective in reducing alcohol-related fatalities by 8% to 71% (Peek-Asa, 1999).

Recently, an evaluation of a large-scale checkpoint program in Tennessee was completed, bolstering these earlier results significantly (Lacey, Jones, and Smith, 1999). In March 1994, Tennessee implemented an extensive statewide sobriety checkpoint program called Checkpoint Tennessee. Checkpoints were scheduled on each weekend of the year in at least four counties in the state. On five week-

ends checkpoints were scheduled in each of the state's 95 counties. The volume of checkpoints increased from about 15 in the preceding year to nearly 900 in the program year. The checkpoint activity was publicized extensively both through public service advertising and earned media. Interrupted time series analyses were used to evaluate the program, indicating that the program resulted in a 20.4% reduction in alcohol-related crashes, extending at least 21 months after conclusion of the formal program. Extensive checkpoint activity was continued after the formal program completion.

A checkpoint program in New Mexico, operated during and shortly after extensive changes to the State's DWI laws, achieved results that were similar to those in Tennessee. Lacey and Jones (2000) evaluated these New Mexico initiatives, and their findings are discussed on page 130.

Foss, Bierness, Tolbert et al. (1997) examined the effects of an intense statewide sobriety checkpoint program implemented in North Carolina in 1994 and 1995. Two statewide blitzes of three to four weeks duration were implemented--one in late November-early December and the other in late June through most of July. These blitzes, which involved over 1,200 checkpoints for the winter blitz and nearly 2,000 for the summer blitz, were accompanied by extensive paid advertising as well as hard news coverage. The effects of the program were assessed through both roadside surveys and interrupted time series analyses of statewide crash data. Overall, the roadside survey results revealed a significant reduction in drivers with BAC's exceeding .08 (from 1.96% to .90%). Surveys were conducted in four communities, and the within-community results were statistically significant only in the two smaller cities. However, the crash analyses did not reveal a sustained reduction in alcohol-related crashes. The authors hypothesized that the effect of such a program is likely to be more pronounced in smaller communities which are more completely saturated by the effort. They also suggested that periodic blitzes may be less effective that a continuous program, but that it may be difficult to obtain sustained media coverage for such a program since the enforcement effort becomes a more routine part of operations.

Jones, Joksch, Lacey et al. (1995) reported the results of a project in three sites to test the hypothesis that combined speed, alcohol, and seatbelt enforcement strategies, coupled with a strong public information and education program (PI&E), can reduce the incidence of speeding, alcohol-impaired driving, and non-use of seatbelts. The three sites were Knoxville, Tennessee; Wichita, Kansas; and Lexington, Kentucky. This project publicized the enforcement of several highway safety laws *in combination*, rather than enforcement of one particular law. This approach was designed to make enforcement more efficient in raising perceived risk of arrest for each type of violation and also to achieve increased deterrence by creating a perception of more severe penalties for multiple violations occurring in a single incident. It was hypothesized that, as a result, deter-

rence for one category of violation may be enhanced by the perceived severity of sanctions for another.

Each program was designed to sequentially emphasize five different combined enforcement strategies during a period of approximately one year. A PI&E campaign focusing on each strategy was to operate for about two months. A general program theme was established for all of these campaigns, stressing the concept of simultaneous enforcement of speeding, DWI, and occupant restraint laws. The first program began in September, 1990, and the last program continued through May, 1992.

The evaluation effort was directed at measuring the effect of the combined enforcement / PI&E program on:

- driver awareness of the program;
- driver perceptions of enforcement;
- driver self-reported behavior with respect to speeding, drinking-driving, and seatbelt use;
- measured speed distributions and seatbelt use at several locations throughout the program period; and
- accidents and accident variables related to drinking-driving, speeding and seatbelt use.

A comparison site was used for each test site to help recognize trends that could affect the test site and confound the effects of the program in the test site. The comparison site was chosen so as to match the test site as closely as possible except that it planned no special traffic law enforcement program.

The evaluation showed that the programs that had increased intensity of enforcement of the target laws as well as a strong public information and education (PI&E) program supporting the enforcement effort and its highway safety benefits were effective for DWI and speeding. Programs that did not have both increased enforcement and supporting PI&E for one or both of these two behaviors did not show an effect. The results for the third target behavior, non-use of seatbelts, were inconclusive in that one site (Wichita) with increased enforcement and PI&E showed no effect, while another site (Lexington) with increased enforcement and PI&E was able to maintain its already high seatbelt usage rate throughout its program period. Of the two sites that showed clearly positive results, one (Wichita) had an effect on DWI, and the other (Lexington) had an effect on DWI *and* speeding.

In Wichita, a variety of analytic methods were used in the analyses of alcohol-related accidents, ranging from visual examination of the data to several kinds of models, including regression models, general linear models, and, finally, interrupted time series models. Terms accounting for trends and seasonal effects were included in many of the models as were terms that acted as "control" variables to

account for non-program effects that might have occurred during the time period studied.

The results of the Wichita analyses using the interrupted time series models of proxies of alcohol-related crashes are summarized in **Figure 5-2**. They indicate reductions in alcohol-related crashes ranging from 20% to 35%. All of these reductions are highly significant, with the probability ***p*** that they could be due to chance alone being less than 0.005.

Table 5-1: Summary of Results of Interrupted Time Series Analyses of Proxies of Alcohol-Related Accidents in Wichita

Type of Accident	Reduction in Accidents as a % of the Mean
Nighttime	20% (30/148)
Nighttime Injury	21% (14/65)
Nighttime Single-Vehicle	35% (24/69)
Nighttime Single-Vehicle Injury	23% (7/30)

Lexington had statistically significant reductions in alcohol-crash proxies in the 10% range and also a 12% reduction in the number of vehicles exceeding the speed limit by at least five mph. Further, Lexington also had a reduction in minor injury accidents of about 17%, a possible reflection of these lower speeds.

The authors found the study results to be encouraging but inconclusive as to the overall traffic safety impact of combined enforcement of DWI, speeding, seatbelt usage laws. In two of the test sites it was not possible to consistently maintain increased enforcement activity and associated publicity for all three of the target behaviors. The one site that was able to maintain increased enforcement activity and a high level of publicity for all three behaviors produced positive results against DWI and speeding. This site did not produce any increase in seatbelt usage, but was able to maintain its already high usage rate. Another site that was able maintain increased enforcement and related publicity against just one of the target behaviors, DWI, showed positive results for that target behavior, but for none of the others.

Adjudication and Sanctioning Countermeasures. The 1991 review found that one adjudicative countermeasure aimed at increasing the probability that a charged drunk driver will be convicted of drunk driving (implied consent) had a traffic safety benefit in itself by suspending refusers' drivers licenses. Another adjudicative sanction, deferring prosecution as an incentive for entering a treatment program, was found to be ineffective.

Of evaluated countermeasures focusing on sanctions, the 1991 review found that those that *suspended or revoked a DWI's driver's license* were clearly the most effective, particularly when well-publicized and applied administratively. One strong study showed that suspending the license of drivers refusing to submit to an alcohol test reduced their crash involvement during suspension, including alcohol-related crashes by about 70%, presumably because most did not drive while under suspension. Several other studies of different degrees of strength showed that suspending or revoking licenses for DWI reduced all accidents as well as alcohol-related accidents during the period of suspension or revocation. Most of the recent literature dealing with driver's license sanctions has been concerned with applications of ALR laws and were discussed in the section above dealing with legislative countermeasures.

The 1991 review found no strong support for the hypothesis that alcohol-related crashes can be reduced by sanctions aimed at *treatment and rehabilitation*[18], although two strong studies found reductions in the re-arrest rate ranging from 10% to 35%. This conclusion applied to programs that dealt with social drinkers and first offenders as well as to programs that deal with persons with drinking problems and with multiple offenders. Further, the review found a "disturbing tendency" for the better designed and executed evaluations to show little or no impact, and for the less rigorous evaluations to show an impact. Nevertheless, the review found that more recent studies continued to confirm past studies indicating that rehabilitative sanctions can be effective when applied in addition to traditional sanctions such as driver's license suspension or revocation.

A later examination of the pertinent literature involved a meta-analysis[19] of the efficacy of so-called "remediation" (i.e., treatment and rehabilitation as traditionally defined) with drinking-driving offenders (Wells-Parker, Bangert-Drowns, McMillen et al., 1995). A total of 215 independent evaluations were studied. The methods used in the studies were rated using scales and protocols developed by expert panels. The authors found that better methodological quality was associated with smaller effect size, and that the better studies suggested that treatment and rehabilitation reduced drinking-driving recidivism by an average of about eight to nine percentage points over no treatment and rehabilitation. (This means, for example, that a two-year recidivism rate of 20% would be reduced, on average, to roughly 18%.) A similar effect size was found for alcohol-involved crashes. Their research also suggested, as had prior reviews, that combinations of treatment modalities were more effective than other evaluated individual modes for reducing drinking-driving recidivism.

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[18] As used here, the term "treatment and rehabilitation" includes DWI / alcohol education programs requiring attendance by drivers convicted of DWI.

[19] Meta analysis is the use of statistical methods in literature reviews to compare and synthesize the findings of studies.

The above findings of Wells-Parker and associates apply to DWIs in general, including first offenders as well as repeat offenders. The recidivism of repeat offenders was not analyzed separately, although two of the three risk categories studied ("moderate" and "high") appear to have contained significant numbers of repeat offenders. The authors found "...some evidence that 'moderate risk' offenders –a category that included multiple offenders–might be more responsive to treatment than either severe or low risk offenders but, because risk type was confounded with treatment type..., this finding is only suggestive" (page 924).

Four recent studies were found that examined the effect of treatment and rehabilitation countermeasures. The nature and results of these studies are presented below.

As indicated above, Langworthy and Latessa (1993) evaluated Turning Point, a program in Cincinnati, Ohio, designed to treat and educate chronic drunk drivers. This program was an attempt to limit the period of incarceration and improve the behavior of "chronic" drunk drivers, therefore easing the strain on jails. Program participants had to have served at least 30 days in jail, and then had to complete a 28-day residential program followed by a six months post-release aftercare program. The evaluation sought to determine whether Turning Point subjects performed better than other chronic drunk drivers did after they were released from custody.

The study group consisted of 531 repeat DUI offenders who participated in the Turning Point program during the first 23 months of project operation. The comparison group consisted of 200 repeat DUI offenders who were adjudicated during the same period, but who did not participate in the Turning Point Project. Random assignment to the two groups was not used, making it necessary to use statistical methods (logistic regression) to control for differences between the groups.

The study found that 33% of Turning Point subjects had new charges within the next 18 months, 8% of which were DUI. By contrast, 40% of the comparison group had new charges, 10% being DUI. From this, the authors concluded that the Turning Point project had its intended effect and that Turning Point subjects were more likely to succeed than comparison group subjects. Note, though, that the observed statistical relations were weak, with the Turning Point subjects doing just marginally better than comparison group subjects.

Langworthy and Latessa (1996) did a follow-up of their original study which extended the tracking data to more than four years. The data dealing with Turning Point participants revealed that about 60% had new arrests since release, and that 25% had further DUI arrests. For the comparison group, it was seen that 58% had a new arrest and that 28% had a new DUI arrest. Subjects with three or more prior DWIs did slightly better in relation to the comparison group.

Peck and associates (1994) analyzed the effect of treatment programs for first-offender and multiple-offender DWIs on a number of criterion measures, including post-treatment DWI recidivism. The subjects studied were 7,316 DWI

offenders in Sacramento County, California who were randomly assigned to several treatment and control groups following their conviction in the period September 1977 through January 1981. The subjects included 2,685 repeat offenders. These treatments were represented in the study by a system of 0-1 dummy codes following the procedure used the earlier study cited above (Arstein-Kerslake and Peck, 1985). For first offenders, the dummy variables represented the following treatment conditions: (1) no-treatment control; (2) in-class educational program (four 2.5-hour sessions); and (3) home study program. For multiple offenders, the treatments were: (1) no-treatment control; (2) therapeutic counseling; (3) counseling plus chemical therapy; and (4) bi-weekly contacts without counseling or chemical therapy.

The authors found that none of the treatments affected recidivism for first offenders or repeat offenders, concluding that:

> ... the present study found no evidence even suggesting a positive impact for the first-offender home study program or the multiple-offender biweekly contact (without counseling) program. In addition, none of the multiple-offender treatments produced effects approaching conventional significance levels. (Page 676)

However, the authors cautioned that their conclusions were limited to the specific data analyzed and should not be interpreted as a general conclusion that all DUI treatment programs are ineffective.

DeYoung (1997a) re-examined the effectiveness of California's treatment programs which had undergone some changes since 1981. In 1997, California had three types of outpatient alcohol education and treatment programs. *First-offender* programs were typically three months in duration and consisted of a minimum of 10 hours education (e.g., the effects of alcohol on the body and on driving, DWI laws, etc.), 10 hours counseling and 10 additional hours of education/counseling. It was also required that the client maintain "close and regular" face-to-face interviews with program staff.

Second offenders (within 7 years) could be sentenced to attend an 18-month "SB 38" (named after the sponsoring legislation) program. SB 38 programs were 18 months in length and required at least 12 hours of education, 52 hours of counseling and bi-weekly face-to-face interviews. *Third and higher offenders* were required to participate in a 30-month program consisting of a minimum of 18 hours education, 117 hours counseling, 120-300 hours of community service, and "close and regular" face-to-face interviews. In 1997, there were less than 500 annual enrollments in 30-month programs.

The DeYoung study examined the effectiveness of these three levels of alcohol treatment programs, comparing them to other sanctions, singly and in combination with others, which were typically prescribed for DWI offenders convicted in California. Drivers studied were all licensed California residents

who were convicted of a DWI in a California court between July 1990 and June 1991. The sample included 88,552 first offenders and 27,293 repeat offenders.

The study found that combining treatment with drivers license action was associated with reduced recidivism for repeat offenders and first offenders as well. For *repeat offenders with one prior*, the mean number of subsequent DWI convictions within 18 months of the index conviction was .096 for offenders assigned to the treatment program *and* receiving driver's license suspension or restriction, and .139 for drivers receiving driver's license suspension or restriction alone. Thus, those receiving license revocation alone were about 1.5 times as likely to recidivate as those receiving license revocation *and* the 30-month program. For *repeat offenders with three or more priors*, a similar effect was noted, with those receiving license revocation alone having about 1.7 times the risk of recidivating as those receiving license revocation *and* the 30-month program.

In recent years there has been increased interest in the potential of treatment programs involving brief interventions by medical care providers, particularly with alcohol positive patients presenting at emergency departments because of accidental trauma, often resulting from traffic crashes. These interventions usually involve a brief screening instrument followed by a short counseling session (15-20 minutes) or referral to an alcohol treatment provider for further assessment and possible treatment. Gentilello, Rivara, Donovan et al. (1999) conducted a randomized trial of such an intervention with patients admitted to a level I trauma center. At twelve month follow up they found reductions in alcohol use, injuries and DWI citations. A study designed to assess the potential of screening of trauma patients in emergency departments conducted by Runge, Garrison, Hall et al. (In Press) found, in a randomized trial, that alcohol problem screening and referral of patients in emergency departments tends to increase the proportion of patients seeking follow up assessment and treatment for alcohol problems. Though this approach shows promise there is still reluctance in the medical community to address alcohol problems with patients presenting for other issues. Rivara, Dunn and Simpson (2000) developed a training program for physicians, residents and medical students to train them in implementing a brief intervention and encourage them to do so. They pilot tested the program in the Pacific Northwest.

The 1991 review by Jones and Lacey concluded that the impact of other, more traditional sanction-directed countermeasures remained unclear. For example, one statewide study of incarceration in a jail reported no effect, while another local study of the same sanction reported a positive effect. In fact, *circa* 1991, there was still considerable controversy about the effect of sanction severity on drunk driving. Three studies suggested that the *severity* of a sanction may be less important than the *certainty* of a sanction, while another study found that certain severe sanctions (including jail) were highly effective. The findings of the first three studies are supported by a later study by Ross and Klette (1995) who

examined the effect of abandoning mandatory jail sentences for persons driving with BACs above specific limits in two Scandinavian countries. This law change was a part of legal reforms in 1998 and 1990 in Norway and Sweden, respectively. Interrupted time-series analysis found that in both countries, traffic deaths *diminished* simultaneously with the reforms, suggesting that Scandinavian success in reducing alcohol-impaired driving does not depend upon mandatory jail.

However, a study in Franklin county, Ohio, by Socie, Wagner, and Hopkins (1994) suggests that jail may be preferable to traditional DWI schools for repeat DWI offenders, but that the opposite may be true for first DWI offenders. The authors compared the DWI / alcohol-related crash recidivism of 124 jailed offenders and to that of 218 offenders assigned to a driver intervention program (DIP). After controlling for gender, age, race, BAC, additional charges filed at the time of arrest, and driving history, they found that, overall, DIP attendees had significantly lower rates of subsequent impaired driving after four years than drivers who were given a jail sentence. Drivers with no priors had a significantly higher four-year recidivism rate when jailed than that of drivers enrolled in a DIP (odds ratio = 2.53), while those with priors fared better after their jail sentence (OR = .56). They also found that drivers younger than 21 years of age had high recidivism rate than other drivers (OR = 2.46).

Recent research suggests that certain alternatives to jail can be successful in reducing recidivism. Such *alternative sanctions* that have been suggested, and some cases evaluated, include referral of drivers to treatment and education, community service in lieu of or in addition to jail, electronic monitoring, intensive supervision probation, impoundment or forfeiture of vehicles or license plates, victim impact panels, victim restitution, visits to a hospital emergency room that treats traffic crash victims, ignition interlocks, and using license plates that identify the vehicle owner as a DWI offender, among other sanctions. Many of these sanctioning concepts do not necessarily require law changes, but may be available under existing laws.

Jones and Lacey (1998b) evaluated a judge-based program in a small county court near Atlanta. This program used a combination of *individually tailored traditional and alternative sanctions* packaged so as to meet the needs of individual offenders, be they repeat offenders or first offenders. All of the sanctions were available under existing laws. The judge-based program was more effective by a wide margin (two to one) than was another sentencing program in a nearby jurisdiction that imposed the minimum sanctions.

Another program operating in Milwaukee County, Wisconsin under existing laws used *intensive supervision probation* for repeat DWI offenders. The evaluation showed that the program reduced a moderate alcohol-related arrest recidivism rate by about one-half, from about 11% to 5.5% after one year (Jones, Wiliszowski, and Lacey, 1996). Yet another program (in Los Angeles County, California) used a combination of *electronic monitoring and home detention* for repeat DWI offenders (Jones, Wiliszowski, and Lacey, 1996). The program reduced a low

alcohol-related conviction recidivism rate by about one-third, from 6% to 4% after one year.

A third, more recent, NHTSA-sponsored study (Jones and Lacey, 1999) examined the effectiveness of a *day reporting center* (DRC), a highly structured non-residential facility that provides supervision, reporting, employment counseling, education and community resource referrals to probationers who had been convicted of a felony DWI. The study found that the DRC program was no more effective in reducing recidivism than was a standard probation program in use by the study jurisdiction. Both programs had a reconviction recidivism rate of about 8% after two years, quite low for this group of offenders. However, the study found that the DRC program was more helpful than standard probation in assisting in the reintegration of the offenders into society and provided correctional services at a significantly lower cost than jail.

Another alternative sanction that has been proposed but not evaluated for DWI offenders is the use of *shock incarceration* or "boot camps" in which rigid military discipline is imposed. Cowles, Castellano, and Gransky (1995) reviewed evaluations of such programs for non-violent offenders in general, and that included treatment components. They recommended that maximally effective treatment regimens should "include substance abuse education and treatment programs involving psychotherapeutic-based interventions, such as individual and small group therapies, with a focus on multimodal approaches that are relevant to the offender population."

The use of *victim impact panels* as an alternative sanction was evaluated by Shinar and Compton (1995) who defined a victim impact panel (VIP) as "a group of three or four persons who were seriously injured or whose loved one was killed in a DWI-related crash." The panel members present their personal stories orally to DWI offenders who are ordered by the court to attend the VIP. This study compared the pre-panel DWI recidivism rates with the post-panel recidivism rates of over two thousand DWI offenders who attended the VIPs in Oregon and California. The study also compared these rates to the rates of age-sex matched control groups of drivers. The control subjects were convicted of DWI in the same states at the same time period, but were not ordered to participate in the VIP. In addition, pre- and post-panel DWI convictions were also studied for 683 drivers who were ordered to attend the VIP but failed to do so (No-Shows).

The results showed that, although in Oregon the VIP attendees had a lower rate of recidivism than their matched control group, the recidivism rate of the attendees was not different than that of either those who were ordered by the court to attend the VIP, but failed to do so (No-Shows), or the age-sex matched control group for the No-Shows. In California, there were no differences in recidivism rates between the VIP group and either the no-show group or the two control groups. Other analyses singling out specific age groups and distinguishing males from females suggested that VIPs may be more effective for offenders of age 35 years or more than for offenders of other ages.

The idea of *removal of an offender's vehicle (or access to it)* as an alternative sanction has been around for some time, but has not been used to any great extent until fairly recently. Several variations on this basic theme have been studied.

DeYoung (1997b) evaluated the effect of two 1995 California laws which provided for the impoundment / forfeiture of vehicles driven by drivers with suspended or revoked licenses (S/R) and by unlicensed drivers[20]. Data used in the evaluation were obtained from police and court records in four jurisdictions (Riverside, San Diego, Stockton and Santa Barbara) that had record systems which would allow impoundment data to be linked to driver record data in the state DMV database.

The study compared the 1-year subsequent driving records of subjects whose vehicles were impounded with similar subjects (i.e., S/R and unlicensed drivers) who would have had their vehicles impounded, but who did not because their driving offense occurred in 1994, the year before the impoundment / forfeiture laws were implemented. Statistical controls were used to attempt to control potential biases resulting from pre-existing differences between the groups.

The study examined three measures of recidivism:

- subsequent convictions for driving while suspended or driving while unlicensed (DWS/DWU);
- subsequent total traffic convictions; and
- subsequent crashes.

The effect of impoundment on subsequent DWI convictions *per se* was not studied, although a DWI conviction would also trigger a license suspension or revocation. The results showed that repeat DWS/DWU offenders who were impounded had 34.2% fewer DWS/DWU convictions, 22.3% fewer traffic convictions and 37.6% fewer crashes, than did similar drivers whose vehicles were not impounded. By comparison, drivers with no prior convictions for DWS/DWU whose vehicles were impounded had, relative to similar drivers whose vehicles were *not* impounded, 23.8% fewer (DWS)/(DWU) convictions; 18.1% fewer traffic convictions and, and 24.7% fewer crashes.

DeYoung (2000) also examined the *general deterrent* effect of impoundment on suspended and revoked (S/R) drivers in California. His analysis involved a comparison of the crash rates of all drivers who were suspended or revoked between January 1992 and January 1997 to a 1% random sample of drivers not suspended or revoked during the same period. An interrupted time series design was used, the intervention occurring at January 1, 1995, when the impoundment law went into effect. DeYoung found that there was a statistically significant

[20] The study was also published as a NHTSA report: DeYoung, DJ. (1997). *An evaluation of the specific deterrent effect of vehicle impoundment on suspended, revoked and unlicensed drivers in California.* Washington, DC: National Highway Traffic Safety Administration.

reduction in crash rates for *both* groups when the groups were analyzed separately, but that there was no significant reduction for the S/R group (p=0.099) when the series for the non-S/R group was used as an input series. He concluded that the study "failed to find compelling evidence of a general deterrent impact of vehicle impoundment/forfeiture in California." Note that this study examined the effect of the impoundment law on drivers who been S/R for any reason, not necessarily DWI.

Voas, Tippetts, and Taylor evaluated the effects a variation on the impoundment theme, *temporary* vehicle impoundment and/or immobilization in two counties in Ohio. The period of immobilization provided by the Ohio law is 30 days for the first DWS offense, 60 days for the second and vehicle forfeiture for the third DWS offense. Second DWI offenders are subject to 90 days, and third DWI offenders to 180 days immobilization--and the vehicles of fourth offenders are subject to forfeiture. The law applies both to the vehicle owned by the offender and, if the offender was driving a vehicle owned by someone else, to that vehicle as well.

The first evaluation (Voas, Tippetts, and Taylor, 1997a) was in Franklin County, Ohio, which includes the city of Columbus. The recidivism of groups of drivers who had their vehicles impounded and/or immobilized were compared to groups of drivers who did not have their vehicles impounded and/or immobilized. Random assignment to the experimental group and the comparison group was not possible in the study. Of particular interest here was the DWI recidivism of DWI offenders. The analysis technique used to study the recidivism of these groups (Kaplan-Meier) did not control for differences between the two groups with respect to such variables as income and employment status.

The study found that during the period of impoundment and/or immobilization, 1.8% had committed another DWI offense by the end of their 90-days period of impoundment and/or immobilization. However, 3.8% of the DWI offenders with one prior DWI in the comparison group had committed another DWI offense after 90 days. This reduction (53%) was statistically significant at the .025 level. A similar effect was found for DWI offenders with two prior DWIs, with the comparable recidivism percentages for the two-priors group after 180 days being 2.4% and 6.6%, respectively, an effect (64%) that was significant only at the .094 level.

After the period of impoundment and/or immobilization, the effect size was much smaller and only significant for DWI offenders with one prior, 5.0% vs. 8.0%, an effect size of 38%.

The second study of vehicle impoundment in Ohio by Voas, Tippetts, and Taylor (1997b) was conducted in Hamilton County which kept the vehicles impounded throughout the applicable sanction period. The applicable sanction period for DWI varied by number of prior DUIs, being 90 days for offenders with one prior and 180 days for offenders with two prior offenses. The principal

objective of the Hamilton County study was to provide an independent replication of the results of the evaluation of the immobilization law in Franklin County.

The study found that impoundment decreased recidivism by large percentages both during the period of impoundment and after the period of impoundment. For repeat offenders with one prior DWI, the reduction in DWI offenses was 80% during the impoundment period and 56% after the impoundment period. For repeat offenders with two prior DWI offenses, the reductions during and after the impoundment period were 56% and 58%, respectively.

Rodgers (1994) evaluated a Minnesota law that provided for the impoundment of the license plate of DWI offenders with two prior DWIs in five years or three or more prior DWIs in ten years. The law took effect in August 1998, and required that such drivers surrender for destruction the license plates of all vehicles registered in their name. Further, the law stipulated that the violator could not sell any vehicle with impounded plates without permission from the Department of Public Safety. To protect innocent persons who depended on a vehicle from being deprived of a vehicle, the law allowed the violator to apply for a special license plate with a distinctive pattern of characters that can be recognized by police but not by the general public.

Initially, the license was to be surrendered in court, but less than 5% of the offenders who should have surrendered their plates were required to do so by the court. The law was subsequently changed to provide for the administrative impoundment and destruction of the plates by the arresting officer, and by the Department of Public Safety, if the officer did not perform the impoundment. In the first 21 months of the law, there were 6,993 violations to the law and 4,494 impoundment orders, a percentage of 64%.

The impact of the law as amended to provide for administrative impoundment is of particular interest here, since the court-based version was clearly not successful from a practical standpoint. Three groups were studied in the assessment, all of whom had violated the law during the 21 months from January 1991 through September 1992. The groups were composed of:

- 1,457 violators who received no impoundment order;
- 1,243 violators whose plates were impounded and destroyed by the arresting officer; and
- 1,893 violators who were ordered by mail by the Department of Public Safety to surrender their plates to a local law enforcement agency.

The analysis examined the recidivism of all three groups. The study found that violators whose licenses were impounded had much lower recidivism rates that did those whose plates were not impounded. The rates for violators with three recorded DWIs and with four recorded DWIs are shown in **Table 5-2**. The officer-impounded groups had the lowest rates. Three-time violators with officer-impounded plates had about half the rates than did violators with mail-order

impounded plates. However, for four-time violators, the rates of the two impounded groups were about the same, and still less than those of the non-impounded group.

Table 5-2: Recidivism Rates After 12 Months and 24 Months For Three Groups Studied by Rodgers (1994)

DWIs on Record	Months After Order	Group		
		Impounded by Mail Order	Impounded by Police Order	Not Impounded
3	12	11%	8%	16%
	24	19%	13%	26%
4	12	11%	10%	18%
	24	18%	17%	26%

Finally, we note a study of the effect of vehicle seizure by Crosby (1995) that may not be readily available to some readers. The study examined the recidivism of drivers sanctioned under Portland Oregon's forfeiture ordinance and found that "perpetrators whose vehicles were seized could reliably expect to be rearrested on average half as often as those whose vehicles were not."

Ignition interlocks that test a driver's BAC and prevent driving for those whose BAC exceeds a specified value have been evaluated in a number of jurisdictions. Coben and Larkin (1999) reviewed six of these evaluations published in the 1990 - 1997 time period, extracting the summary data shown in **Table 5-3**, below.

Table 5-3: Recidivism Effect of Six Evaluations of Ignition Interlocks (After Coben and Larkin, 1999)

Study	Outcome Measures	Relative Risk	Prevented Fraction	P Value
The EMT Group, 1990	DWI recidivism	.71	30%	>.05
Popkin et al., 1992	DWI recidivism	.38	64%	<.05
Morse and Elliott, 1992	Re-arrest for DWI	.33	69%	<.05
Jones, 1992	Re-arrest for DWI	.85	16%	.05
Weinrath, 1995	Impaired driving	.40	66%	<.05
Beck et al., 1997	Re-arrest for DWI	.36	65%	<.05

Cites are in Coben and Larkin, 1999

All six of the evaluations compared the recidivism of a group of repeat offenders who participated in an interlock program to a comparison group that did not participate in an interlock program. The "prevented fraction" column in the table indicates that the interlock participants had recidivism rates that were 16%-69% less than those of the participants in the comparison groups. Note that these figures were for the period during which the interlocks were attached. One of the studies (Popkin et al., 1992) also examined the recidivism rates after the interlock was removed, finding that the recidivism returned to higher levels after removal. Comparison group participants varied widely – they included a those receiving a conditional license (Popkin et al., 1992), those receiving a matched license suspension (Morse and Elliot, 1992), all other DWI offenders in the state (Jones, 1992), license-suspended impaired drivers (Weinrath, 1995), and those given "usual post-licensure treatment" (Beck et al., 1997).

Only the study by Beck and associates assigned its participants randomly to the interlock group and the comparison group. A total of 1,380 persons participated, and their recidivism was tracked for one year after their assignment to the interlock group or the comparison group. Subjects in the interlock group were required to drive an interlock-equipped vehicle for the entire one-year period. The study found that 2.4% of the interlock group had committed an alcohol traffic offense, compared to 6.7% of the comparison group.

Another study of the use of interlocks in Alberta, Canada, also found them effective for second offenders during the period in which they were required to be installed (Voas, Marques, Tippetts et al., 1999). The Alberta interlock program was introduced in 1990 as a required program for repeat offenders, but, according to the paper, was changed in 1994 to a voluntary program for first offenders. In this study, only about seven percent of repeat offenders eligible chose to participate. In addition, all participants (and all comparison group members who did not participate in the interlock program) were required to have their license suspended prior to entry into the interlock program, with the length of the suspension for the participating second offenders having a mode of two years. Persons assigned to the interlock group were free to drive without restriction during the interlock period, 6 to 12 months for first offenders and 12 to 24 months for second and third offenders. Persons assigned to the comparison group remained fully suspended during the interlock period. After the interlock period, the licenses of the interlock group were reinstated, and the licenses of the comparison group were either reinstated or remained suspended.

The Alberta study used survival analysis techniques to compare the recidivism of the interlock participants with that of the non-participants, finding that during the program period, the recidivism of the interlock group was less than 1% after one year, and the recidivism of the suspended comparisons was about 4%. However, during the period that the interlocks were removed, the recidivism of the participants was about 4% after one year, and the recidivism of the still-

suspended comparison group was about 3%. Also, during the removal period the recidivism of the *reinstated* comparison group was about 5%.

It has also been suggested that, rather than impound or confiscate a convicted DWI's vehicle, one might "confiscate" the driver's vehicle registration. Two states, Oregon and Washington, enacted legislation in 1990 and 1988, respectively, establishing a procedure by which law enforcement officers, upon apprehending a driver whose driver's license has been suspended (for DWI or other applicable offense), could take possession of the driver's vehicle registration. In such cases, the driver was given a temporary registration certificate, and a striped ("Zebra") tag was placed over the annual sticker on the vehicle license plate. Officers were allowed to stop a vehicle with such a tag without additional probable cause, thus providing a means for interdicting offenders who continue to drive after suspension. A new annual sticker could only be obtained by the owner demonstrating that he or she was properly licensed. The Oregon law and the Washington law differed mainly in that the latter applied only to suspended or revoked drivers who own the vehicles they are operating, while the former law applied to all suspended or revoked drivers, regardless of whether the driver owned the vehicle.

The specific and general deterrence effects of this "Zebra" Tag Law for DWIs in general (first offenders and repeat offenders alike) and the general deterrence effects for persons not yet arrested were evaluated by Voas and Tippetts (1995), who found a general deterrent effect in Oregon (on moving violations and crashes) but none in Washington. Available data did not permit an evaluation of the effect of the law on recidivism in Washington, but the Oregon data indicated a reduction of more than 50% in mean number of subsequent DWIs. The effect of the laws on *repeat* offenders was not determined, but the results suggest that the effect of such a tag would not be limited just to first offenders.

Comprehensive Countermeasures. Evaluations of two early comprehensive programs employing multiple Traffic Law System countermeasures, the British Road Safety Act of 1967, and NHTSA's Alcohol Safety Actions Projects (ASAP), were discussed at length in the 1978 update. Because of their significance to the field, these two programs are revisited briefly here.

The program known as the British Road Safety Act of 1967 was actually much more that just a legislative change. The act limited BAC to .08% and prescribed a mandatory punishment of a one-year license suspension and a fine of £100, or imprisonment for up to four months, or both (Ross 1973). The Act also authorized a preliminary breath test when an officer had "reasonable cause" to suspect that a driver had alcohol in his or her body or had committed a traffic violation, or in the event of a crash. Refusal to take the test was penalized by a fine of £50, and if the test after a given stop were refused a second time, the driver was punishable as though the sample had been given and the test failed (Jones and Joscelyn,

1978). The Act made extensive use of a public information campaign to support law enforcement by increasing the perception of apprehension for drunk driving.

The number of tests per month (in Great Britain) went from the neighborhood of 3,000 in 1967 to around 7,000 or 8,000 by early 1971. In all of 1970, approximately 70,000 breath tests were given in Britain. In the three years following the implementation of the Act, conviction rates averaged more than 90%, compared to 80% before the Act.

In one of the better known post hoc evaluations of its time, Ross analyzed the effect of the Act. He used the technique of the interrupted time series analysis (see page 99), and determined that the Act was effective for a period of three years in decreasing the rate of accident casualties. A later analysis of the Act (Department of the Environment 1976) found indications that the effects of the Act may have been more lasting among drivers in the 40-60 age group and that they wore off most rapidly among those in the under-30 age group. Ross also found evidence that the public engaged in less drinking and driving after the Act. A pre- and post-survey of adults found that more people said they walked to drinking sites and fewer admitted to drinking and driving. In addition, among traffic fatalities, there was a smaller percentage who had illegally high BACs.

Ross attributed the effectiveness of the 1967 Act primarily to the public education campaign which led drivers to believe that the chances of their being apprehended when drinking and driving were great. He concluded that after the driving public learned that there was little increased enforcement of drinking-driving laws, they adjusted their estimate of the chances of apprehension accordingly. Consequently, the effectiveness of the Act decreased (Ross 1973).

NHTSA's Alcohol Safety Action Projects (ASAP) was by far the most ambitious and comprehensive of any alcohol-crash countermeasure program ever conducted. It attempted to apply the principles and some of the methods of the systems sciences used so successfully in the aerospace field to the alcohol-crash problem. It began in 1969 when the National Highway Safety Bureau (later the National Highway Traffic Safety Administration) announced a nationwide ASAP program and established an Office of Alcohol Countermeasures to manage it. The program provided financial assistance to and coordinated the efforts of, initially, nine and, ultimately 35, individual ASAPs around the country.

ASAP was heavily oriented toward the problem drinking-driver who, it claimed, was responsible for two-thirds of the alcohol-involved traffic fatalities in the U.S. and 34% of all traffic fatalities. They believed it useful to distinguish between problem drinkers who must drastically change a behavior over which they have little or no control, and social drinkers who need to make only a relatively minor change in their behavior. ASAP also placed emphasis on drinking drivers who drive at night and on weekends. This policy was implemented at most ASAP sites by fielding more police units (e.g., an enforcement task force) during the hours between 6 p.m. and 4 a.m.

Individual ASAP projects were conducted at the local level, emphasizing improved law enforcement, traffic court procedures, public information, and special efforts to counsel and assist drivers. The local activities were complemented by state-level efforts in driver licensing, motor vehicle registration, traffic records and legislation. The first group of nine ASAPs began operation in 1971. Twenty-six additional ASAPs initiated operations in 1972. The locations were widely distributed around the U.S. and included one site in Puerto Rico.

ASAP used a combination of the legal, health, public information and education, and technological approaches in its attack on the alcohol-crash problem. Eventually, five separate categories of countermeasure activities evolved (U.S. Department of Transportation 1975a):

- Enforcement;
- Judicial and Legislative;
- Pre-sentence Investigation and Probation;
- Rehabilitation; and
- Public Information and Education.

Very large increases in activity occurred in all of these categories. The increases in activity were not, however, reflected in proportionate decreases in night fatal crashes. On the average, night fatal crashes per 100,000 licensed drivers per year decreased from 12.9 to 12.5, or about 3%. However, NHTSA analysts found no correlation between activity and impact. Further analyses of night fatal crashes using the interrupted time series analysis indicated a statistically significant reduction in such crashes for sites with two years operational experience but no significant reduction for sites with only one year of operation. By contrast, the overall trends of night fatal crashes in the reporting states were said to be upward rather than downward.

This first ASAP evaluation of operations lacked control groups as a basis for comparison of the outcomes experienced at the ASAP sites. Zador (1976) attempted to correct this deficiency "by comparing year-to-year variations in fatality statistics between groups of areas with ASAPs and comparison groups of areas without ASAPs." He concluded the ASAP countermeasures could not have been responsible for the observed reductions in the ratio of night fatal crashes to day fatal crashes, and that "ASAPs, as large-scale social programs, have been ineffective". After a subsequent analysis of crash data, NHTSA (Johnson, Levy, and Voas, 1976) expressed a disagreement with Zador's conclusions, prompting another response by Zador (1977) repudiating NHTSA's criticisms.

The 1991 review examined evaluations of several comprehensive programs conducted since the 1978 update, noting mixed results regarding their impact on alcohol-related crashes. Three evaluations found a positive effects, while four others found no effect. However, as with NHTSA's ASAP evaluations, none of the evaluations of statewide programs used other states as a control.

Roger and Schoenig (1994) evaluated the impact of California's 1982 legislative reforms, including enhanced penalties, greater sentencing uniformity, and the introduction of an illegal per se standard. Interrupted time series analysis was used to evaluate the general deterrent effects of these laws, as measured by alcohol-related fatal and injury accident rates, both statewide and in counties sharing similar demographic and enforcement patterns. The formation of Mothers Against Drunk Driving (MADD) as well as the legislation changes were used as intervention variables, and measures of daytime crashes were used as controls. Both interventions were statistically significant, with the legislation associated with an 8% reduction in nighttime injury crashes, and the MADD intervention with a reduction of about the same size. The effect of the legislation extended for five years beyond the implementation of the legislation.

Neustrom and Norton (1993) used a similar time-series analysis to measure the impact of tougher, deterrence-based drunk driving legislation in Louisiana. The study found a statistically-significant 20% reduction in nighttime fatal and injury accidents that lasted 36 months after the new law was implemented. A smaller (5%) reduction was found in daytime fatal and injury accidents, suggesting a positive effect of the new law on drinking-driving.

Recently, Lacey and Jones (2000) evaluated New Mexico's omnibus anti-DWI legislation which was introduced in the later half of 1993 and the beginning of 1994. New Mexico further initiated an extensive statewide DWI checkpoint initiative in December 1993.

The legislation contained provisions for:

- lowering the BAC per se and presumptive limits for adults from .10 to .08;
- lowering of the BAC per se and presumptive limits for persons under 21 from .05 to .02 ("Zero Tolerance" legislation);
- a general increase in the severity of the sentencing guidelines for DWI;
- creation of a new offense of aggravated DWI;
- an increase in the penalties for driving while licensed revoked for DWI;
- a $25 fee to request a hearing disputing an implied consent offense administrative revocation;
- making the Metropolitan Court in Albuquerque a court of record for DWI cases;
- not requiring statements from sworn police officer revoking licenses of implied consent offenders to be notarized;
- increases on taxes for all forms of alcoholic beverages;
- an increase of special dispenser permit fees (special permits for parties and special events);
- increased fines and penalties for service to minors;
- requiring alcohol server education;
- creating a local DWI grant fund;
- creating a DWI program fund; and

- requiring DWI education before receiving driver licenses.

Though the specific effect of each individual component on alcohol-related crashes could not be discerned because of multiple, simultaneous interventions, time series analyses indicated an overall reduction on the order of 19% in drunk driving fatal crashes (a crash where one or more of the involved drivers had a BAC of .10 or more) when the period December 1993 through 1995 is compared with January 1988 through November 1993. Crash trends in five neighboring states were examined as a comparison and no such reduction was observed.

Several researchers have continued to explore the concept of community-based countermeasure programs to prevent alcohol-related injuries in general. These programs are hybrid in nature, employing other risk management systems in addition to the Traffic Law System. Holder and associates (2000) recently completed a five-year community trials program in three experimental communities (two in California and one in South Carolina). The project included a component devoted explicitly to drinking and driving, concentrating on the TLS functions of enforcement and public information and education. This involved training local project coordinators and others in "media advocacy," and assisting local law enforcement staff in obtaining funds to bolster DWI enforcement and in designing an improved enforcement program.

The drinking and driving component was evaluated by Voas, Holder, and Gruenewald (1997). The evaluation took particular care to relate project activity to project impact through a chain of intermediate variables, using statistical techniques to do so (see page 100 of this report). This, along with the use of matched comparison communities, helped insure that any positive impact was due to the drinking and driving component, and not to some other factor.

From their report, it appears that the project resulted in substantial increases in the use of breath-alcohol testing devices, enforcement-related news coverage, and the use (monthly) of sobriety checkpoints. The impact evaluation indicated a positive effect on nighttime single-vehicle crashes in the California sites, but none in the South Carolina site. The report estimated a reduction in the number of nighttime single-vehicle crashes in the two California sites of approximately 50 to 80 over the two-year operational period, or (from the report's Figure 1) about 12% to 20% of all such crashes in that period. An analysis of the contributions of the individual variables indicated that only the breath-alcohol testing devices and the enforcement-related news coverage contributed to this positive effect.

A recent paper by Holder, Gruenewald, Ponicki et al. (2000) summarized the results of an evaluation of the complete five-year program (1992-1996), including the four non-drinking and driving components (that is, community mobilization, responsible beverage service, underage drinking preventions, and alcohol access reduction). In this evaluation, nighttime injury crashes and so-called DUI crashes (crashes in which a citation was issued for DUI) were used as measures of alcohol-crash impact. The evaluation indicated a 10% relative decrease in number

of nighttime injury crashes per month, and a 6% relative decrease in the number of DUI crashes per month. Note that these decreases were *relative* to the rates in the comparison communities. In addition, analyses of data from hospital emergency departments indicated that violent assaults also declined during the program period.

Wagenaar and associates (2000) also conducted a community-based intervention in the mid-1990s, but the program had a more specific objective for a more restricted target group, that is, to reduce the accessibility of alcoholic beverages to youths under the legal drinking age. The program, called Communities Mobilizing for Change on Alcohol (CMCA), was a randomized 15-community trial of a community-organizing intervention designed to reduce the accessibility of alcoholic beverages to youths under the legal drinking age. The communities were located in Minnesota and Wisconsin, seven of which were assigned to the program and the remainder to a control group (Wagenaar, Gehan, Jones-Webb et al., 1999). The 15 participating districts were matched on state, presence of a residential college or university, population size, and on the results of the baseline alcohol purchase survey. The average population of the study communities was 20,836 (range 8,029 to 64,797). Communities that were already addressing the issue of underage drinking, or were participating in other major funded efforts, were eliminated from the pool of communities considered for CMCA. The authors found that, not only were the selected communities not necessarily "ready" for the program, but many were resistant to defining youth drinking as a serious problem in their community.

The program used a community organizing approach involving part-time community organizers over a 2½ year period to accomplish changes in the policies and practices of pertinent local institutions, for example, increased patrol time by enforcement agencies and increased media coverage of alcohol-related issues. Specific interventions varied among the seven test communities. Two communities prepared a report form for merchants to record (and report to police) underage buy attempts. Another community worked with a local legislator to draft state legislation to repeal a law exempting alcohol licensees from punishment for serving underage drinkers. Several communities restricted alcohol availability at major community events, such as university homecomings. Other interventions included:

- regular police compliance checks of alcohol outlets to reduce underage purchasing;
- discouraging underage drinking parties at motels;
- reinstating security at high school dances following reports of easy access to alcohol;
- distributing fliers to graduating seniors and their parents discussing summertime drinking and drinking at prom and graduation;
- producing videos about alcohol use by underage drinkers; and

- developing and distributing model local ordinances that restricted underage access to alcohol.

Activities focusing on community awareness included:

- developing fliers for local outlets warning customers of the legal consequences of purchasing alcohol for youth; and
- writing periodic columns for local newspapers.

The results of an evaluation of the effect of the CMAC program on alcohol-related crashes are described by Wagenaar, Murray, and Toomey (2000). The authors collected annual arrest and quarterly traffic crash data for the year 1987-1995, providing a 6-year baseline and 3 years of data during the intervention. Data were stratified into two target age groups (16-17 and 18-20) and a control group (age 21 and over). The authors observed net declines in the intervention communities for all arrest and traffic crash indicators. The decline was statistically significant for driving under the influence (DUI) arrests among 18-20-year-olds and approached significance for DUI arrests and disorderly conduct violations among 15-17-year-olds. However, the decline in alcohol-related crash surrogates was not significant, possibly because (as the authors noted) of the small numbers of such crashes involving the target group.

Provide Alternatives to Drinking-Driving

Ride service programs (RSPs) have been used for many years to provide alternative transportation for alcohol-impaired persons. Programs vary from those that are organized in conjunction with a major holiday associated with drinking (e.g., New Year's Eve) to programs that operate on a year-around basis. Harding, Apsler, and Goldfein (1988) examined the literature on such programs and identified 325 that had been operating in the U.S. They found that most ride service programs (two-thirds) used taxis to provide the transportation, but that other types of vehicles were also used, including privately owned vehicles (often used in programs run by or for students), tow trucks, buses, vans and even police cars. Some dispatched two drivers, one to provide the ride home and the other to transport the drinker's vehicle. Harding and associates concluded that ride service programs were widespread and relatively easy to set up and operate, but that "Rigorous (impact) evaluations of RSPs were virtually non-existent" and that, for program operators, "the fact that they are delivering rides (even a small number of rides) is evidence enough for them that the program is working" (p. 56).

Molof, Dresser, Ungerleider et al. (1995) examined the effectiveness of two types of RSPs, those that operate on a year-round basis, and those that operate sporadically during perceived high-risk periods. They studied both a year around

program in Syracuse, New York and a holiday program that operated between December 25 and January 1 in Minneapolis and St. Paul, Minnesota. They found that, while these programs functioned quite smoothly and there was good awareness of the programs in both service areas, the study did not detect an effect on alcohol-related crashes from either program.

A recent evaluation of an alternative ride program in Aspen, Colorado had a different result, providing evidence that year-around RSPs can, under the right conditions, have a positive effects on alcohol-related crashes (Lacey, Jones, and Anderson, 2000). The program (named *Tipsy Taxi*) is administered through the Pitkin County Sheriff's Office as a crime prevention program with assistance from Aspen and Snowmass, Colorado Police Departments and the local restaurant association. The program is designed to be easy for an alcohol-impaired person to use for a free ride home instead of driving.

A *Tipsy Taxi* ride can be initiated in several ways. Most often, a *Tipsy Taxi* ride is offered by a bar employee or peace officer who identifies a person as needing help. However, a ride can be requested by a bar patron from his or her bartender. A host of a private party can call the police or sheriff for a voucher for a guest who has over-indulged. In this case, the responding officer congratulates the host for caring for his or her guests and arranges the safe *Tipsy Taxi* ride home.

Once an individual has been identified as a *Tipsy Taxi* client, the bartender or peace officer responsible for arranging for the ride follows a few simple guidelines designed to create a safe atmosphere for the rider and to minimize liability to the Sheriff's Office and the director.

The program operates 24-hours a day, 365 days a year. Funding has come from regular fund-raising events, mailed solicitations, grants, alcohol license fees, fees for DUI offenders, and the like.

In addition to occasional publicity events, on-going public information efforts have included advertisements in the local newspaper, radio public service ads (in English and Spanish), flyers distributed in rental cars, and hard news coverage about the program.

Interrupted time-series analyses of crash data indicated that injury crashes decreased by 15% in Pitkin County after the implementation of *Tipsy Taxi* ($p=0.020$), and that there was no reduction of injury crashes in the comparison counties. Nighttime and fatal crashes also declined coincident with the implementation of the *Tipsy Taxi* program, but the declines were not statistically significant.

Designated drivers provide another alternative to drinking-driving, and have been widely promoted in public information campaigns. An interesting discussion of the concept and some impediments to its effective use is provided in a recent NHTSA report (Lange, Baker, and Johnson, 2000). We found no evaluations of the traffic safety impact of the concept, but Caudill, Harding, and Moore (2001) studied the characteristics of designated driver users obtained from 1,391 Computer-Assisted Telephone Interviews (CATIs) and from 902 barroom patron

surveys. Their analyses showed that designated driver users, compared to non-users, tended to be at-risk, heavier drinkers. For example, logistic regression using the CATI sample indicated that designated driver users were more likely to drink more often outside the home, to achieve higher BACs when drinking outside the home, to ride with intoxicated drivers, and to be heavy drinkers. Analyses using the barroom sample showed that designated driver users tended to be heavy drinkers, and were more likely to drive after drinking and to ride with intoxicated drivers. Additional analyses showed that designated driver users also were more likely than non-users to engage in other behaviors to avoid DWI, including drinking less, waiting to drive until the effects of alcohol diminish, walking home, and staying overnight.

Educate Drivers and Potential Drivers

Most of the evaluative literature in this area deals with school-based educational programs designed to acquaint students with the seriousness of the alcohol-crash problem and ways of avoiding one's own, or others, involvement in such crashes, either as a driver or a passenger. Often, the curricula are a part of a broader course in alcohol education. As observed by Shope and associates (1992), such programs have been concerned primarily with information dissemination and attitudinal change rather than ways of modifying behavior. These researchers cite reviews concluding that programs stressing information dissemination and attitudinal changes were ineffective and lacking in appropriate evaluation techniques. They report the results of an evaluation of an alcohol misuse prevention study (AMPS) curriculum for fifth- and sixth-grade involving over 5,000 students in Michigan.

The program provided training in the immediate effects of alcohol, the risks of alcohol misuse, and social pressures to misuse alcohol. The students were then taught how to deal with these pressures. Sessions were conducted over two years. In the first year, there were four sessions, four weeks apart; while in the second year, there were three "booster" sessions, also one week apart.

The evaluation of AMPS used random assignment of 49 schools in southeastern Michigan to curriculum, curriculum-plus-booster or control groups, with half of each group pretested and all post-tested. Measures focused on susceptibility to peer pressure, internal health locus of control, understanding of the curriculum material, alcohol use and alcohol misuse. Self-reported data were used in the evaluation, but considerable care was taken to acquire valid self-reports. It was found that, after 26 months, there were significant positive effects with respect to knowledge and attitudes, but none with respect to alcohol use and misuse for the treatment group *as a whole*. However, there were positive effects on alcohol use and misuse among sixth grade students who had prior unsupervised use of alcohol.

Newman, Anderson, and Farrell (1992) also reported promising behavioral effects of an educational program targeted at ninth graders, and more recently, Shope and associates (1996) implemented and evaluated a program for high school students. The Shope paper is of especial interest here, since it contains specific material on drinking-driving. The program it addresses is an alcohol misuse prevention curriculum for tenth-grade students that was developed, implemented, and evaluated through twelfth grade with 1,041 students from four school districts in southeastern Michigan. The students had participated in the prior AMPS program for elementary school students described above. As with the prior program, the curriculum emphasized social pressures resistance training, immediate effects of alcohol, risks of alcohol misuse, and social pressures to misuse alcohol. The curriculum involved five sessions of 45 minutes each.

The evaluation used self-reported data obtained from surveys of the students. Measures of knowledge, alcohol refusal skills, alcohol use and alcohol misuse were obtained. The study found significant positive program effects on alcohol misuse prevention knowledge ($p < 0.001$), alcohol misuse ($p < 0.02$), and refusal skills ($p < 0.09$). Gender differences over time were found on alcohol use, alcohol misuse, and driving after drinking, with boys' rates increasing more than those of girls. The authors concluded that, despite high levels of alcohol use among high school students, a tenth-grade curriculum can result in some desirable effects, cautioning that "creative approaches are needed, however, especially for boys who tend to use and misuse alcohol at rates that increase more steeply than those of girls." Interestingly, exposure to the sixth-grade program, as well as the tenth-grade program, did not result in better outcomes

In a study published just prior to the publication of his report, Shope, Elliott, Raghunathan, et al. (2001) examined the effects on subsequent driving of the AMPS 10th grade program. The study reported the findings of a randomized test of the effectiveness of program among 4,635 10th-grade students, 1,820 of whom were assigned to the intervention group and 2,815 to the control group. Both groups were followed for an average of 7.6 years after licensure, which typically occurred during or shortly after the 10th grade. Outcomes examined included alcohol-related and other serious offenses, and at-fault, single-vehicle, and alcohol-related crashes. The authors found that only serious offenses (which included alcohol-related offenses) had a significant treatment effect (statistically marginal) after adjustment for sex, age, race, alcohol use/misuse, family structure, presence of prelicense offenses, age of driver licensure, and parental attitudes toward teen drinking. The effect was found only during the first year of licensure. Also, two first-year serious offense interactions were found. The positive effect was strongest among the largest subgroup of students, those who were drinking less than one drink per week on average before the curriculum, compared with those who drank more than one drink per week ($p = 0.009$). The effect was also stronger for the small subgroup of students whose parents had not expressed disapproval of teens' drinking, compared with those whose parents had disap-

proved ($p = 0.004$). The authors concluded that their findings suggested that a high school-based alcohol prevention program can positively affect subsequent driving, particularly that of students who do not use alcohol regularly.

COUNTERMEASURES TO PREVENT EXCESSIVE DRINKING BEFORE DRIVING

The 1991 review of impact evaluations of alcohol-crash countermeasures (Jones and Lacey, 1991a) found that nearly all such evaluations in this category dealt with countermeasures aimed at regulating the availability of alcohol, observing that, among these, "the evaluations of countermeasures that raised the legal minimum drinking age (LMDA) include many that are among the best in the highway safety field." The review clearly showed that controlling the availability of alcohol by raising the LMDA reduced alcohol-related fatal crashes among the affected age group on the order of 9% to 14%.

The 1991 review found that other attempts at controlling the availability of alcohol had rarely been evaluated to determine their traffic safety effect. Such countermeasures included restricting the sales of alcohol (for example, banning happy hours, and having self-testers in bars for determining blood alcohol concentration) and placing increased taxes on alcoholic beverages. The few evaluations of countermeasures in the former group found that none of them had any significant highway safety impact, either directly or indirectly. The evaluations of the latter group were plagued by methodological difficulties, but did suggest that raising the cost of beverage alcohol through increased taxes may have potential.

This review indicates that, since 1991, there have been very few evaluations of programs aimed at preventing excessive drinking prior to driving, and that the programs evaluated have pursued this objective by controlling the availability of alcohol. Toomey and Wagenaar (1999) discuss a range of policy options for preventing alcohol-related problems, including alcohol-related crashes.

One strategy explored during the 1980s was training servers of alcoholic beverages to be more responsible in their serving practices. Two small-scale programs had obtained positive results, encouraging NHTSA to sponsor a larger scale study in two states. The program, which requires three hours on the part of servers and six hours on the part of managers, dealt with the need for responsible alcohol service, preventing intoxication, identifying signs of intoxication, and preventing driving by intoxicated patrons (McKnight, 1987).

The program was field-tested on 245 servers and managers in Louisiana and Michigan. It produced significant improvement in knowledge, attitudes, and self-reported serving practices at both sites. Improvement in reported policy, as well as increases in observed intervention in patron drinking, occurred only in Michigan. However, the impact of the program on alcohol-related crashes was not determined. The program was later expanded to include 876 servers and 203 managers in eight states, with positive results reported in five of the states (Mc-

Knight, 1991). Again, the study did not attempt to measure the alcohol-crash impact of the program.

However, Holder and Wagenaar (1994) evaluated the alcohol-crash impact of an Oregon law (effective January 2, 1987) requiring all new applicants for beverage service permits to successfully complete a state-approved server-training course. The bill also required that all persons holding existing alcohol retail licenses or applying for new licenses must complete a management training program. An amendment required existing server permit holders to complete training only on the five-year anniversary when their permit expired. Approximately 20% of existing permit holders in Oregon were trained each year, with all servers trained by the end of 1991.

Classes in server education were conducted by 20 state-certified providers. The one-day training course covered seven areas:

- the effects of alcohol on the body;
- interaction effects of alcohol with other drugs, both prescription and illicit;
- problem drinking and alcoholism;
- State of Oregon alcohol service laws;
- drinking and driving laws in Oregon as well as legal liability issues;
- effective server intervention techniques including how to intervene with a customer who is drinking too much or shows signs of intoxication; and
- alcohol marketing practices for responsible alcohol service.

Students paid $20 tuition and $13 for program administration. A standardized written test had to be passed by all students with a score of at least a 70%.

Approximately 36,000 servers and 6,000 owners / managers of establishments licensed to sell alcohol completed the course by the end of December 1988, and by 1994, approximately 13,000 new servers and existing licensed servers seeking their renewal were completing the required training each year.

The evaluation of the Oregon server training program used an interrupted time-series design in which the effect of the intervention on nighttime single-vehicle crashes was analyzed. Two other confounding interventions occurring during the program period, reducing the legal BAC limit to .08 and the passage of new DWI legislation, were accounted for in the analyses, and nighttime single-vehicle fatal crashes in the other 47 continental states were used as an explanatory series. The analysis found that, by the end of the third year of the program, nighttime single-vehicle crashes had been reduced by 23% ($t = -2.40$).

The server training programs had been stimulated, in part, by the notion that legal liability of alcoholic beverage servers for damages resulting from patrons being served too much alcohol would help promote more responsible serving practices and thus reduce alcohol-related crashes. In an evaluation design similar to the design of the evaluation of server training described above, Wagenaar and Holder (1991) assessed the alcohol-crash impact of the filing of two highly-publicized server liability cases in Texas. The evaluation found a 6.5% reduction

in nighttime single-vehicle crashes after the first case (1983) and a 5.3% reduction after the second case (1984).

The nature of server exposure to legal liability nationwide was examined by Holder and associates (1992). The study developed a conceptual model linking pertinent variables, and an expert legal panel was used to identify and rate the major legal factors contributing to server liability. As a result, each state was ranked according to its relative level of liability exposure. States that ranked highest in server liability were found to have more publicity about such liability, greater awareness and higher concern among licensed establishment owners / managers and different serving practices compared to states with lowest liability exposure. As a result, the authors concluded that server liability had a real potential for reducing alcohol-involved problems.

Our literature search failed to find any pertinent recent evaluative research on server liability or stand-alone programs promoting responsible beverage service. However, the community trials programs discussed in the prior section included components with such objectives. The five-year community trials program reported by Voas and associates (1997) and Holder and associates (2000), had a responsible beverage service component, described in detail by Saltz and Stranghetta (1997), as did the youth-oriented program (Communities Mobilizing for Change on Alcohol) evaluated by Wagenaar and associates (2000). The evaluations of both programs indicated positive results overall in reducing alcohol-related crashes, but could not determine the effects of individual non-TLS components such as responsible beverage service.

The use of behavioral tests for use by social hosts has been suggested to help avoiding over-serving of guests at social gatherings. Streff and Kalsher (1990) explored the efficacy of four sobriety tests for use by individuals with little training (one-leg stand, horizontal gaze nystagmus, backward counting, and ruler drop). The tests predicted BAC with statistically significant accuracy, but prediction accuracy varied. Inter-observer reliability was high for each except the nystagmus test. The ruler drop was found to affect self-reported driving decisions most. We found no studies of the effects of such tests on crashes.

The use of self-testing devices for determining one's own BAC has been studied extensively in Australia. Research by Haworth, Bowland, and associates (Haworth and Bowland, 1995; Haworth, Bowland, Vulcan et al., 1997) has demonstrated potential benefits in Australia, but an early evaluation of such devices in the U.S. found that study participants were no more likely to avoid driving under the influence of alcohol than were individuals not exposed to the breath test (Oates, 1976). Further, there was no evidence that participants in the U.S. study moderated their drinking on subsequent occasions. (It has been suggested that placing such devices in bars could result in BAC "contests" to see who could reach the highest BAC.)

The concept known as "Cops in Shops" for restricting alcohol availability for under-21 youth has been incorporated into several countermeasures programs in recent years. Cops in Shops is a program where officers in civilian clothes are

stationed in retail outlets. If they observe underage persons attempting to purchase beverage alcohol, they issue appropriate citations. The most recent reported evaluation of this countermeasure is of a youth-alcohol program in Salt Lake City, Utah (Lacey, Wiliszowski , and Jones, In Press). Cops in Shops was a major component of the Salt Lake City program, which also included working with Peer Leadership Teams engaged in such activities as graduation, ribbon week, December anti-drunk driving month activities, and Teen Courts for "adjudicating" drinking violations. A time series evaluation of the program suggested a possible positive impact gradually increasing to a 14% reduction in youth nighttime crashes after three years.

Some new studies of the effect of alcoholic beverage taxes on traffic crashes have appeared since the last state of knowledge update. Ruhm (1996) performed another econometric analysis, examining the impact of beer taxes (and other alcohol-control policies) on total fatality rates of 18 to 20 year olds per capita and per mile driven, and on per capita death rates of the same age group, from nighttime fatal crashes occurring during 1982 to 1988. The alcohol-related policies included minimum legal drinking age for purchases of beer with an alcohol content greater than 3.2%; preliminary breath test laws; dram shop laws; administrative per se laws; implied consent laws; and mandatory jail or community service for the first DUI conviction. Macroeconomic conditions in the states, local efforts, and enactment of other legislation related to highway fatalities were controlled for. Ruhm concluded that most of the laws have had little or no impact on traffic mortality, with increasing the minimum legal drinking age having only an initial significant impact. On the other hand, the author found that raising beer taxes "was associated with consistently robust reductions in highway vehicle fatalities," and concluded that "further legislative activity related to DUIs is unlikely to produce further declines in traffic fatalities, while preferred estimates indicate that raising alcohol tax rates would continue to have significant effects on drinking and driving and traffic fatalities."

Some of these findings are at odds with many other careful evaluations of alcohol-crash countermeasures, for example, the finding with respect to the minimum legal drinking age. This causes serious concerns about the validity of the conclusions on beer taxes. Dee (1999) questioned the effect of beer taxes on traffic crashes after finding an implausible reduction in daytime crashes (which are much less likely to be alcohol-related than nighttime crashes) with increasing taxes.

Manning, Blumberg, and Moulton (1995) examined the sensitivity of alcohol consumption to price (as might be affected by taxes) among light or moderate drinkers. The study used data on alcohol consumption on the 1983 National Health Interview Survey and found that both light and heavy drinkers are much less price elastic than moderate drinkers. The authors concluded that "we cannot reject the hypothesis that the very heaviest drinkers have perfectly price inelastic demands."

Mast, Benson, and Rasmussen (1999) expressed surprise that many studies of alcohol-related traffic fatalities find beer taxes to be an important policy variable, "since beer taxes only have a small impact on consumption and heavy drinkers are the least responsive to prices." The authors found that the tax relationship is not robust across data periods and that it reflects missing-variable biases. They concluded that failure to include determinants of alcohol consumption other than taxes and drinking age, and / or factors that simultaneously determine drinking behavior and political support for alcohol taxes, bias coefficients in the regression equations.

Thus, despite the emergence of some new literature on the subject, the effect of taxes on alcohol-related crashes remains uncertain, with the need for further research clearly indicated.

The Tenth Special Report to the U. S. Congress on Alcohol and Health provides an extensive discussion of restrictions on advertising as a means for reducing alcohol consumption and alcohol-related problems. In general, the discussion indicates little consistent support for any relationship between advertising and consumption or alcohol-related problems, although a recent study by Saffer (1997) concludes that a ban on broadcast alcohol advertising and eliminating the tax deductibility of alcohol advertising could have a positive effect of traffic crashes. This study differs from other econometric studies of on the subject study in that it considers the market-specific price of advertising and uses metropolitan-level data rather than aggregated national data. Again, more research is needed to establish any basis for a national policy for more restrictions on advertising as a traffic-crash countermeasure.

COUNTERMEASURES TO PREVENT CRASHES WHILE DRINKING-DRIVING

Countermeasures of this type have rarely been implemented in the U.S., and are seldom even discussed in the literature. One such countermeasure would address the impairment of some modalities of vision 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. (See Chapter 4.) 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 edge more visible could reduce the number of run-off-the-road crashes by alcohol-impaired drivers. The 1989 update cited research indicating 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. Another approach to prevent "ran off road" crashes is the use of grooved "rumble strips"at the edge of the road, estimated by the U.S. Federal Highway Administration to reduce the incidence of such crashes by up to

70%. Again, no new research was found on the effect of edge warning techniques on alcohol-related crashes.

Drunk Driving Warning Systems (DDWS) have been proposed for alerting drivers and pedestrians of a nearby vehicle driven by an alcohol-impaired driver. If a person in a DDWS-equipped vehicle does not take a critical tracking test (CTT) for alcohol impairment (or fails the test), emergency flashers are triggered, and if the car is driven above a certain speed, the horn honks intermittently. DDWSs have been tested in the U.S. (Snyder, 1984) and Australia (Bodi, O'Connor, and King, 1986), but have not been used operationally and evaluated with respect to their traffic safety impact. The last version tested in the U.S. had a CTT display unit and an electronics module in the trunk that scored test performance, activated the alarm as required, and recorded data (test scores, ignition on, alarms activated, etc.) Tampering countermeasures were included. Snyder concluded that DDWS use is feasible as a sanction or condition of probation, and that people are unlikely to drive a vehicle when its DDWS alarms are activated.

COUNTERMEASURES FOR ALCOHOL-RELATED PEDESTRIAN AND BICYCLIST CRASHES

The sparseness of literature on this subject has been noted in prior updates. The 1989 update did not discuss pedestrian countermeasures at all because of a lack of published literature in this area. It cited a 1989 report of a conference session on alcohol-impaired pedestrians, during which experts in the field were unable to cite any new work in this area.

In our review of the more recent literature on the subject for this update, we found only a single U.S. study documenting the design, implementation, and evaluation of a pedestrian countermeasure program (Blomberg and Cleven, 2000), and no studies at all on bicycle countermeasure programs.

The study by Blomberg and Cleven was well-designed and thorough. It dealt with a program instituted in Baltimore, Maryland in 1995. The program used *Walk Smart Baltimore* as its slogan, and included an extensive public information and education (PI&E) campaign. Retroreflective caps were distributed to persons at risk in zones with large numbers of nighttime pedestrian crashes. Several improvements were made to the roadway environment in the high-risk zones, including warning signs, improved lighting, refreshed crosswalk markings, and removal of items that prevented drivers and pedestrians from seeing each other.

The evaluation used several measures of effectiveness, the one involving a "surrogate" measure of pedestrian-alcohol crashes being the most appropriate for measuring direct program effects. The surrogate crash was defined as one occurring between 7:00 p.m. and 3:59 a.m. on Thursday through Sunday, and involving a male pedestrian between the ages of 30 and 59. Surrogate crashes in the zones where the majority of countermeasures were concentrated decreased by 22% from the baseline period, and stayed about the same outside the zones. A time series analysis of the surrogate measure did not show any significant reduc-

tion, but a time series analysis of crashes occurring on treated roads and involving male pedestrians of age 14 and over did show a significant reduction of 16%.

ALCOHOL-CRASH COUNTERMEASURES FOR COLLEGE STUDENTS, A SPECIAL TARGET GROUP

The most comprehensive study of programs for reducing excessive drinking by college students was performed as a part of the Harvard School of Public Health College Alcohol Study. The School surveyed 734 U.S. college presidents and administrators to learn what colleges were doing to prevent binge drinking among students. Respondents were asked to rate the severity of alcohol abuse problems among students and specify prevention programs used to address this problem.

The study found that prevention practices were widespread regarding general education about alcohol, use of policy controls to limit access to alcohol, restricting alcohol advertising at home-game sporting events, and creating alcohol-free dormitories (Wechsler, Kelley, Weitzman et al., 2000). However, specific programs for alcohol education, outreach, and restrictions on alcohol advertising in campus media were less prevalent. Efforts involving more specific functions (e.g., in-house program evaluation), more personnel (e.g., a task force), and more community involvement (e.g., cooperative agreements and community meetings) were less common, and cooperative agreements were rare. Nevertheless, many colleges reported having task forces, and about half were performing in-house data collection.

Many colleges have established substance-free housing as a part of their efforts to reduce student drinking. The nature of substance-free housing programs at 10 colleges and universities in different geographic regions was investigated by Finn (1996) using information based primarily on extended telephone interviews with college administrators. Students gave a number of reasons for choosing substance-free housing, including: 1) avoid roommate problems associated with drinking or drug use (78%), 2) academic issues such as wanting a quiet study atmosphere (59%), 3) parental influence (26%), 4) religious beliefs or preference (22%), 5) family member with alcohol of other drug problem (6%), and 6) recovery from an alcohol or other drug problem (less than 1%).

College administrators recommended the following guidelines for making substance-free housing a success 1) start new programs small to assist in bonding and commitment; 2) involve students in the planning and operation of the program; 3) keep substance-free areas separate; 4) pick the substance-free locations carefully; 5) consider whether to offer special programming; 6) enforce the rules; 7) utilize peer pressure to enforce conforming behavior; 8) and establish recovery housing for addicted students. Responses to the various concerns and objections from the students concerning the establishment of substance-free residence halls are addressed.

Another survey of college anti-drinking programs investigated the characteristics of alcohol education (Flagstad-Kramer, 1997). Six colleges were identified as having programs with a positive impact, and telephone interviews were conducted with senior student affairs officers, health educators, and campus security officers to define the characteristics of these programs. The characteristics which contributed to effective alcohol education programming were determined to be a broad-based or campus-wide effort, student involvement, policy development and enforcement, top-down commitment, programming specific to campus environment, and the use of "teachable moments."

Finally, Mitka (1998) studied programs at the University of Wisconsin, the University of Vermont, and the University of Iowa, and described them in general terms.

Other studies have described and, in some cases, evaluated specific college anti-drinking programs. Researchers at Northern Illinois University (NIU) evaluated a new strategy to prevent binge drinking that focused on changing students' perceptions of the typical drinking behavior of college students (Haines and Spear, 1996; Haines, 1996). The new strategy involved changing the perception of the norm regarding heavy binge drinking and presented a campaign designed to change this perception. The researchers then collected data (self-reported), comparing students' own binge drinking practices and their perceptions of binge drinking college-wide after implementation of this strategy with a strategy involving a "traditional" approach that included three prominent themes: 1) It's OK to abstain; 2) It's OK to drink in moderation; and 3) Heavy drinking / intoxication causes harm to oneself and others.

They found that there was a significant difference between students' perception of typical drinking behavior and the self-reported drinking behavior. Students significantly overestimated the proportion of their peers who engage in heavy or binge drinking at parties. After implementation of the change-in-perception-of-the-norm strategy, the proportion of students who reported heavy or binge drinking as the norm decreased significantly, and the proportion of students who reported binge drinking dropped significantly. Outcome data on more traditional strategies indicated no significant change in drinking behavior.

The UNC program alluded to above followed a similar strategy to that tested at NIU. It put in place a campaign based on the theme "2 out of 3, .00 BAC." The evaluation of the program is still in progress, but preliminary results are positive, indicating that 71% of the students had heard of the campaign, and that 70% understood its message.

Steffian (1998) evaluated another program using a normative education technique designed to encourage more responsible use of alcohol by college students through correcting misperceptions students have concerning campus drinking norms. This study examined the utility of employing a group program designed to challenge college students' misperceptions of college drinking norms. As in the study at NIU, students were assigned either to a normative education group or to a control group representative of "traditional" alcohol education

efforts. Subjects in the normative education groups demonstrated more accurate perceptions of campus drinking norms at follow-up periods relative to baseline perceptions. These subjects also demonstrated a trend toward fewer binges and a significant reduction of consequences due to alcohol use relative to baseline, while those in the control group did not. Discriminant analyses revealed the variables "change in perception of the average student's number of drinks per week," "change in approval of moderate drinkers," and "change in approval of heavy drinkers" to be the strongest contributors to the function discriminating between those who decreased their drinking and those who did not.

So-called brief intervention programs have been implemented in some colleges. Ivy (1999) investigated the effectiveness of a brief intervention using motivational enhancement therapy techniques to motivate subjects to reduce intended and actual alcohol consumption. Information was presented and discussions were held on the relationship between alcohol use and sexual assault and between alcohol use and violence in courtship and dating. An evaluation showed reductions in the number of drinks and in the number of people who could be classified as problem drinkers. Also, the heaviest drinkers showed reductions in comparison with light drinkers. However, episodes of binge drinking and intentions about future drinking were not reduced, and motivation to change drinking decreased after the intervention.

Another study (Borsari and Carey, 2000) of brief intervention consisted of a randomized controlled trial of a 1-session motivational intervention for college student binge drinkers. Sixty students who reported binge drinking two or more times in the past 30 days were randomly assigned to either a no-treatment control or a brief intervention group. The intervention provided students with feedback regarding personal consumption, perceived drinking norms, alcohol-related problems, situations associated with heavy drinking, and alcohol expectancies. At a six-week follow-up, the brief intervention group exhibited significant reductions on number of drinks consumed per week, number of times drinking alcohol in the past month, and frequency of binge drinking in the past month.

Hoy (1996) describes a peer education training program at San Antonio College. A campus survey, which was used to direct the development of the training program, showed that students at the college were involved in binge drinking, intoxicated driving, and marijuana use at a significantly higher level than students in other studies of two-year higher education institutions. The program was found to have a positive impact on excessive drinking.

Several researchers in the field have offered advice about which programs or program components should or should not be tried. Broughton (1997) determined the impact of three information methods on health beliefs among drinking college students: (1) perceived threat, (2) perceived benefit, and (3) perceived barrier. The author concluded that the informational interventions had little effect on health beliefs and behavior change, indicating that the Health Belief Model employing these informational methods may not be an appropriate theoretical model for college students.

Erenberg and Hacker (1997) developed an action guide for dealing with college drinking issues. The report has six chapters. Chapter 1 examines drinking and its consequences for college students and others in the community. Chapter 2 discusses alcohol marketing and promotional practices on campus and in campus media, and strategies to reduce irresponsible marketing and service practices at bars frequented by students. Chapter 3 examines laws and policies that restrict alcohol advertising on college campuses. Chapter 4 discusses laws to limit high-risk alcohol promotions. Chapter 5 presents community-based approaches to reduce problems associated with heavy drinking at bars frequented by college students. Chapter 6 provides suggestions for organizing a coalition, gathering information, developing a strategic plan, and taking action to alter bar marketing and service practices.

Keeling (2000) examined two different approaches for dealing with the problem of collegiate binge drinking: 1) an environmental intervention that depends on community health assumptions and seeks to produce definable population-based goals, and 2) a clinical approach using very personalized, direct feedback to influence the behavior of self-acknowledged heavy drinkers. The author suggests that colleges consider "opportunistic prevention" whereby students might be approached during routine brief clinical visits to identify problems associated with alcohol and to engage in more intense areas of prevention. An integrated approach is recommended, focusing on clusters of related, intertwined behaviors, rather than on separate behaviors in isolation. Love (1998) also stressed the need for multiple strategies to address the complex interplay of drinking behaviors, college culture, and environmental factors as they are related to alcohol use and consequences. Love asserts that programs should strive to strengthen protective processes and factors, but more critically, to reduce the impact of identified risk factors.

Robinson (1998) observed that, while the literature indicates that many male undergraduates suffer numerous negative consequences from alcohol usage, little is known about what, if any, consequences female undergraduates experience. After analyzing 1992 and 1993 United States Department of Education CORE Survey data, the author concludes that, despite their predominately occasional and moderate drinking, females were still similar to men in suffering 15 negative consequences, such as memory loss, thoughts of suicide, arrest for drinking and driving, or missing classes. It is also concluded that with little exception, females use less alcohol than males but suffer similar negative consequences, and that, therefore, male and female undergraduates need similar alcohol intervention and prevention programs.

Turrisi (1999) studied the cognitive and attitudinal factors relevant to binge drinking at colleges using data from a sample of 250 psychology students in a moderately-sized northwestern city. The author suggests that educational efforts to prevent binge drinking include opportunities for new students to interact with groups whose values are compatible with non-binge drinking, having peer groups to help students consider pressures for binge drinking; and individuals who have

contact with college-bound teens should inform students of college binge-drinking and avoidance strategies.

Riordan and Dana (1998) examined ways in which student affairs officers and the Greek organizations can address drinking problems. They conclude that the Greek letter organizations must themselves confront the problems of alcohol abuse by their members, recommending collaboration across campuses and throughout student and community groups. They note that there are no simple solutions to the problem, and that as students and campuses change, so must the approaches to student alcohol abuse.

Several researchers have examined the use of designated drivers by college students as a means to reducing the traffic-crash consequences of drinking. DeJong and Winsten (1999) surveyed a representative national sample of students attending four-year colleges in the United States to learn whether they had served as or ridden with a designated driver within the past 30 days and how much alcohol they had consumed the last time they had used this strategy. Among those who had consumed alcohol in the past year, 36 percent said they had served as a designated driver in the past 30 days; of these, 40 percent said they usually binged when they drank but had not done so the last time they served as a designated driver, with the majority either abstaining or having one drink. Among drinkers, 37 percent reported riding with a designated driver in the past 30 days; of these, 22 percent said they did not usually binge but did so the last time they had a designated driver because they had consumed one or more extra drinks. The authors concluded that "among college students, using designated drivers is now a well-established strategy for avoiding impaired driving."

Meier and associates (1998) performed three experiments designed to test methods for increasing participation in designated driver programs at drinking establishments. Experiment 1 involved young adults at two bars in university communities in the western United States. Graduate and undergraduate observers monitored the activities of designated drivers. Incentive programs were established to encourage and reward designated driving, promoted through a print advertising campaign. A significant increase in designated driving was observed in Bar 2, but only a slight increase in Bar 1. Experiment 2 was a systematic replication of Experiment 1, but conducted in a larger urban-suburban setting, and with a significantly smaller proportion of college students. The bars also were considerably different from each other and from those in Experiment 1. Results were very similar to Experiment 1. Experiment 3 incorporated a variation in advertising the program, using television rather than newspaper ads and modeling them on a game show. The incentive program and ads had a statistically significant positive impact on the number of designated drivers. An important and unanticipated result was that the bar had a 350 percent increase in sales of non-alcoholic beverages. However, no binge drinking effect of the program was observed. The authors concluded that designated driving can be increased through incentives and advertising, and has the potential to play an important role in reducing DWI and alcohol-related traffic accidents.

In a third study of designated drivers among college students, Raimondo (1998) investigated the alcohol use behavior of college students who use a designated driver compared with students who do not. Data were collected from a questionnaire survey of 243 undergraduate seniors at a private, four year, liberal arts college in the northeast United States. The author found a significant difference in the quantity of alcohol consumed by male students who utilized a designated driver compared to male students who did not use a designated driver, with the heavier drinkers being less likely to use a designated drivers. White males were found to be most likely to engage in binge drinking but were least likely to use a designated driver.

SUMMARY AND CONCLUSIONS

At the millennium, we find that the literature reporting scientific evaluations of alcohol-crash countermeasures deals overwhelmingly with countermeasures using strategies of deterrence and incapacitation carried out by elements of the criminal justice system, that is, the Traffic Law System (TLS). Whether this is reflective of the extent of the total societal effort directed toward the problem, or is more indicative of the conduciveness of these types of countermeasures to evaluation cannot be said. For example, advocacy groups such as Mothers Against Drunk Driving (MADD) mounted a very strong effort against alcohol-impaired driving during a time when many of the evaluated deterrence / incapacitation countermeasures were in place. A large part of this early MADD effort was publicity-oriented and did not involve activities to influence passing new laws, enforcing laws more effectively, and convicting and sanctioning drunk drivers. The effectiveness of this effort and, no doubt, other efforts, has not been examined quantitatively in the scientific literature[21].

At any rate, the evaluations that have been performed clearly indicate that many TLS-based countermeasures have been effective in reducing alcohol-related crashes. These include those seeking general deterrence as well as specific deterrence. Among those that were primarily *legislative* is nature, laws establishing administrative license revocation (ALR) been found to reduce alcohol-related fatal crashes among arrested DWIs by up to 40%. This adds support for prior research showing the effectiveness of driver license sanctions in general.

A consensus is growing that laws which lower the legal BAC limit from .10 to .08 do result in reductions in alcohol related fatalities. It is clear that such laws work best in conjunction with enforcement, publicity and other laws which are intended to make the TLS work more smoothly--such as ALR laws. Estimates of effects vary but there is mounting evidence that a reduction in alcohol related

[21] Rogers and Schoenig (1994) considered the *formation* of MADD (not separate MADD initiatives) as an intervention in their evaluation of California's 1982 DWI legislation (See page 130).

fatalities on the order of 6-8% might be expected in conjunction with the passage of such a law.

Zero tolerance laws, which in effect prohibit driving with any alcohol in one's system for persons under 21, have been shown to result in reductions in youth alcohol-related fatal crashes ranging from zero to 40%. The key elements for this law are also effective enforcement and increased awareness of the law. States where DUI or DWI cases are essentially diverted into zero tolerance cases and there is no net increase in youth alcohol-related driving citations are less likely to receive the potential beneficial effects of such laws

Recent evaluations of comprehensive changes in State laws that *have* been accompanied by activities to implement those laws have shown positive results in reducing surrogates of alcohol-related crashes from 8% to 20%.

With respect to TLS countermeasures that are *enforcement*-oriented, recent research strengthens prior findings that programs using multiple strategies (including sobriety checkpoints and saturation patrols) and supported by strong public information and education efforts can be effective in reducing various surrogates of alcohol-related crashes by some 10% - 30%. Strong evaluations of large-scale checkpoint programs alone indicate positive impacts on alcohol-related crashes of the order of 20%.

Countermeasures focusing on *sanctions* for drivers convicted of DWI have received considerable attention in the recent evaluative literature. Earlier research on countermeasures that attempted to *treat and rehabilitate* DWIs had found mixed results, with some programs reporting recidivism reductions of up to 35%, and other programs achieving no reductions. More recent research provides evidence that treatment and rehabilitation combined with driver's license suspension can be more effective than suspension alone, obtaining recidivism reductions in the 30% range.

No recent research was found on the use as *jail* as a sanction for DWI, but earlier research reported conflicting results, with some evaluations indicating a positive effect and others no positive effect. However, there has been considerable recent research on the effectiveness of *sanctions used as an alternative to jail.* Three forms of such sanctions have been found to be effective in reducing recidivism for DWI: intensive supervision probation, electronic monitoring, and sanctions tailored expressively for individual offenders. For these sanctions, 33% - 50% recidivism reductions over traditional sanctions have been found. Other alternative sanctions that show promise but need further evaluation are day reporting centers, boot camps with strong treatment programs, and possibly, victim impact panels.

A number of evaluations of *vehicle-oriented sanctions* have been conducted in recent years. Of those that require the vehicle to be impounded or seized, recidivism reductions of 50% or more have been found. A similar effect has been noted for just seizing and destroying the offender's license plates. Ignition interlocks that prevent an offender from starting his or her car have also been found to reduce recidivism (by up to 69%) during the period in which interlocks are

attached, but the effect disappeared after the interlocks were removed. The use of specially marked license plates for DWIs also reduced recidivism in one state.

Other countermeasure programs have not relied totally on the TLS, but have used it in conjunction with other risk managements systems. Two recent *community trials programs* had TLS components, and one these evaluated the TLS component which was composed primarily of enforcement system support. The evaluation indicated a positive impact on alcohol-related crash surrogates in the 10% - 20% range. The other evaluation dealt with a similar program of enforcement system support and suggested a reduction in alcohol-crash surrogates for the targeted under-21 age group.

Several countermeasures not involving the TLS have been evaluated. One of these was a large-scale, long-range prevention program consisting of *school-based education* in avoidance of alcohol-related problems. Self-reported data suggest reductions in alcohol use and misuse, and a recent study suggests a positive effect on alcohol-related crashes as well. Another education-oriented program to has just been developed, this time to enable medical practitioners to identify and help patients with alcohol problems, but its impact on alcohol-related crashes is not yet known. *Ride-service programs* providing a transportation alternative to drinkers have been evaluated recently in two locations, one evaluation indicating no effect on crashes, but the other, an extensive full-time program extending over several years, indicating a 15% reduction in injury crashes. Ride service programs have been found to raise public awareness programs of the alcohol-crash problem even where no direct effect on crashes was found.

Of programs aimed at limiting the availability of alcohol, legislation *raising the legal minimum drinking age* has been the most extensively evaluated, with results that clearly indicate a reduction of 9% to 14% in alcohol-related fatal crashes for the affected age group. Evaluations of other early attempts to limit alcohol availability have not provided convincing evidence of any positive impact on alcohol-related crashes, but preliminary evaluations of alcohol-server programs have appeared promising. More recent evaluations provide evidence of alcohol-crash impact of *server training*, especially if used as a component of a broad community-based program or mandated by law. Evaluations of behavioral tests that help servers and social hosts identify alcohol-impaired guests also suggest potential impact on alcohol-related crashes. Finally, there is some hard evidence that more vigorous *enforcement of alcohol sales to minors* through such programs as "Cops in Shops" can reduce alcohol-related crashes for under-21 drivers. The traffic safety impact of alcohol self-testers in drinking locations has yet to be evaluated in the U.S.

Several countermeasures aimed at *reducing the probability of a crash involving an alcohol-impaired driver* have been suggested and even tested in field experiments, but their possible impact on crashes has not been determined. Including among such countermeasures are wider and better-marked road edges, rumble strips ro warn drivers they have left the roadway, and drunk driver warning systems to alert roadway users of the presence of an alcohol-impaired driver.

The above discussion has dealt with alcohol-crash countermeasures aimed at alcohol-impaired drivers. However, as indicated in Chapter 2, a significant number of fatalities involve non-drivers such as pedestrians and bicyclists, Unfortunately, there have been very few evaluations of such countermeasures. However, one recent evaluation of a multi-faceted pedestrian countermeasure program in Baltimore, Maryland indicated a positive effect on alcohol-related pedestrians crashes. The program included an extensive public information and education (PI&E) campaign, reflective caps for persons in high-risk zones, and improvements to the roadway environment in the high-risk zones. The evaluation indicated a reduction of 16% -22% in surrogates of pedestrian-alcohol crashes.

The recent scientific literature on programs to reduce excessive drinking among college students (and resultant alcohol-related crashes) does not reveal many program evaluations, although many colleges have such programs in place. We found four types of programs that had been the subject of an evaluation:

- normative programs - education and publicity aimed at changing the perception of the norm regarding heavy binge drinking;
- alcohol education - education on the nature, consequences, and avoidance of excessive drinking;
- peer education - involvement of students' peers in alcohol education; and
- brief interventions - short-term, intensive motivational sessions.

Three evaluations of *normative programs* were identified, all indicating a positive effect on excessive drinking. The evaluations of the alcohol education programs (at six colleges) could be more accurately described as assessments and also indicated a positive effect on excessive drinking. The one evaluation of a *peer education program* found a positive effect, but the *brief intervention* evaluations obtained conflicting results, one indicating a positive and the other indicating no effect. While none of these evaluations measured drinking-driving or alcohol-crash impact, the normative programs seemed to offer the most potential. Also, other non-evaluative studies suggest that the programs that have a component that promotes the use of designated drivers could reduce the prevalence of drinking-driving.

In short, the literature on anti-drinking programs for college students provides considerable information on the nature and location of such programs, but every little information on the effects of such programs, especially their effects on the alcohol-crash problem. In addition, many suggestions are offered for the content of programs that could be of value in selecting programs to evaluate in future projects, including:

- substance-free housing;
- "opportunistic" interventions performed in conjunction with routine clinical visits;
- the use of an extensive action guide for dealing with college drinking;

- an environmental intervention that depends on community health assumptions;
- multiple strategies to address the complex interplay of drinking behaviors, college culture, and environmental factors as they are related to alcohol use and consequences;
- providing opportunities for new students to interact with groups whose values are compatible with non-binge drinking; and
- having Greek letter organizations confront the problems of alcohol abuse by their members, and work together across campuses and throughout student and community groups.

Some of the limitations to alcohol-crash countermeasures discussed at the beginning of this chapter should be kept in mind when interpreting the above findings on effectiveness. It is especially important to note that many evaluations have been conducted against a background of other anti-DWI activity, making it difficult to ascribe an observed effect to any single countermeasure. This is especially true of multi-state evaluations of legislative countermeasures where the evaluations often not have analyzed the level of activity supporting the implementation of the countermeasure in the various States. Clearly, when considering the simultaneous application of more than one countermeasure, one cannot assume that their total impact would be the sum of their individual impacts. For programs involving many countermeasures, this could lead to the absurd conclusion that the program would eliminate more than 100% of the alcohol-crash problem.

Another limitation is that most of the evaluations were of countermeasures that were implemented in just one or a few jurisdictions. Thus, it cannot be assumed that such a countermeasure would be effective in every jurisdiction, regardless of local conditions. Similarly, a finding of no effect in a one or two jurisdictions does not necessarily mean that the countermeasure would be ineffective in every jurisdiction. And of course, the lack of any evaluation at all also does not necessarily indicate that a countermeasure is ineffective.

6 - CONCLUSIONS AND RECOMMENDATIONS

Our overall conclusions and recommendations flowing from our review of the scientific literature dealing with the alcohol-crash problem and societal responses to it are presented in this chapter. Detailed conclusions are contained in the summary and conclusions sections of prior chapters.

THE ALCOHOL-CRASH PROBLEM

We conclude that currently available hard data on the nature of the alcohol-crash problem are adequate for defining the gross prevalence of alcohol-impaired drivers in fatal crashes. For example, it is known that some 12,500 persons are killed each year in crashes in which one or more drivers had a BAC of .10+, and about 16,000 persons are killed annually in crashes in which a driver had a BAC of .01+. (There is also evidence that drivers at BACs much higher than .10 account for a disproportionate share of the alcohol-crash problem.) Since virtually all drivers are impaired at .10+ (and recent research indicates impairment and high risk at even lower BACs), using a BAC of .10+ as a measure is reasonable for determining a lower bound to the current magnitude of the problem. Less is known about the role of alcohol in non-fatal crashes, since comprehensive data based on objective measures of impairment (such as driver BAC) do not exist at the national level.

Research also clearly indicates that the size of the alcohol-crash problem in general has declined significantly in recent years, to the point that it can be said that alcohol-related fatal crashes are a smaller societal problem at the millennium than they were 10 or 20 years ago.

The characteristics of persons who drink and drive are also generally better known than they were at the times of prior state-of-knowledge updates. Basic demographic data for such variables as age and sex exist in abundance, and data are starting to appear on ethnic and racial characteristics. From this knowledge it is more clear than ever that young drivers have especially high alcohol-crash risk and alcohol-crash involvement, and that, young, White males in particular account for a large share of the alcohol-crash problem . Other demographics are available for certain groups of drinking-drivers (e.g., DWIs), but, except in small studies, generally not for drivers in crashes. Also, the drinking patterns and drinking-driving patterns of drinking drivers are becoming better defined. The role of prior DWI convictions in drinking-driving, is now better understood, indicating that while multiple DWI offenders have higher recidivism rates than first offenders, persons with no priors at all may have the highest involvement in total crashes and in alcohol-related crashes of all degrees of severity. Further, research suggests that repeat DWI offenders and first offenders share many of the same characteristics.

Our review found that pedestrians and bicyclists account for a much smaller, but still highly significant, portion of the alcohol-crash (approximately 1,500 fatally injured pedestrians at .10+ BAC). Data from FARS indicate that fully 34% of fatal pedestrian crashes involved either a pedestrian or a driver whose BAC was .10 or higher, and that very high BACs were common among alcohol-positive pedestrians. The contribution of alcohol-impaired bicyclists to the problem is much lower than that pedestrians, probably of the order of a few hundred fatalities a year at the .10+ level.

In general, the literature suggests that data from existing research are sufficient for defining broad groups of alcohol-crash targets, but are still inadequate for identifying more narrowly defined target groups. For example, there are sufficient data to say that young male drivers should be a target group, but not enough data to say that young, unemployed males without a college diploma who drive light trucks are an important subgroup to be singled out for special countermeasure action. In a word, more research is needed on the characteristics of alcohol-crash involved drivers and their relative risk. Specific areas where significant knowledge gaps exist and where significant research efforts are recommended are:

- non-fatal alcohol-related crashes;
- characteristics of drivers not involved in alcohol-related crashes;
- alcohol-crash risk as a function of biographical and other pertinent variables;
- the relationship of biographical variables other than age and sex (especially race and ethnicity) to alcohol-related crashes;
- data on a range of other variables needed for more detailed definition of the alcohol-crash problem, for example, sociological, economic, and environmental variables; and
- driving history and its relationship to alcohol-related crashes.

RESPONSES TO THE PROBLEM

Nearly all countermeasure programs that have been evaluated have focused on the pre-crash phase. Their objective has most often been to reduce driving after drinking, although there has been increasing attention given to reducing excessive drinking before driving. The great majority of programs have used strategies of deterrence and incapacitation carried out by elements of the criminal justice system.

Countermeasures with strong evidence favoring their effectiveness are:

- Administrative license revocation (ALR) laws in conjunction with strong public information and education activities and efficient case processing procedures;
- Laws reducing the legal BAC limit to .08, in conjunction with ALR laws;

- For drivers under the age of 21:
  - ✓ laws raising the illegal minimum drinking age and
  - ✓ laws lowering the legal BAC to zero or near-zero;
- Comprehensive changes to state laws accompanied by enhanced activity to implement those laws;
- Enforcement of existing DWI laws in general (and sobriety checkpoints in particular) with strong PI&E components;
- Traditional sanctions using actions against the driver license;
- Carefully designed treatment and rehabilitation programs when used in combination with other sanctions;
- Certain alternative sanctions requiring extended contact with offenders, including intensive supervision probation, electronic monitoring, and sanctioning programs tailored to individual offenders;
- Removal of an offender's vehicle (or access to it);
- Alcohol interlocks (while the interlocks are installed);
- Comprehensive community-based programs; and
- Multi-component pedestrian programs.

Countermeasures that have shown promise but for which evaluations of alcohol-crash impact are as yet inconclusive are:

- Other alternative sanctions such as day reporting centers;
- Enforcement of laws against alcohol sales to minors;
- Year-around ride-service programs;
- Server training programs; and
- School-based education programs.

While the state of knowledge about ways of dealing with the alcohol-crash problem has grown enormously since the first comprehensive report on alcohol and traffic safety, significant knowledge gaps remain. The most glaring of these is the knowledge about the effect of countermeasures that do not rely on the Criminal Justice System. These other countermeasures include approaches focusing on technology, the vehicle, the highway environment, and the more effective control of alcohol consumption. To date, such approaches have either been insufficiently developed, insufficiently evaluated, or both. Two additional areas where significant new knowledge is needed are: countermeasures targeted at specific groups of drinking drivers, (e.g., groups defined by such variables as race / ethnicity and type of vehicle), and pedestrian countermeasures.

We recommend a coordinated program of countermeasure research and development to fill these gaps. For the short term, the major thrust of operational programs should be on maintaining the 20-year downward trend in alcohol-related crashes. This will require refining current deterrent / incapacitation programs and generating and evaluating new such programs. But concurrently, new approaches will have to be developed, evaluated, and refined for later

widespread adoption as the marginal utility of deterrence-based programs becomes exhausted.

Such an effort across a such a broad front will be beyond the capability of any one governmental agency, advocacy group, or industry. Instead, it will require merging of the interests and resources of many organizations and individuals. NHTSA is planting the seeds of this approach in its Partners in Progress program, and is exploring ways of expanding this program into a collaborative effort involving many other partners outside its agency. Clearly, this effort must be cooperative rather than managed because of the diversity of its participating organizations and individuals. Establishing and operating such a program will no doubt require new organizational arrangements, and this may well be one of its most challenging aspects.

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☆U.S. GOVERNMENT PRINTING OFFICE: 2002-720-421/98042

DOT HS 809 383
November 2001

U.S. Department of Transportation
National Highway Traffic Safety Administration