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16. Abstract

This document examines new literature and data on selected alcohol-crash targets or problems that have become available since the November 1989 State of Knowledge review. Specifically, this update addresses research since the 1989 review dealing with characteristics of drinking-drivers and drinking-driving that are associated with increased levels of alcohol-crash risk and/or alcohol-crash incidence. With the exception of NHTSA's Traffic Safety Facts 1996, the cutoff date for literature included in this study was February, 1994. This document contains a description of the methods followed in determining the topics and issues of concern; identifying, acquiring and screening the articles to be reviewed; and a synthesis of the individual reviews.

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This is the final report of a project entitled "Alcohol Highway Safety Problem Update." The project was conducted by Mid-America Research Institute, Inc., of New England for the National Highway Traffic Safety Administration (NHTSA) under contract number DTNH22-93-C-05083.

The work reported here critically examines new literature and data on selected alcohol-crash targets or problems that have become available since the last NHTSA sponsored State of Knowledge review published in November, 1989 (Jones and Lacey, 1989). Specifically, this update addresses research since the 1989 review dealing with characteristics of drinking-drivers and drinking-driving that are associated with increased levels of alcohol-crash risk and/or alcohol-crash incidence. Broad categories of topics covered by this research are:

- People at risk
- BAC (blood alcohol concentration) levels at risk
- Environmental situations at risk

The materials reviewed here are those dealing with the epidemiology of the alcohol-crash problem created by various groups of drivers in various drinking and driving situations. The materials included foreign as well as U.S. literature with a direct bearing on highway safety. The intent of the review was to identify high-risk groups or situations which might be amenable to countermeasures so that appropriate countermeasures could be developed and tested in further research activities. With the exception of NHTSA's Traffic Safety Facts 1996, the cutoff date for literature included in this study was February, 1994.

STUDY APPROACH

Potentially relevant documents were identified through an extensive search of the literature with input from researchers and practitioners in the field of alcohol and highway safety. The principal investigators used two primary criteria for screening substantive materials for subsequent review. First, a document actually had to address pertinent topics. Second, a document had to at least purport to have scientific validity. Documents merely reflecting the unsupported opinions of their author were not retained for review. Documents surviving this initial screening underwent further screening to determine whether they really did have scientific validity and whether the treatment of the results was objective and balanced.

The reviews of each document followed a common format, each review taking into account the major issue or issues addressed by the research and identifying any

trends that may have been suggested by the research when considered in the light of prior research or prior trends. Major topics addressed in the individual reviews were:

- The research method followed;
- Quality of the data;
- Sample sizes and statistical significance of the results;
- Actual amount of differences among groups that may be compared in a study;
- Appropriateness of the techniques used to analyze the data; and
- Appropriateness of the findings and conclusions in light of the actual results reported.

After preparing the individual reviews, we developed a synthesis of the materials along with our own conclusions about the findings of the literature.

FINDINGS AND CONCLUSIONS

The identification of targets for alcohol-crash countermeasures requires information about the number of alcohol-related crashes, the extent of alcohol-impaired driving, and the relative risk of an alcohol-related crash. The literature examined in this update relates almost entirely to the first two of these areas, adding useful information about:

- The involvement of various groups of alcohol-impaired drivers in fatal crashes, and to a limited extent, serious injury crashes;
- The involvement of various groups of drivers in "non-crashes" (that is, the driver was stopped at a roadside survey checkpoint); and
- DWI (driving while impaired or intoxicated) arrests or convictions of various groups of drivers as a percentage of all drivers arrested or convicted of DWI.

Nearly all of the useful fatal-crash data are from the Fatal Accident Reporting System (subsequently renamed the Fatality Analysis Reporting System or FARS), the only exception being data on involvement as a function of race which are from North Carolina. Information on serious injury crashes comes largely from studies emanating from trauma centers in the U.S. and Canada. Roadside survey data come primarily from the 1986 National Roadside Breathtesting Survey (Lund and Wolfe, 1991) conducted during weekend, nighttime hours. The data on DWIs are from a range of studies, including those whose subjects were DWIs who had been sent by the court to alcohol assessment or treatment.

Clearly, only the first of the three above areas (involvement in alcohol-related crashes) bears directly upon the measurement of a group's alcohol-crash incidence. The non-crash area is pertinent by providing an estimate of a group's involvement in the nighttime, weekend drinking-driving that may lead to a crash. The DWI indicator is at best an indirect, second-order indicator, to the extent that drivers with prior DWI

convictions are over-represented among all alcohol-involved drivers in fatal crashes. Unfortunately, no satisfactory direct indicator of relative risk of a crash (that is, probability of a crash given alcohol divided by the probability of a crash given no alcohol) is available from recent research. This is because, as indicated above, there are no recent studies based on matched sets of crash data and non-crash data. Relative risk can only be discussed indirectly. For example, over-representation of a group in crashes relative to that group's representation in some non-crash measure, such as the roadside survey, would suggest high crash risk for that group.

With respect to *BACs at risk*, recent research adds little new knowledge about the role of a high BAC in alcohol-related crashes, but does reinforce the findings of prior studies indicating that a high BAC is strongly related to both high alcohol-crash incidence and high alcohol-crash risk. A recent examination of the BAC distribution of fatally injured drivers from FARS data underscores the very strong role of the high-BAC driver in fatal crash incidence. Considerable new information regarding high BACs comes from studies of DWIs.

There is also new research to suggest that lower BACs (that is, 0.01%-0.09%) are associated with increased alcohol-crash risk and involvement. FARS data indicate that there were a sizable number of fatal crashes at these BACs in 1996 (3,507), but there are no comparable data from non-crashes to get a good estimate of relative risk. Instead, we have very rough estimates based on FARS data combined with data from unmatched roadside surveys. These estimates suggest a significant relative risk at BACs in the 0.05%-0.10% range, and a lower but still not insignificant risk in the 0.02%-0.05% range. Further, a study of fatal crashes in Texas found that, as BAC increased, there was a significant increase in the probability of the killed driver having *caused* a given multiple-vehicle fatal crash (Mounce and Pendleton, 1992). This relationship held over the entire BAC range studied, from 0.05% to 0.20%, with the largest marginal increase occurring in the 0.00-0.05% range.

In the case of *people at risk*, a relatively large number of factors have been studied in the recent literature, but only driver sex, age, and to some extent, race, are based on hard epidemiologic data. These data indicate that male drivers, drivers in the 21-34 age group, and drivers who are of the "white" race constitute the largest percentage of alcohol-impaired drivers in fatal crashes. It should be noted that recent data continue to indicate that the role of females in the alcohol-crash problem appears to be increasing. In 1982, 12.3% of drivers in fatal crashes with a BAC of 0.10% or more were female, and this percentage has grown steadily to 15.7% in 1996, an increase of 28%. There is also some evidence from recent data to support the prior hypothesis that the alcohol-crash risk of females is higher than that of males. Similarly, there is some evidence to suggest that non-whites (including blacks, Hispanics, and Native Americans) are over-represented among alcohol-impaired drivers in fatal crashes even though their overall share of the alcohol-crashes is small in comparison to that of whites.

Data pertaining to the role of other people-related factors in the alcohol-crash problem are spotty, coming mainly from studies of DWIs, and from the 1986 National

Roadside Breathtesting Survey. These data suggest that persons who are unemployed, without a college diploma, moderate to very heavy drinkers, and whose trip purpose was visiting friends are *over-represented among weekend, nighttime alcohol-impaired drivers*. Impaired drivers appearing in *relatively greater frequency among weekend nighttime drivers and/or DWIs* are those who: are employed, are married, have no college diploma, have a record of many traffic violations and prior DWI convictions, or drink in many, rather than a single, location. In addition, recent studies continue to confirm prior studies *that impaired drivers (especially young drivers) with certain personality/psychosocial characteristics appear more frequently among DWI populations.* These characteristics are relatively high levels of verbal hostility, assaultiveness, sensation-seeking, impulse expression, tobacco and drug use, and personal problems, and relatively low levels of responsible values and parental compatibility. Most of these findings are not new, but do add confirmatory evidence to the knowledge base.

Recent research on *environmental situations at risk* appears to have been limited to examination of the day of the week and the time of day of impaired driving incidents, and of the types of vehicle used by impaired drivers in fatal crashes. FARS data continue to show that weekend days have higher numbers and percentages of impaired drivers in fatal crashes than do week days. FARS data also show that late nighttime and early morning hours have *much* higher numbers and percentages of alcohol-impaired drivers (and also alcohol impaired non-occupants, i.e.; pedestrians and bicyclists) than do other hours. One study of the time of day of incidents involving alcohol-impaired drivers found that the greatest percentage of impaired drivers on the roads occurred during the 2 a.m.-3 a.m. period. The same study also calculated the time of highest relative risk of a fatal single-vehicle crash involving an alcohol-impaired driver, identifying 5 p.m.-8 p.m. with a relative risk of 238.

The 1997 FARS report provided data on the type of vehicles driven by alcohol-impaired drivers involved in fatal crashes. Passenger cars and light trucks were by far the most frequently used by such drivers, but motorcycle drivers in fatal crashes were more likely to have been alcohol-impaired than were drivers of any other type of vehicle. Drivers of heavy trucks in fatal crashes are the least likely to have been alcohol-impaired.

It should be noted that the above discussion applies to variables treated one at a time rather than to combinations of variables examined through multivariate techniques. Very few recent studies have approached the problem from a multivariate standpoint, and most of these have not had hard data on many of the most important variables dealing with the crash-involved drivers (for example, BAC). Lack of such data makes it impossible to identify with confidence detailed levels of alcohol-problem groups, for example, young, unemployed males without a college diploma who drive light trucks.

Nevertheless, some useful findings have emerged from recent multivariate studies. A study of interactions among driver age, sex, and race based on hard data from North Carolina found that alcohol-impaired *non-white* male drivers were significantly

more frequent than were alcohol-impaired *white* males in alcohol-related crashes. This latter finding was apparently due to an age-sex interaction effect: in the over-24 years group, *non-white* males were significantly more frequent than were *white* males, while in the under-25 group, *white* males were significantly more frequent than were *non-white* males. For female drivers in North Carolina, the picture was more complex, with the frequency of whites outnumbering that of non-whites by a factor of almost 2 to 1. In the under-25 and over-54 group of alcohol-impaired drivers, white females were *less* frequent than were non-white females, while in the 25-54 group, the frequencies of white females and non-white females were about the same.

Another multivariate study by James (1990) profiled several "high-risk" groups of DWIs through factor analyses, but the crash involvement of such groups was not treated in the analysis, and so the profiles have limited utility in identifying target groups for countermeasures.

The most comprehensive of the multivariate studies examined in this review dealt with personality and psychosocial variables in combination with a variety of other variables, including biographical variables and variables available from driver records. These studies, while enlightening as to the directions of relationships among the variables and in supporting hypotheses about the underlying structure of the relationships, again do not provide much information for estimating the magnitude of the alcohol-crash problem due to groups having various combinations of characteristics.

Overall, we conclude that the currently available hard data on the nature of the alcohol-crash problem are adequate 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 (to use the above example) that young, unemployed males without a college diploma who drive light trucks are an important subgroup to be singled out for special countermeasure action. At this juncture, it appears that such more detailed levels of target identification can best flow from combination objective-subjective processes.

To help fill this data gap in the problem-identification state of knowledge, there is a need for new controlled studies of the role of alcohol in traffic crashes, preferably conducted periodically (say, every five years) in several different regions of the U.S. These studies should collect detailed information in the subject areas discussed in this update and be of sufficient magnitude to permit the multivariate analysis of pertinent study variables. At this writing, NHTSA was conducting a case-control crash risk study that would constitute an important first step toward this goal. The controlled epidemiologic studies should be augmented by periodic national surveys of the driving population of the type recently completed by NHTSA.

These recommendations for research at the national level do not obviate the need for continued research on a more limited geographic scale. To the contrary, special studies at the state and local levels are probably the only economically practical way of obtaining more detailed information on some topics and should be continued. Such

studies can be useful when examined in the light of other studies, providing data that can be pieced together with other information to help in identifying potential target groups for alcohol-crash countermeasures.

1 - INTRODUCTION

This is the final report of a project entitled "Alcohol Highway Safety Problem Update." The project was conducted by Mid-America Research Institute, Inc., of New England for the National Highway Traffic Safety Administration (NHTSA) under contract number DTNH22-93-C-05083.

Nearly 30 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 1984 (U.S. Department of Transportation, 1985), and the third in 1989 (Jones and Lacey, 1989). The 1978 update was actually a complete revision, 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 most recent review (Jones and Lacey, 1989) again covered the complete spectrum of alcohol-crash issues but was limited in its treatment of those issues to identify trends and new developments since the 1985 update. Over 2,000 documents were examined in the 1989 review, 756 of which were retained as references.

The work reported here is, in essence, an interim update of the literature, this time concerned with new literature and data on *selected alcohol-crash targets or problems* that have become available since the last state of knowledge review published in November 1989[1]. Specifically, this update addresses research since the 1989 review dealing with characteristics of drinking-drivers and drinking-driving that are associated with increased levels of alcohol-crash risk and/or alcohol-crash incidence. Broad categories of topics covered by this research are:

- People at risk
- BAC levels at risk
- Environmental situations at risk

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[1] With the exception of NHTSA's Traffic Safety Facts 1996, the cutoff date for literature included in this study was February, 1994. Note that Traffic Safety Facts 1996 bears a publication date of 1997.

The remainder of this volume is presented in two chapters. Chapter 2 contains a description of the methods followed in determining the topics and issues of concern in the update; identifying, acquiring and screening the articles to be reviewed; and conducting the individual reviews. Chapter 3 is devoted to the synthesis of the individual reviews. A glossary, an index of terms, and a bibliographic listing of references follow. Two categories of references are included in the listing, those of documents for which individual reviews were conducted, and other documents not meeting our criteria for an individual review, but that may be of interest for further reading.

2 - METHOD

The materials reviewed here are those dealing with the epidemiology of the alcohol-crash problem created by various groups of drivers in various drinking and driving situations. The scope of the review included foreign as well as U.S. literature with a direct bearing on highway safety. As indicated in Chapter 1, broad categories of topics covered were:

- People at risk
- BAC levels at risk
- Environmental situations at risk

Mid-America obtained input from specialists that could be used to more clearly define the components of these broad categories. Input included *detailed* topics and issues; criteria for identifying target groups; and definitions of target groups. We also contacted professional committees and societies whose members contribute to the pertinent scientific literature. Two such committees were particularly important:

- The Transportation Research Board Committee on Alcohol, Other Drugs, and Transportation; and
- The National Safety Council Committee on Alcohol, Drugs, and Traffic Safety.

Input was also obtained from members of public action groups such as Mothers Against Drunk Driving (MADD) and from industry-sponsored associations such as the Insurance Institute for Highway Safety. We also obtained input from NHTSA and from contractor staff not directly involved in the project.

These individuals and organizations were contacted by letter and by personal telephone calls, as appropriate, early in the project. We also asked for input on pertinent literature as well as topics and issues.

The library of The University of Michigan Transportation Research Institute (UMRTI) was the central focus and coordinating element of the literature search and collection activities. This facility now has a collection of some 80,000 documents relating to highway safety, not including some 40,000 on microfiche. It has recently been computerized, permitting rapid and effective searches by keyword. Further, it has access to other computerized information services (such as TRIS/HRIS) through DIALOG and other time-sharing systems.

The starting point in the search was recent bibliographies and reviews of directly related materials. Relevant bibliographies and reviews were identified through a search of the UMTRI library, and through discussions with subject-matter experts and others as indicated above. The publications *Alcohol, Drugs and Traffic Safety, Current Research Literature*; *Alcohol, Drugs and Driving: Abstracts and Reviews*;

and *Addiction Research Foundation Library Acquisitions List* were particularly useful at this point in the project.

We also obtained input from our colleagues on pertinent collections and individual documents covering the entire range of subjects to be addressed in the update. We were particularly interested in obtaining cites to literature that may not routinely be acquired by specialized highway-safety libraries. We also were interested in identifying important work in progress. Other research in progress was identified by contacting likely sponsors of research, most particularly, the National Institute on Alcohol Abuse and Alcoholism (NIAAA). The *ICADTS Reporter* (International Council on Alcohol, Drugs and Traffic Safety) and the *UMTRI Research Review* (University of Michigan Transportation Research Institute) also contained information on research in progress.

The next step in the search was to methodically examine specific journals and conference proceedings known by the principal investigators to contain pertinent materials. These documents were not necessarily concerned directly with highway safety, but tended to focus on other related disciplines such as human factors, toxicology, issues concerning "special populations," and alcohol studies in general. Particularly important examples of journals in this group of publications were:

- Accident Analysis and Prevention;
- American Journal of Public Health;
- Alcohol and Health Research World;
- Blutalkohol;
- British Journal of Addiction;
- Human Factors;
- Journal of Criminal Justice;
- Journal of Forensic Sciences;
- Journal of Hispanic Studies
- Journal of Safety Research;
- Journal of Studies on Alcohol;
- Journal of Traffic Medicine;
- Law and Policy; and
- Psychopharmacologia.

Examples of ongoing conferences generating proceedings of interest were:

- The triennial international conferences on Alcohol, Drugs and Traffic Safety; and
- The annual conferences of the Association for Advancement of Automotive Medicine.

The documents that were identified through the above process were **potentially** relevant, but they could not actually be **selected** for review until they were read and screened by the principal investigators.

There were two primary screening criteria for substantive materials. First, a document actually had to address pertinent topics as it appeared to when it was identified as a candidate. Second, a document had to at least purport to have scientific validity. Documents merely reflecting the unsupported opinions of their author were not retained for review.

Documents surviving this initial screening underwent further screening to determine whether they really did have scientific validity, that is, whether the methods used in designing and executing the research, and in analyzing the results were sound. Further, they were examined to determine whether the treatment of the results was objective and balanced. However, documents that were believed to be flawed in some respect were not necessarily rejected in this screening. For example, a study that was well-designed and executed, but drew conclusions that did not flow from its findings was kept for the update. The update's commentary on that study noted the inconsistencies between the research results and the conclusions, and offered a more consistent interpretation of the results.

As in prior state of knowledge reviews, each document identified for inclusion in the alcohol update report was critically reviewed by the authors. However, these individual reviews were formalized in this project to follow a common format for incorporation. Each review took into account the major issue or issues addressed by the research and identified any trends that may have been suggested by the research when considered in the light of prior research or prior trends. Major elements of the reviews were:

- the research method followed;
- quality of the data;
- sample sizes and statistical significance (α) of the results (findings with α greater than the usual 0.05 were not necessarily disregarded);
- effect size: actual amount of differences among groups that may be compared in a study (e.g., 85% of group 1 vs. 80% of group 2 has a small effect size);
- appropriateness of the techniques used to analyze the data; and
- appropriateness of the findings and conclusions in light of the actual results reported.

As indicated earlier in this chapter, if the reviewers believed the conclusions of a study were inappropriate, the inconsistencies between the research results and the conclusions were noted, and a more consistent interpretation of the results was offered.

Bibliographic information on each article was entered into a computerized bibliographic database. Finally, the last step in conducting the update was the preparation of this report synthesizing he reviews.

3 - SYNTHESIS

This review was performed to identify information that could be used for better defining alcohol-crash target groups or problems so that new or improved counter-measures could be developed. This chapter contains a synthesis of the individual reviews. The discussion is in three sections, (1) some general comments on the general nature of the literature, (2) the synthesis of literature findings, and (3) a summation of the findings and the authors' general conclusions about those findings. This section deals with the literature from the perspective of BACs at risk, people at risk, and environmental situations at risk.

GENERAL NATURE OF THE LITERATURE

The articles identified in our literature search and reviewed in this report fall into three major categories, as follows:

1. Those that examine the *alcohol-crash incidence or risk* of various subgroups of *drivers*;
2. Those that examine the *characteristics* of various subgroups of *drinking-drivers* and drinking-driving *situations*; and
3. Those that set out explicitly to identify target groups of drinking-drivers.

The first category deals primarily with subgroups that can be defined from variables in the archival crash data sets and driver data sets that are available to traffic safety researchers, and from variables in special data sets that have been developed from roadside surveys of non-crash involved drivers. This type of study is called an *epidemiologic study* in the traffic safety literature. We note that no epidemiologic study was found that developed both the crash data and the non-crash data that were used in the study.

The second category deals with data on subgroups of drivers that have already been identified as engaging in drinking-driving. Examples of such subgroups are drivers who have been arrested for DWI and drivers who have been convicted of DWI and required by the court to attend treatment or educational sessions. Sometimes, surveys of drivers or subgroups of drivers (for example, young drivers) are used to identify, through self-reports, drinking drivers who may then be compared with non-drinking drivers to identify characteristics that differentiate the drinking drivers and the non-drinking drivers. Very often, additional data are gathered on the drivers studied, including data resulting from administering various psychological scales and from instruments designed to measure alcohol abuse or dependence.

Articles in the second category far outnumbered those in the other two categories. Only a few articles fell in the third category, some based on primary data and others on secondary data, including literature reviews and interpretations of literature reviews.

As might be expected, the *research method and data* used in the documents reviewed here varied according to the type of study or report. Some documents, such as the 1997 report from NHTSA's Fatality Analysis Reporting System (FARS), were simply a straight presentation of data on a drinking-driving group, with no comparison to any other drinking-driving group. At the opposite end of the spectrum were studies that attempted to follow an experimental or quasi-experimental design, with random assignment to treatment and control groups. Because of self-selection of subjects or other factors that could not be controlled by the investigators, very few studies achieved such a design and accounted analytically for differences between treatment and control groups, if at all.

More common were studies that used a study population and study sample of convenience, often in some location nearby the offices of the investigators. The few studies that were based on national data or on a sample chosen to represent the nation as a whole used data from FARS or from the National Roadside Breathtesting Surveys of 1973 and 1986. Clearly, generalizing the results of a localized study to the nation as a whole is not warranted, a fact that severely limits the usefulness of most of the *individual studies* reviewed in this report in developing national policies and strategies. However, many of these studies *are* useful for this purpose when examined in the light of other studies, providing information that can be pieced together with other information to suggest or support a hypothesis or line of inquiry. This situation is, of course, not unique to the field of traffic safety, occurring commonly in just about all of the sciences and especially in the field of epidemiology.

Another type of study that appeared rather frequently in the literature was an examination of the attributes of some high-risk drinking-driving group (usually DWIs) to identify factors that were associated with just that group. Usually, this type of study used no control or comparison group of non-DWIs, but was simply concerned with the attributes of the chosen high-risk group. Still other, more sophisticated studies used multiple comparison groups, sometimes drawing their subjects for one group from one source (for example, DWIs in a treatment program) and its subjects for another group from another source (for example, a survey of the general driving population).

The *sample sizes* used in the research reviewed in this report varied from the entire population of U.S. drivers in fatal crashes to less than 100 drivers who had been injured in traffic crashes in some city or county. The studies based on the smaller sample sizes often appeared adequate from the standpoint of sample size for detecting meaningful general effects at a reasonable level of significance. The comments on statistical power of the tests the investigators used in their analyses are based on the reviewers' experience with similar research, since none of the studies explicitly identified the power of their tests.

Most of the studies that performed statistical tests reported the level of significance determined by the test, even when the result was below the 0.05 level. However, very few of the studies reporting the *statistical* significance of their findings discussed the *practical* significance of their findings, for example, whether a statistically significant difference of 0.04 in the mean scores of two groups on a psychometric test scale with a range of 0 to 1 has any practical significance in classifying the subjects in the two groups.

For the most part, the investigators were candid and objective about their findings, offering appropriate caveats. However, there were some glaring exceptions, including the finding of one study with a sample size of 58 about adequacy of the U.S. legal system in dealing with the drinking-driving problem.

FINDINGS OF THE LITERATURE

BACs at Risk

The latest published data from NHTSA's Fatality Analysis Reporting System (U.S. Department of Transportation, NHTSA 1997) indicate a continuing downward trend in the percentage of drivers in fatal crashes who had been drinking (**Figure 3-1**). This holds both for drivers with any measurable amount of alcohol in their blood as well as those at or exceeding most states' legal limit for blood alcohol concentration (BAC) of 0.10%. For the latter group, this percentage has gone from 30% to just under 19%, a decrease of 37%.

Simpson and Mayhew (1992) examined the BAC distributions of fatally injured drivers in states that tested the BACs of at least 80% of such drivers during the 1988-1991 period. Their data showed that over 80% of all fatally injured drivers who had a measurable BAC had a BAC in excess of 0.10%. Sixty-four percent had a BAC in excess of 0.15%, and about 40% had BACs of 0.20% or above. The data indicated that this situation had changed very little over the period studied. The authors also found that, among drivers who were above 0.10%, almost eight out of 10 had BACs of 0.15% or more and about half had BACs of 0.20% or more. This situation also did not change over the period studied, indicating the large role played by the high-BAC driver in fatal crashes.

The study of data from FARS and the 1973 National Roadside Breathtesting Survey mentioned above (Connolly, Kimball, and Moulton 1989) provided additional confirmation of the general shape of the *relative risk* curve for a fatal crash developed in prior case-control studies.

Mounce and Pendleton (1992) used logistic regression techniques to estimate the probability of crash *responsibility* of the driver killed as a function of BAC. The crashes analyzed were fatal crashes occurring in Texas during 1988. Both multiple-vehicle and single-vehicle crashes were analyzed, and the results of the analyses were presented for multiple-vehicle crashes and all crashes. The results indicated a

relatively small but statistically significant difference (p=0.01) in the probability of crash responsibility as a function of BAC (**Figure 3-2**).

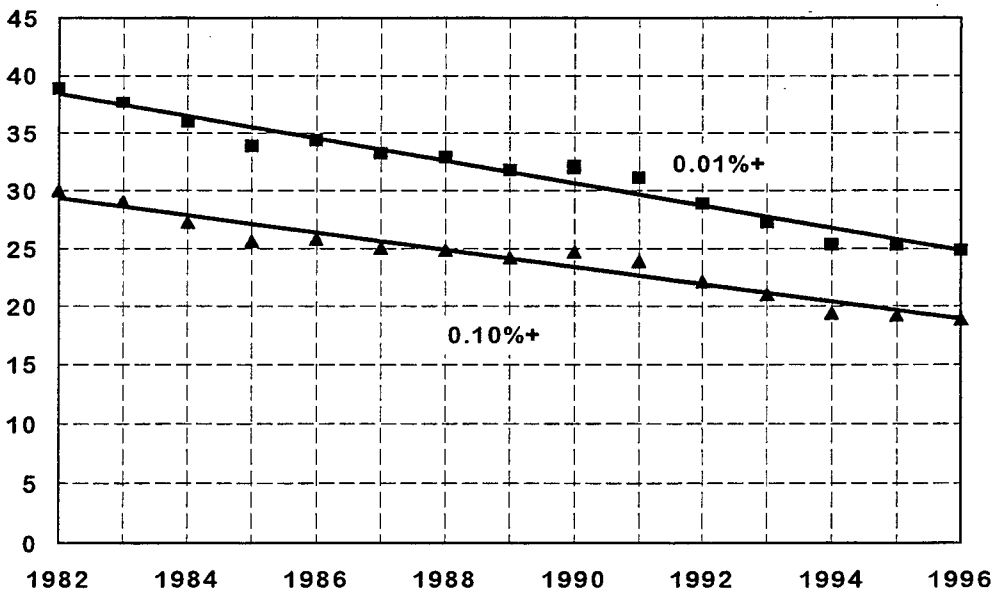
The data also indicate that the marginal change in crash responsibility between the BAC groups decreased with BAC (**Figure 3-3**). An increase in responsibility of 14.2% occurred in the 0.00-0.05 interval, compared to only 6.6% in the 0.15-0.20 interval.

A study by Wieczorek, Miller, and Nochajski (1992) has cast some doubt on the traditional view that the high-BAC driver is necessarily a "problem drinker." These researchers examined the relationship between BAC at arrest and a number of variables related to drinking patterns and alcohol abuse or dependence. 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 0.05% 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 alcohol diagnoses. 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 ($BAC \geq 0.15\%$) had slightly fewer non-critical alcohol problems. Some caution is in order for generalizing these results to high-BAC drivers or even DWIs in general, since the subjects had been referred on the basis of factors indicative of drinking problems.

A Texas study of DWI arrestees (Watson and Garriott, 1992) found that the mean BAC of the motorcycle drivers with a positive BAC was slightly lower than that of comparable car/truck drivers, 0.14% vs. 0.16% (p=0.016). The difference in mean BAC was even wider for the subjects who had been arrested for DWI after a crash, 0.11% vs. 0.17% (p =0.01).

The 1997 FARS report (U.S. Department of Transportation, NHTSA 1997) indicates that alcohol continues to be a factor in fatal pedestrian crashes (**Table 3-1**). About one-third of the pedestrians involved in fatal crashes in 1996 were intoxicated, with BACs of 0.10% or greater. The intoxication rate for the drivers involved in fatal pedestrian crashes was 11.8%, about one-third that for the pedestrians. In 5.1% of the crashes, both the driver and the pedestrian were intoxicated. These percentages have changed very little since 1988.

Figure 3-1: Percentage of Drivers in Fatal Crashes with a BAC≥0.01% and BAC≥0.10%



Source: US DOT NHTSA 1997

Figure 3-2: Probability of Crash Responsibility of Killed Driver for Fatal Multiple-Vehicle Crashes and All Fatal Crashes - Texas, 1988

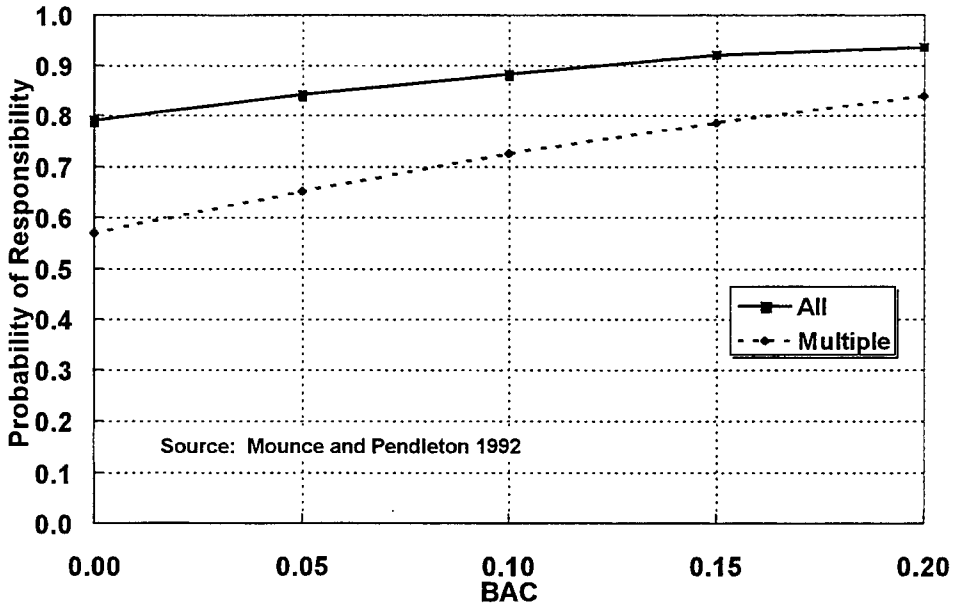


Figure 3-3: Percentage Change in Probability of Crash Responsibility with BAC for Fatal Multiple-Vehicle Crashes - Texas, 1988

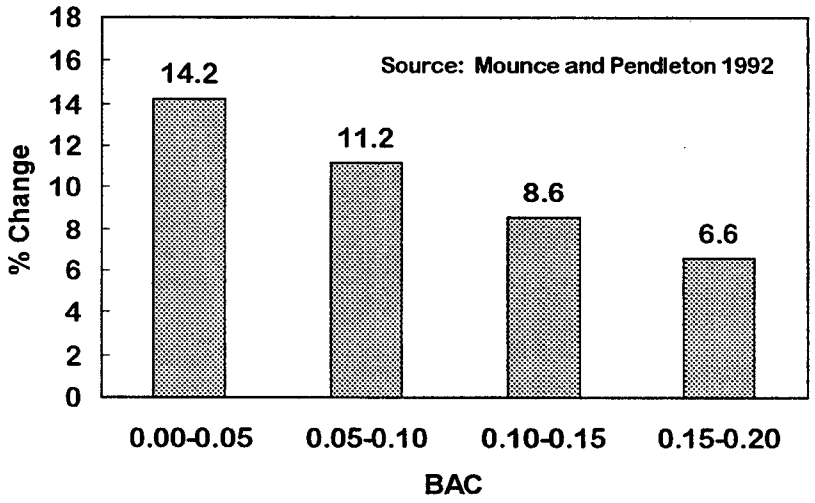


Table 3-1: Alcohol Involvement in Fatal Pedestrian Crashes, 1996

	No Driver Alcohol Involvement	Driver Alcohol Involvement, BAC 0.01–0.09 %	Driver Alcohol Involvement, BAC 0.10 % or Greater	Total
No Pedestrian Alcohol Involvement	52.7%	3.3%	5.7%	3,299 61.8%
Pedestrian Alcohol Involvement, BAC 0.01–0.09 %	4.4%	0.6%	1.0%	323 6.1%
Pedestrian Alcohol Involvement, BAC 0.10 % or Greater	24.2%	2.8%	5.1%	1,717 32.2%
Total	4,346 81.4%	361 6.8%	778 11.8%	5,340 100.0%

Source: U.S. DOT, NHTSA 1997

People at Risk

Biographical Variables. Several recent studies have examined the effect of various *biographical variables* on alcohol-crash risk. Findings with respect to each of these variables are summarized below.

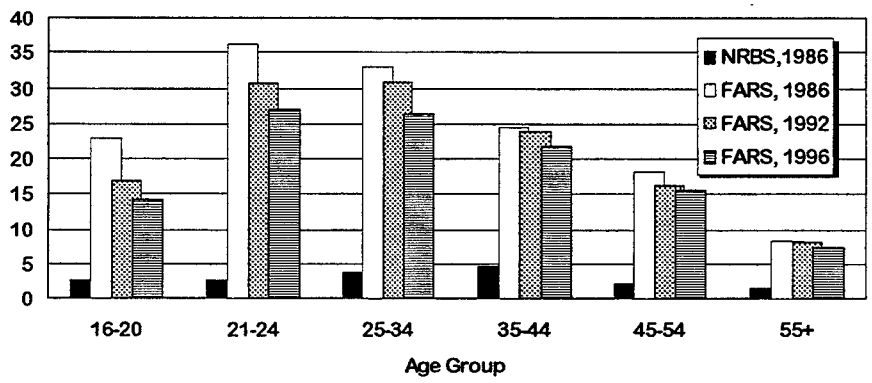
Driver Age

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.

In general, the findings of this review with respect to *driver age* tend 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. For example, the 1986 National Roadside Survey reported by Lund and Wolfe (1991) indicates that the percentage of drivers with a BAC of ≥0.10% on the road during nighttime weekend hours follows a relatively smooth curve with respect to driver age, starting at 1.4% for the 16-17 year age group, peaking at 4.7% for the 35-44 year age group, and then diminishing to about 1.5% for the over 55 years age group (See **Figure 3-4**). Data from NHTSA's Fatality Analysis Reporting System (U.S. Department of Transportation, NHTSA 1997) also indicate a fairly smooth curve for percentage of fatally injured drivers versus age group in 1986, and also in 1992. However, in 1986, this curve peaks for the 21-24 age group with a value of 36%, and for the 21-34 age group in 1992. FARS data for 1996 show a similar effect.

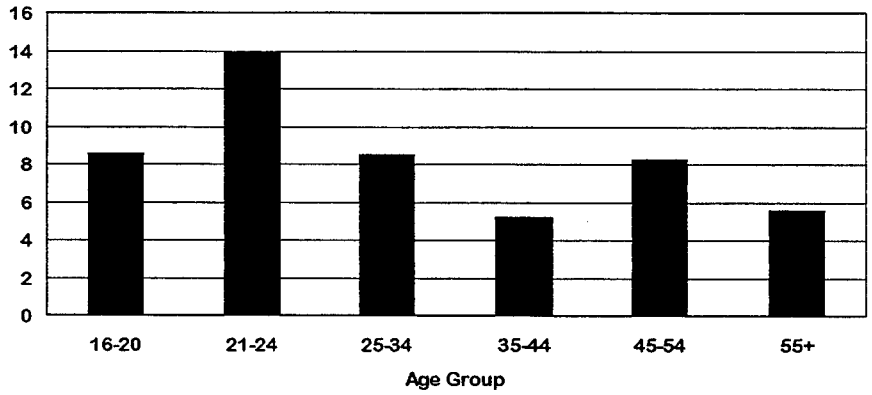
Vingilis *et al.* (1994) compared the biographical characteristics of 96 alcohol-negative and alcohol-positive drivers who had been seriously injured in traffic crashes in Ontario, Canada in the 1986-1989 time period, and referred to a regional trauma unit. The mean ages of the two groups were about 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 3-4: Percentage of Drivers of Various Ages with a BAC of 0.10% or More



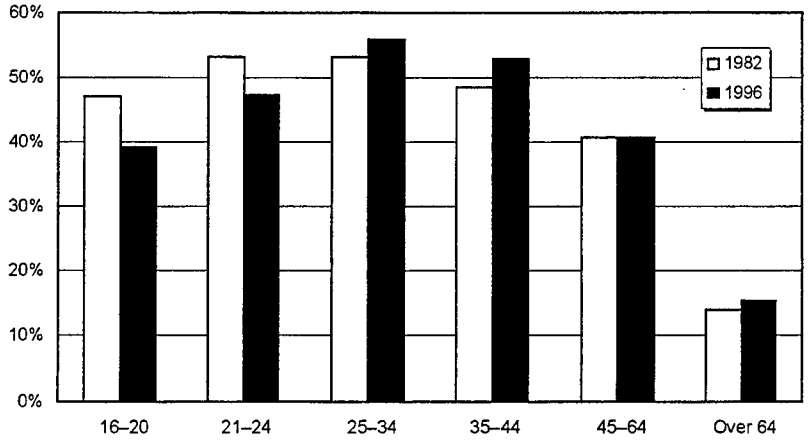
The quotient of the FARS data and the roadside data for 1986 provides a rough estimate of a driver's relative risk of a fatal crash at ≥0.10% BAC, which reaches a peak for the 21-24 age group at a value of about 14 (**Figure 3-5**).

Figure 3-5: Rough Estimate of Fatal Crash Risk at BAC≥0.10% Versus Age - 1986



FARS data also indicate that the age distribution of intoxicated pedestrians who were killed in traffic crashes is quite similar to that of intoxicated drivers, but the pedestrian distribution for 1996 is displaced slightly to the right of the driver distribution for 1996 (**Figure 3-6**). The 1996 pedestrian distribution had a peak value for the 25-34 age group, with a near-peak value for the 35-44 group. A fairly large reduction occurred for the youngest age group over the 1982-1996 period.

Figure 3-6: Percentage of Fatally Injured Pedestrians of Various Ages with a BAC of 0.10% or More, 1982 and 1996

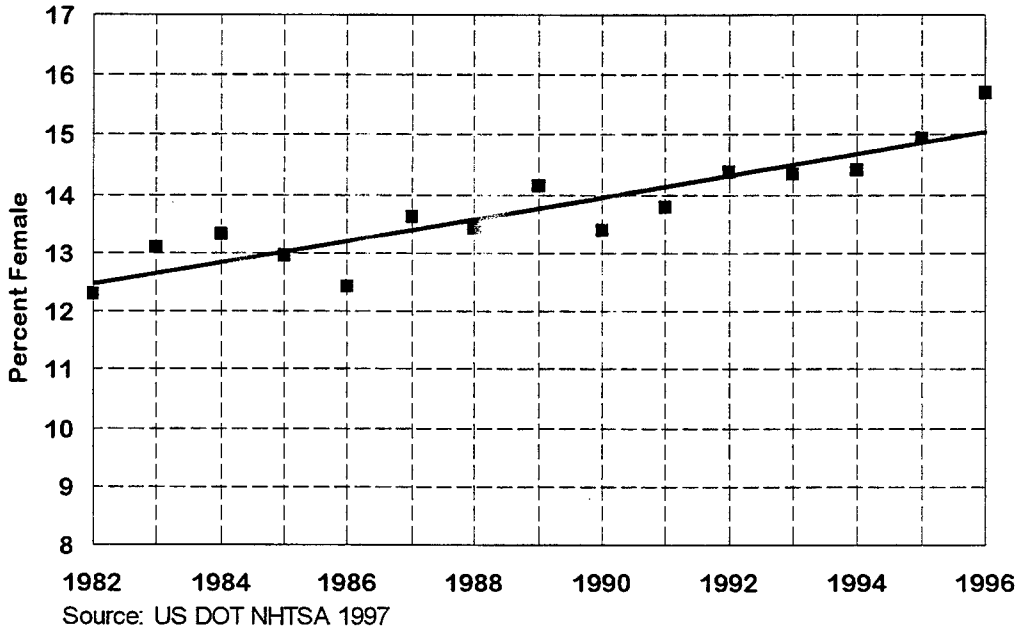


Driver Sex. Prior State Of Knowledge Updates found that a person's *sex* was found to be one of the best differentiaters of drinking drivers, with males being significantly over-represented in all kinds of drinking-driver populations. Possible explanations of this were that males simply drink more or that social customs call for males to do most of the driving at night when most drinking-driving occurs. The 1989 report found that although the alcohol-crash problem is still predominantly a male problem, the share of female drivers was increasing slightly.

Research reviewed here continues to provide evidence that males are significantly over-represented in a variety of drinking-driving populations. The latest report from FARS (U.S. Department of Transportation, NHTSA 1997) indicates that, in 1996, about 86% of all fatal-crash involved drivers with a BAC of 0.10% or more were male. Approximately 78% of the drivers who had been seriously injured in traffic crashes in Ontario, Canada (Vingilis *et al.* 1994) were male, and this figure held for both the alcohol-negative and alcohol-positive drivers. Data from the 1986 National Roadside Breathtesting Survey indicate that 90% of nighttime, weekend drivers with a BAC of 0.10% or more were male (Lund and Wolfe 1991). Shore, *et al.* (1988) report that 86% of persons arrested for driving under the influence in Wichita, Kansas in 1984 were men, and James (1990) came up with almost an identical figure for the State of Washington in 1987 (85%).

However, there continues to be some evidence that the role of women in alcohol-related fatal crashes and violations is increasing. The FARS data in the report cited above indicate an increasing trend in the percentage of women drivers with a BAC of 0.10% or more in fatal crashes since 1982 (**Figure 3-7**). A similar effect was noted in North Carolina by Popkin (1991). Shore *et al.* (1988) found that the proportion

Figure 3-7: Women Drivers with a BAC of 0.10% or More in Fatal Crashes as a Percentage of All Such Drivers, 1982 - 1996



of women arrested for DWI in Wichita, Kansas increased from 10.6% to 14.5% in the 1980-1984 period.

The analysis by Connolly, Kimball, and Moulton (1989) mentioned above suggests that female drivers have both a higher overall crash risk and a higher alcohol-related fatal-crash risk. Combined data from FARS and the 1986 National Roadside Breathtesting Survey suggest that the relative fatal-crash risk of a female driver with a BAC of 0.10% or more could be of the order of 50% higher than it is for a male driver at the same BAC. Of course, estimates based on these two unmatched data sets are, as indicated above, are only very rough, but they are consistent with prior case-control studies (see Jones and Joscelyn 1978).

Donovan *et al.* (1990) examined the driver records of a 1% sample of all licensed drivers in the State of Washington in 1979. They found that, overall, 2.1% of these 39,011 drivers were arrested for DWI during a three-year follow-up period. However, these rates were quite different for male and female drivers, the rate for males being 3.4% compared to only 0.7% for females.

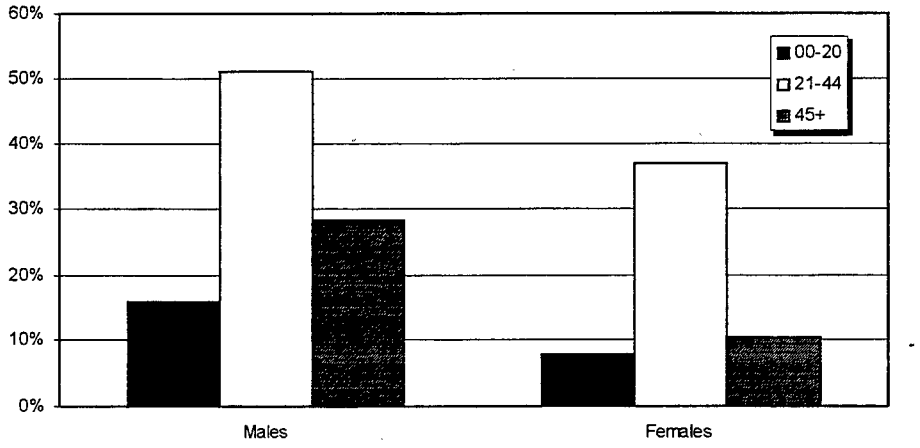
Wells-Parker and associates (1991) found a number of differences and similarities between male and female DWIs referred by the courts in 11 Mississippi jurisdictions to a follow-up project that may be useful in identifying specific target groups for countermeasures. Female DWIs were more likely to be older, Caucasian, divorced,

and unmarried, and to have no prior DWI offenses and fewer arrests for public drunkenness offenses. Further, females were only half as likely as males to recidivate in the two years following their conviction. Females and males did not differ with respect to BAC at time of arrest, nor with respect to the distribution of their Mortimer-Filkins scores. Meyers *et al.* found that males were significantly more likely to be multiple offenders than females (Transportation Research Board 1993).

Shore and associates (1988) gave the characteristics of female DWIs in Wichita, Kansas, but, for the most part, did not compare them with those of male DWIs. These researchers did note, however, that the distribution of arrests by day of the week did differ significantly for males and females, with females tending to be arrested less frequently during the weekend.

Data from FARS indicate that male non-occupants (pedestrians and pedacyclists) who have been killed in traffic crashes are also more likely to have a high BAC than are female non-occupants. This relationship holds for males and females across a range of age groups, with individuals in the 21-44 age group having the highest percentages of BACs in excess 0.10% (**Figure 3-8**).

Figure 3-8: Percentage of Fatally Injured Male and Female Non-Occupants of Various Ages with a BAC of 0.10% or More, 1996



Driver Race

The role of race in the alcohol-crash problem has rarely been addressed in prior research. 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. The 1989 update reported that data from the first report on the 1986 National Roadside Breathtesting Survey showed that the percentage of white drivers with a BAC of 0.10%+ was about half what it was in 1973, but the percentage of black drivers at these BACs had remained essentially unchanged. The most recent report on the 1986 survey (Lund

and Wolfe 1991) found that 5.9% of blacks had a BAC of 0.10% or more compared to 2.7% for whites (p=0.03). Hispanics were also over-represented compared to whites (4.4%), but this difference was not significant because of the small number of Hispanics (124) in the sample and the small percentages involved. Further, the percentage of white drivers with a BAC of 0.10% or more declined nearly 90% from the 1973 roadside survey (5.1% to 2.7%), while the percentages of black drivers and Hispanic drivers with a BAC of 0.10% or more stayed about the same.

Popkin and Council (1993) examined crash data in North Carolina to determine the role of white and non-white drivers. Their findings on fatally injured drivers are of particular interest, since BACs were available. Their data indicate that 51% of non-white drivers and 49% of white drivers had a BAC of 0.10% or more, but this difference is not statistically significant (p=0.30).

However, there were significant differences in North Carolina with respect to race for various age and sex subgroups of drivers. For example, 58% of male non-white drivers had a BAC of 0.10% or more compared to 53% of male white drivers (p=0.009). The higher percentage of male non-white drivers was due to a much higher percentage with 0.10% or more in the over-24 years age group -- in the under-25 years age group, a higher percentage of white males had a BAC of 0.10% or more than did non-white males.

The picture was different for female non-white drivers, with only 23% having a BAC of 0.10% or more compared to 40% of female white drivers. The higher percentage for female white drivers was due to much higher percentages in the under-25 years age group and the over-54 years age group. White and non-white females in the 25-54 age group had about the same percentage of ≥0.10 drivers, 25% and 22%, respectively.

James (1990) examined the characteristics of non-white drivers who had been arrested for DWI in the State of Washington. He found that non-whites comprised 10.5% of the total DWI population. Among non-whites, 11% were Asian, 33% were African-American, 36% were Native American, and 20% were "unknown." His data indicate a small but significant (p=0.007) difference between whites and non-whites with respect to sex (15.7% of whites were female versus 13.8% of non-whites). With respect to age, James' data indicate highly significant (p=0.0000) differences between whites and non-whites, with the differences occurring in the under-30 (38% of non-whites versus 51% of whites) and 30-49 (53% of non-whites and 40% of whites) age groups.

James also compared the percentage of various ethnic groups in the DWI population with percentages in the general population and found that Asian-Americans were under-represented in the DWI population by a factor of about 3 to 1, blacks were over-represented by a factor of 1.25 to 1, and Native Americans were over-represented by a factor of 2.53 to 1. Data on Hispanics were not available in the James study, but Tashima and Helander (1993) found that Hispanics are substantially over-represented (38%) among DWI arrestees in California compared to their adult population representation (22%), a factor of 1.73 to 1. The degree to which any

racial biases among the arresting officers may have influenced these figures is not known.

Using factor analysis, James identified five different profiles of non-white DWIs which he thought might be appropriate for the development of specially-targeted countermeasures:

- non-white female homemakers;
- Blacks in the military;
- unemployed non-whites from blue-collar occupations;
- Asian-Americans in unstructured jobs; and
- Older, unemployed non-whites from unstructured jobs.

The relative contributions of these sub-groups to the DWI problem were not discussed.

While the objective data cited above tend to indicate a general over-representation of blacks and Hispanics in various drinking-driving populations, survey results of self-reported drinking-driving indicate the opposite. A national survey of drunk driving by Herd (1989) found that 10.4% of black men and 2.1% of black women reporting drunk-driving as a problem they had experienced, compared to 27.2% of white men and 10.8% of white women.

Finally, Ross *et al.* (1991) reviewed the literature on drunk driving among blacks and Hispanics in the U.S. *circa* 1990 and concluded that "most of the research supports the view than American Blacks and Hispanics are disproportionately more likely to be drunk drivers," but that "the general relationship seems to be reduced or even reversed for minority youth." These conclusions are consistent with the data cited above. Ross and associates also noted that studies based on self-reported behavior contradict those based on official statistics.

Other Biographical Variables

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. With respect to *driver employment status*, prior updates suggest that unemployed drivers are over-represented among high-BAC drivers on the road and the present update reinforces this finding. Data from the 1986 National Roadside Breathtesting Survey showed that 3.3% of employed drivers had a BAC of 0.10% or more, compared to 5.6% of unemployed drivers. However, because of the small sample size for unemployed drivers, this difference was significant only at about the 0.16 level. Figures for other categories of employment were not meaningful, again, because of the small sample sizes.

The study of seriously injured drivers in Ontario, Canada revealed even larger 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 Ontario data indicate 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 is 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.

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 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 0.10%+ compared to 2.2% of drivers with a bachelor's degree or more. The Ontario study found no meaningful nor significant differences among drivers of different numbers of years of formal education with respect to BAC level, mainly because of the very small number of subjects in the unemployed group.

Various studies reviewed in this report have examined the biographical variables associated with *drivers arrested for or convicted of DWI*. These studies provide information on biographical variables that were not discussed in prior updates, including employment status, marital status, and education. For example, the study by James cited above found that 14.2% of the 19,235 DWIs with usable records were unemployed. This is very close to the percentage of unemployed in a sample of 5,051 DWIs referred to a treatment program in New York State in 1992 (Nochajski, Miller, and Wieczorek 1992). The Wichita, Kansas data (Shore *et al.* 1988) show an even higher percentage (31%) of unemployment among *female* DWIs. By contrast, data from the 1986 National Roadside Breathtesting Survey indicates that less than 5% of its sample of drivers (male and female) using the roads during weekend nighttime hours were unemployed.

The study by Wells-Parker and associates of Mississippi drivers assigned to a DWI intervention study found that only 18% of the female subjects were *single* (never married), compared to 29% of the male subjects ($p<0.01$). About 43% of the New York State sample of DWIs of both sexes were single, while the Ontario study of seriously injured drivers found that 37% of its cases (male and female) were single. The single drivers and non-single drivers in the Ontario study had the same percentage of BAC-positive drivers (23%).

The Mississippi study also found that 28% of its female subjects were *married*, compared to 43% of its male subjects. The Wichita study also found that 28% of its female DWIs were married, but no figures were given for males. About 36% of the

New York DWIs of both sexes were married, and 46% of the Ontario subjects were married.

Finally, a study by Wilson (1992) included a comparison of the self-reported biographical characteristics of a group of DWIs in Ontario, Canada with those of three other groups of drivers: drivers who had been involved in three or more reportable accidents in the past three years; drivers who had accumulated nine or more demerit points on their driver record over the past three years; and a control group of drivers who were a random sample of all drivers in the province. The groups were matched by age and sex by constructing a "target" distribution from the combined distributions of the three non-control groups. Target proportions for each age-sex cell were then applied uniformly across groups through a process of quota sampling. **Table 3-2** shows how the four groups compared with respect to education, marital status, and employment status and indicates significant differences among groups with respect to each of these variables.

Table 3-2: Biographical Characteristics of Study Groups, (Wilson, 1992)

Variable	Group				
	DWI	Accident	Demerit	Control	p
Education (%)					0.001
Elementary only	7.2	9.8	2.1	5.9	
Some secondary	26.6	22.5	21.8	16.7	
Grade 12	32.9	29.6	38.0	28.8	
Some postsecondary	12.7	17.6	19.0	18.6	
College diploma	8.4	10.6	8.5	8.9	
Degree	12.2	9.9	10.6	21.2	
Marital Status (%)					0.001
Single	36.3	23.9	48.6	29.2	
Married/cohab.	46.4	68.3	44.4	62.2	
Sep./div./wid.	17.3	7.8	7.0	8.6	
Employment status (%)					0.010
Employed	88.1	85.2	82.4	82.5	
Unemployed	6.8	5.6	8.5	4.1	
Other	5.1	9.2	9.1	13.4	

Differences between the DWI group and the control group are especially interesting, since the studies of DWIs cited above did not compare DWIs with the general driving population. With respect to *education*, the two groups compare quite

well, except that the DWI group had a much smaller percentage of subjects with a college diploma. With respect to *marital status*, the DWIs were more likely to be unmarried, and with respect to *employment status*, the DWIs were more likely to be unemployed. Also, the DWIs group had a much smaller percentage of "other" employment categories (for example, student, homemaker, and retired) than did the control group.

Drinking Variables. Prior updates have presented considerable information on the effect of various drinking-related variables on alcohol-crash incidence and risk. They reported that beer is the preferred *type of alcoholic beverage* of drinking drivers by a large margin, especially among high-BAC drivers and by drivers reporting that they were heavy drinkers. *Persons with severe drinking problems* were found to be over-represented among fatally injured drivers with high BACs and among drivers who were judged responsible for the crashes in which they were killed.

We found no recent studies of the effect of drinking patterns on alcohol-crash risk, but several studies have examined various drinking-related variables for groups of drivers, and these studies expand the knowledge base in this area.

The 1986 National Roadside Breathtesting Survey (Lund and Wolfe 1991) presented data on the *drinking habits and most recent alcohol beverage* of drivers using the roads during weekend nighttime hours. The survey data indicate that 3.8% of the drivers who reported that they were very light or fairly light drinkers had a BAC of 0.10% or higher. However, 6.7% of drivers reporting that they were moderate to very heavy drinkers had a BAC of 0.10% or higher. Looked at another way, these data indicate that 35% of the ≥0.10% drivers were moderate to very heavy drinkers compared to only 22% of the drivers with a BAC of less than 0.10%. The survey data were consistent with earlier research indicating the preference of drivers for beer and wine over distilled spirits -- 78% of the ≥0.10% drivers and 69% of the other drivers preferred beer or wine over distilled spirits.

Data from the study by Vingilis *et al.* (1994) of drivers who had been seriously injured in traffic crashes in Ontario, Canada indicate that the drinking patterns of BAC-negative and BAC-positive differ along several dimensions that reflect heavy drinking. For example, 7% of the BAC-negative drivers and 15% of the BAC-positive drivers said that they had been intoxicated "many times" over the past 30 days. Similarly, 7% of the BAC-negative drivers and 14% of the BAC-positive drivers said that they drank every day over the past 30 days. Further, 4% of the BAC-negative drivers and 14% of the BAC-positive drivers reported a self-perceived drinking problem. On the other hand, the study by Wilson (1992) of various groups of Ontario drivers indicated that the crash-involved group (not necessarily "serious" crashes) had slightly more drinks per week and drinks per drinking occasion on the average than did the control group, but that the drinking frequency of the two groups was the same.

Recent studies continue to provide strong evidence of patterns of heavy drinking and alcohol abuse for DWIs as a group. For example, Nochajski, Miller, and Wieczorek (1992) found that a group of DWIs referred to an alcohol treatment

program in western New York State had consumed five or more drinks per drinking occasion (a measure of "binge" drinking) on the average six to eight times in the past 30 days. Donovan *et al.* (1990) reported that a group of "high-risk" drivers who subsequently were arrested for DWI during a one-year follow-up period also had consumed five or more drinks per drinking occasion an average of 8.3 times in the past 30 days. By comparison, high-risk drivers who were *not* arrested for DWI during the same follow-up period had consumed five or more drinks per drinking occasion an average of *3.9 times* in the past 30 days.

Another study by Wieczorek, Miller, and Nochajski (1992) applied criteria from the third edition of the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders (DSM-III and DSM-IIIR) to the diagnosis of alcohol dependency of DWIs referred to a treatment program by the court. Their data indicate that, by these criteria, over 70% were alcohol abusers and that some 10% to 50% were alcohol-dependent. Data collected by Windle and Miller (1989) for a similar group of DWIs from the same area indicate that one-half of female subjects and two-thirds of male subjects had attended Alcohols Anonymous sessions. Further, about 6% of the females and 12% of the males in this group had been treated for alcohol abuse in the past.

Driving Variables. Prior updates have indicated that drinking-driving was primarily a nighttime phenomenon, with drinking drivers being found some two to four times as often in nighttime crashes as in daytime crashes. *Day of the week* was also found be a strong differentiator of drinking-driving, with more alcohol-related crashes and more drinking drivers found on the weekend than on weekdays. The *origin of the trip* which involved drinking-driving was most frequently bars or taverns and other persons' homes. The 1989 update reported that high-mileage drivers, drivers visiting friends, and drivers who were traveling for cultural or recreational purposes appeared to defy the general downward trend toward less involvement in higher-BAC driving, remaining about the same in this respect as they were in 1973.

Some data were obtained in this update on some driving-related variables that had not been discussed in prior updates. For example, data from the 1986 National Roadside Breathtesting Survey (Lund and Wolfe 1991) of nighttime, weekend drivers permit comparison of such drivers with illegally high BACs with other such drivers with respect to vehicle occupancy, driver belt use, annual mileage, and trip purpose (**Table 3-3**). The table indicates that, compared to the less-than-illegal BAC group, the illegal-BAC group ($\geq$0.10) had higher percentages of: vehicles with a driver alone; unrestrained drivers; high-mileage drivers; and drivers whose trip purpose was traveling to or from drinking/eating places or visiting friends. However, only the last factor was statistically significant because of the relatively small case numbers in the illegal-BAC group. The study by Wilson (1992) also found that the DWI group had a lower restraint-usage rate than did the control group of drivers in general.

Data from the study by Vingilis *et al.* (1994) showed that the percentage of drivers with at least one license suspension in the BAC-positive group was about four times that in the BAC-negative group. By contrast, the percentage of drivers with

Table 3-3: Comparison of Drivers with Illegal BACs with Other Drivers on Various Driving-Related Factors

Factor	Group		p
	Illegal BAC	< Illegal BAC	
% driver alone	47.2	41.0	0.2570
% restrained	33.4	41.5	0.1580
% over 20k annual mileage	25.2	19.8	0.2090
% to eating/drinking/visiting	77.8	60.1	0.0003

Source of data: Lund and Wolfe 1991

one or more traffic convictions on their record was about the same for the two groups. Interestingly, only 23% of the BAC-positive group was a driver education graduate as compared to 60% of the BAC-negative group.

Both the Wilson study and the study by Vingilis and associates administered scales on driving-related attitudes among their study groups, but neither found any meaningful differences with respect to the various measures. In addition, the Wilson study presented data on the driving histories of its four study groups, the data indicating that, compared to the control group, the DWI group had: about the same number of crashes, a higher number of traffic violations (a mean of 2.7 for the DWIs compared to 1.8 for the controls), and a much higher number of license suspensions (a mean of 1.7 for DWIs versus 0.2 for controls).

Drinking-Driving Variables. Prior updates indicated that drinking drivers had slightly more previous crashes and substantially more enforcement actions (including DWI) against them than did other drivers. The only available recent U.S. data on the incidence of drinking-driving come from the 1986 National Roadside Breathtesting Survey (Lund and Wolfe 1991) of nighttime, weekend drivers. These data are discussed throughout this synthesis section as they apply to drivers with various characteristics.

Other recent studies have collected data on prior drinking-driving incidents among various groups of drivers. For example, driver record data from Donovan (1993) indicate that some 14% of male drivers of age 21-25 years in Colorado had a prior alcohol-related driving conviction, compared to only about 3% of female drivers in the same age group. Self-reported data from the paper by Wilson (1992) discussed above indicate an average of 3.7 driving while impaired incidents during the past 30 days for the DWI group compared with 1.4 for the control group. The figure for DWIs is consistent with data from Wieczorek, Miller, and Nochajski (1992) who report 2.5 to 4.0 DWI incidents during the past 30 days for their study group of DWIs. Wieczorek, Mirand, and Callahan (in press) report that 23% of their 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. Driver record data from the study by Wieczorek, Miller, and Nochajski (1989) indicate an average of about two prior DWI arrests on the records of 461 drivers referred to an alcohol-treatment program in New York State. Wells-Parker and associates collected driver record data from the State of Mississippi which showed that of 3,339 DWIs assigned to a DWI treatment program, 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.

There is also evidence that drivers with prior DWIs are more likely to be involved in severe traffic crashes than are other drivers. Data from FARS (Fell 1991) show that, in 1988, 3.3% of all licensed drivers had been arrested for DWI in the past three years, but 5.7% of all fatally injured drivers had been arrested for DWI in the past three years. This indicates that drivers with prior DWIs were over-represented in fatal crashes by a factor of about 1.8. Vingilis *et al.* (1994) found that their BAC-positive group of seriously injured drivers had five times the percentage of subjects who reported having driven at least once during the past month with a BAC of 0.08% or more than did the BAC-negative group (38% versus 7%).

The study by Donovan *et al.* (1990) which examined the driver records of 39,011 Washington State drivers illustrates the effect of having a prior arrest for DWI on the probability of a subsequent arrest for DWI. Nearly 20% of the drivers with priors were arrested again during a three-year follow-up period, compared to only 2.0% of the drivers with no priors. As indicated above, other variables also influence DWI arrest probability, including driver sex and driver age. In the study by Donovan and associates, males from the general driving population were five times as likely to be arrested for DWI during the follow-up period as were females. Further, 2.7% of drivers less than 30 years were arrested for DWI during this period compared with only 1.7% of drivers 30 years and older.

Personality and Psychosocial Variables. The 1978 update found evidence that several *personality and stress* variables were associated with drinking-driving, including alienation and hostility, belligerence, and negativism, but concluded that these findings were not conclusive or amenable to generalizing. The 1989 update found that subsequent research provided support for the hypothesis that drivers with a variety of behavioral problems are a factor in the drinking-driving problem, but did not provide a basis for estimating the relative importance of the role of such drivers in that problem.

A growing number of research studies are examining the influence of personality and psychosocial factors on the alcohol-crash problem, and some of these are directly related to the identification of target groups for DWI countermeasures. Several of these studies have been cited above. As we indicated in the 1989 update, the research designs involve a survey research approach, sometimes augmented by driver records data from state files. Usually, the questionnaires are self-reports, but they may also involve personal interviews and the use of psychometric scales. Sample sizes for the

better studies range from a few hundred to several thousand. Populations surveyed include those of known high risk (for example, DWIs and drivers with multiple driving offenses or crashes in a recent time period), drivers in general, and special groups of drivers (for example, youthful drivers). Sophisticated multivariate statistical techniques are often used in analyzing the data. Much of this work has been done in Canada.

The above discussion has referred to the 1992 study by Wilson comparing four groups of drivers in Ontario, Canada on a number of variables. Wilson also collected and analyzed data on a number of personality and "lifestyle/social influence" variables (see **Table 3-4**). As indicated above, the four groups were: DWIs; drivers who had been involved in three or more reportable accidents in the past three years; drivers who had accumulated nine or demerit points on their driver record over the past three years; and a control group of drivers who were a random sample of all drivers in the

Table 3-4: Personality and Lifestyle/Social Influence Variables Analyzed by Wilson (1992)

Personality Variables	Lifestyle/Social Influence Variables
Verbal hostility	Tobacco use
Assaultiveness	Drug use
Sensation seeking	Personal problems
Impulse expression	Parental compatibility
Depression	Peer influence
External control	Religiosity
Responsible values	

province. In addition, results were presented for a fifth group defined as the combination of the accident group and the demerit group (the so-called "high-risk" group). With respect to the personality variables, there were no significant differences among the groups on perception of control, depression, or responsible values ($p>.0.05$). On the other measures, the control group had the lowest level, and the DWI group had the highest.

Reporting on the results of an analysis of covariance of the personality variables (age and education as covariates) Wilson states:

> "On sensation-seeking, the DWI, high-risk, and control groups were significantly separated, while on impulse expression, the contrast between the high-risk and DWI groups were only marginally significant ($p<0.10$). On assaultiveness, the DWI subjects differed from the

> control subjects, while the high-risk group members were intermediate, but did not differ significantly from either group. A similar pattern was observed on verbal hostility, but the overall F was nonsignificant. No differences were found between the accident and demerit groups." (pp. 339-340).

The age covariate was highly significant ($p<0.001$) for all personality variables except depression and external control. Younger respondents scored higher on verbal hostility, assaultiveness, sensation-seeking, and impulse expression, and older respondents scored higher on responsible values. Education was also significantly related to all measures except sensation-seeking ($p<0.05$ for assaultiveness and impulse expression, and $p<0.001$ for the others), with a higher education being associated with lower scores. Unfortunately, the values of each group's mean scores on the scales were obscured due to rounding, so that the *amount* of the differences among the groups could not be ascertained for most of the personality variables.

Another series of analyses of covariance was conducted on the lifestyle/social influence variables. It revealed significant differences with respect to four of the six variables studied, tobacco use ($p<0.001$), drug use ($p<0.001$), personal problems ($p<0.05$), and parental compatibility ($p<0.001$). Tobacco use was higher for the high-risk group than for the control group, but the high-risk group and the DWI group had essentially the same extent of tobacco use. The highest percentage of drug use (marijuana, amphetamines, and cocaine) was found among the DWI group, followed by the high-risk group and then the control group. The DWI group and the high-risk group each had significantly more personal problems and less compatibility with parents than did the control group.

Again, age as a covariate was negatively related to many of the lifestyle variables, outweighing the effect of group membership on measures indicative of risk-taking, impulsiveness, and aggression. Education also had the expected effect, being associated with, for example, lower use of drugs and tobacco and a better adjusted personality.

Much of the recent research into the influence of personality and psychosocial factors on drinking-driving has been directed toward youthful drivers. Donovan (1993) examined the behavioral and psychosocial characteristics of young adults in this high-risk age group, finding that drinking-driving in this group is related to a number of other behaviors that increase traffic crash risk, for example, driving after using marijuana and other illicit drugs, and violating other traffic laws. Youthful drinking-driving was also related to other problems such as problem drinking and illicit drug use. Donovan found that the correlations among these behaviors were explained by a single underlying factor, suggesting that drinking-driving is a part of a larger syndrome of problem behavior in young adults. Other recent research (Wilson 1992; Gruenewald, Stewart, and Klitzner 1990) has also found evidence of this problem behavior syndrome among youthful drivers.

Donovan also found that youthful drinking-drivers tended to show higher levels of personality and social unconventionality, including enjoying risk-taking. Hayes and Swisher (1991) concluded that negative social behaviors and social activity

participation are critical precursors to the drinking and driving problem among adolescents.

Recent research does not provide much evidence to suggest that young drivers may take risks because of misconceptions about the hazardousness of driving after drinking, although one study (Martens, Ross, and Mundt 1991) found that a sample of university students who were heavy drinkers judged that there was significantly less driving impairment due to alcohol than did light or moderate drinkers in the case of overall driving ability.

Connolly, Kimball, and Moulton (1989) computed risk factors as a function of several variables using crash data from FARS (1976-1981) and non-crash data from the 1973 National Roadside Breathtesting Survey conducted by The University of Michigan. They used logistic regression analysis to examine the contributions of various factors to the relative risk of a fatal crash and found that even after controlling for BAC, youth alone increased the risk of a fatal crash.

These findings suggest that impairment alone may not be behind the higher risk of alcohol-related crashes for young drivers. A proclivity toward problem behavior in general and, possibly, a lower perception of the increased impairment and crash risk due to drinking may exacerbate the impairing effects of alcohol on driving for this group.

Research by Mookherjee (1988) on a group of 800 drivers selected from DWIs who had been referred to an educational rehabilitation program in rural middle Tennessee provides some evidence that such individuals with certain personality and psychosocial attributes may be more prone to traffic crashes than are other drivers. Drivers who reported they had been involved in one or more crashes were more guided by peer influence in their decisions (mean score of 9.54 for the crash group versus 10.09 for the non-crash group, $p<0.005$). Drivers from the crash group also indicated less satisfaction with their job and their leisure activities than did the drivers from the non-crash group.

There is evidence that DWIs who have also been diagnosed as alcohol-dependent have levels of psychiatric symptomatology that are significantly higher than those of the "normal" population. Pristach *et al.* (1991) compared the scores of 184 DWIs on the somatization, obsessive-compulsive, depression, anxiety, and psychoticism subscales of the SCL-90-R, as well as the global severity index for these subscales, with those of 974 non-patient "normals" and 806 psychiatric outpatients. They found a linear trend for the levels of psychiatric symptomatology, with the non-patient normals reporting lower levels of symptomatology than alcohol-dependent DWIs, who in turn had a lower level of symptomatology than psychiatric outpatients. By comparison, the global severity index for the alcohol-dependent DWIs was about *three* times that of the non-patient normals, while the global severity index for the psychiatric outpatients was about *four* times that of the non-patient normals. These findings are of particular interest given the high levels of alcohol dependency among DWIs (Wieczorek, Miller, and Nochajski 1992; Windle and Miller 1989).

Finally, the role of personality and psychosocial factors in drinking-driving among drivers of all ages (not necessarily "youthful") who have already been identified as "bad drivers" was examined in a paper by Donovan, Umlauf, and Salzberg (1990). In this study, a bad driver was defined as a driver who had accumulated four traffic-related convictions and/or crashes within a one-year period, or five such incidents within two years. These researchers found that during a three-year follow-up period, 11.4% of the bad drivers had been arrested for DWI. Extensive scales measuring risk-enhancing attitudes, general personality functions, and hostility were administered to those who were subsequently arrested for DWI and also to those who were not detected. No significant difference was found between these two groups with respect to any of these classes of variables ($p>0.50$). The amount of the differences between the groups was not indicated in the paper.

Table 3-5: Mean Scores on Personality and Psychosocial Factors From Vingilis *et al.* 1994

Trait	Group	
	BAC-negative	BAC-positive
Assaultiveness	2.86	3.00
Verbal hostility	5.91	5.64
Resentment	1.64	1.50
Depression	1.77	1.68
Social deviation	1.70	1.27
Impulse expression	3.14	3.09
Social introversion	2.43	1.55
Self-depreciation	0.86	0.68
Sensation-seeking	2.04	2.05
Internality-externality	1.51	1.14
Social desirability	6.31	6.59

The study by Vingilis *et al.* (1994) also examined personality and psychosocial factors associated with what might be termed a high-risk group of drivers, seriously injured drivers who had been admitted to a regional trauma unit in Ontario. About 23% of these drivers had a positive BAC. Eleven different traits including most of those measured by Donovan and associates were measured for the BAC-positive group and the BAC-negative group. The results are shown in **Table 3-5**. Because of the small sample size, none of the differences shown was significant at the 0.05 level.

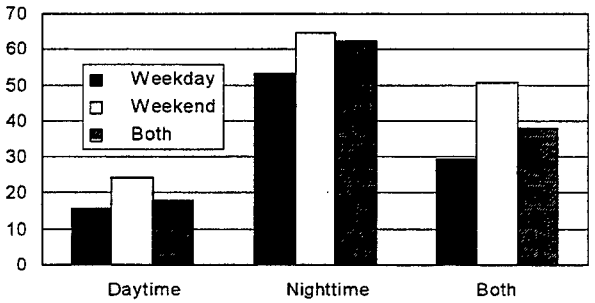
The findings from these two studies suggest that deviance from personality and psychosocial norms are associated with risky driving in general of which drinking-driving is just one component. However, such a generalization must be viewed with

caution, because of the small sample sizes of these studies. The sample size used in the study by Donovan and associates was 254, with only 29 of these belonging to the group with a subsequent DWI. The study by Vingilis and associates had a sample size of 96, with only 22 of these belonging to the BAC-positive group.

Environmental Situations at Risk

Day of Week and Time of Day. Prior updates have clearly shown that alcohol-related crashes occur more frequently during the weekend and during nighttime hours than on weekdays and during daytime hours. Data from FARS (U.S. Department of Transportation, NHTSA 1997) indicate that this continues to be the case. In 1996, approximately 38% of drivers killed in the U.S. were alcohol-positive, that is, had a BAC of 0.01% or more (**Figure 3-9**). Approximately 50% of drivers killed during the weekend were alcohol-positive compared to 29% of drivers killed during weekdays. Similarly, 62% of drivers killed during nighttime hours were alcohol-positive com pared with only 18% of drivers killed during daytime hours. As might be expected, the group of drivers killed during weekend, nighttime hours had the highest percentage with a positive BAC (65%), while the group killed during weekday, daytime hours had the lowest (16%).

Figure 3-9: Alcohol-Positive Drivers As A Percentage of All Drivers Killed During Weekends, Weekdays, Daytime, and Nighttime



Source: US DOT NHTSA 1997

Data for drivers with higher BACs were not presented in the FARS report as a function of time of day and day of week. However, we developed a time-of-day distribution directly from the FARS 1996 data base available on a CD-ROM (**Figure 3-10**). The figure shows a characteristic peaking in the early morning hours, followed by a rapid decline to a minimum at 7:00 a.m. to noon, and then a steady rise from 3:00 p.m. to midnight.

No comparable new data were available for drivers not involved in crashes. (The 1986 National Roadside Breathtesting Survey was conducted during nighttime, weekend hours only.) However, Stein (1989) developed an estimated distribution for three classes of drivers differentiated by BAC (<0.01%, 0.01-0.09%, and ≥0.10%) from data from the 1973 roadside survey, the 1986 survey, and other considerations. These data are plotted in **Figure 3-11** for drivers with a BAC of 0.10% or more, indicating a peak percentage of about 8% in the 2 a.m. - 3 a.m. period.

Figure 3-10: Time-of-Day Distribution of Fatal-Crash Involved Drivers with a BAC ≥ 0.10%, FARS 1996

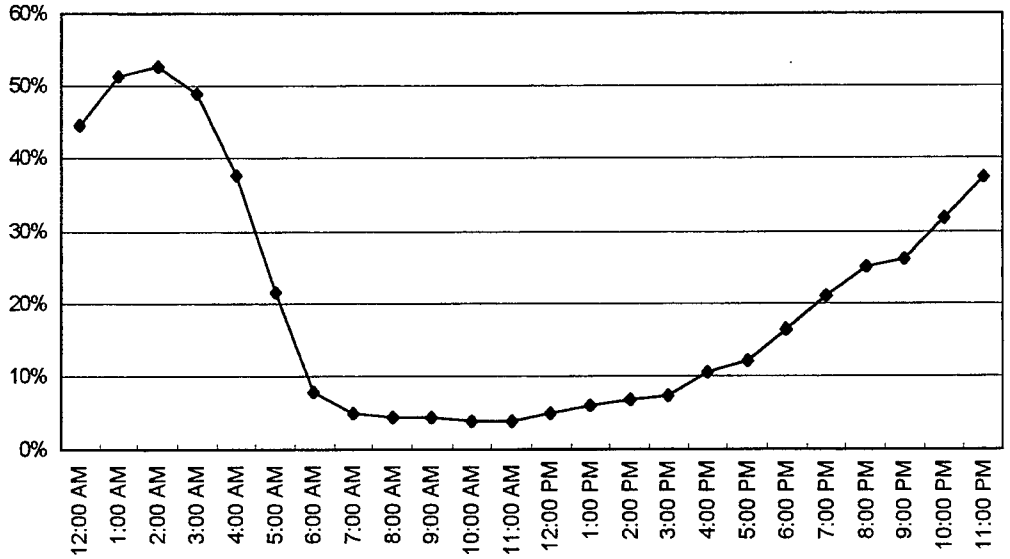
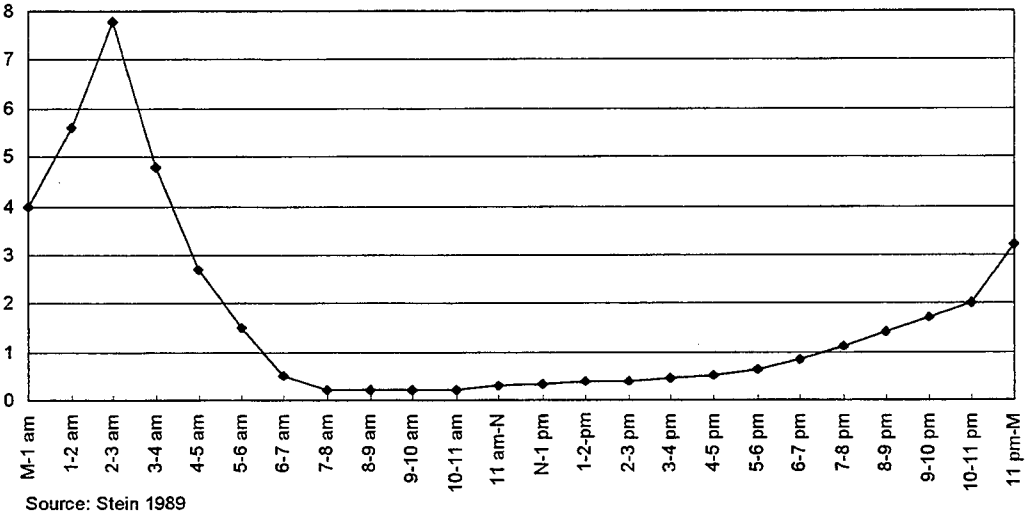
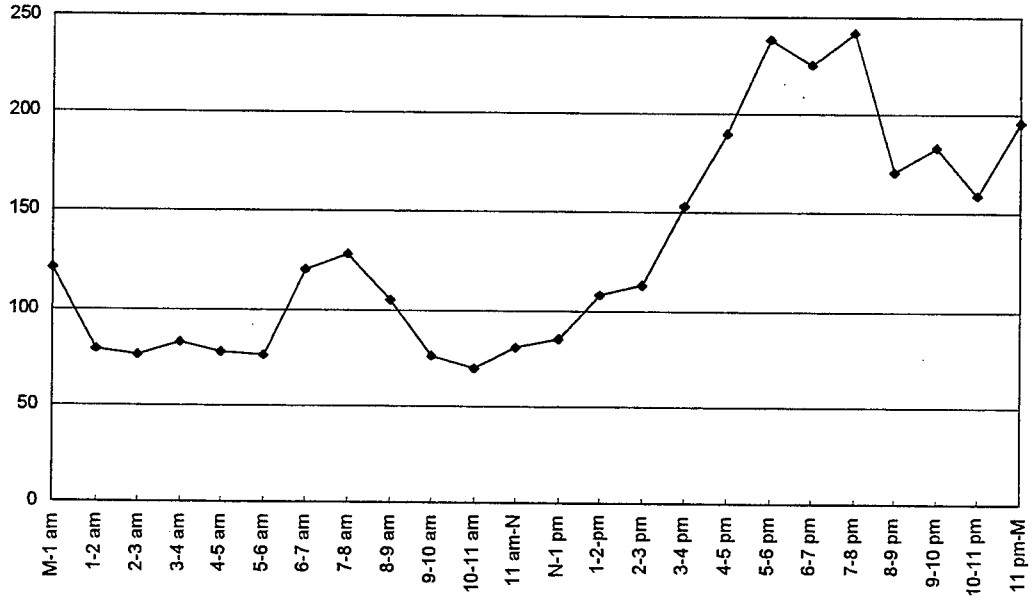


Figure 3-11: Estimated Percentage of Drunk Drivers On the Road Versus Time of Day



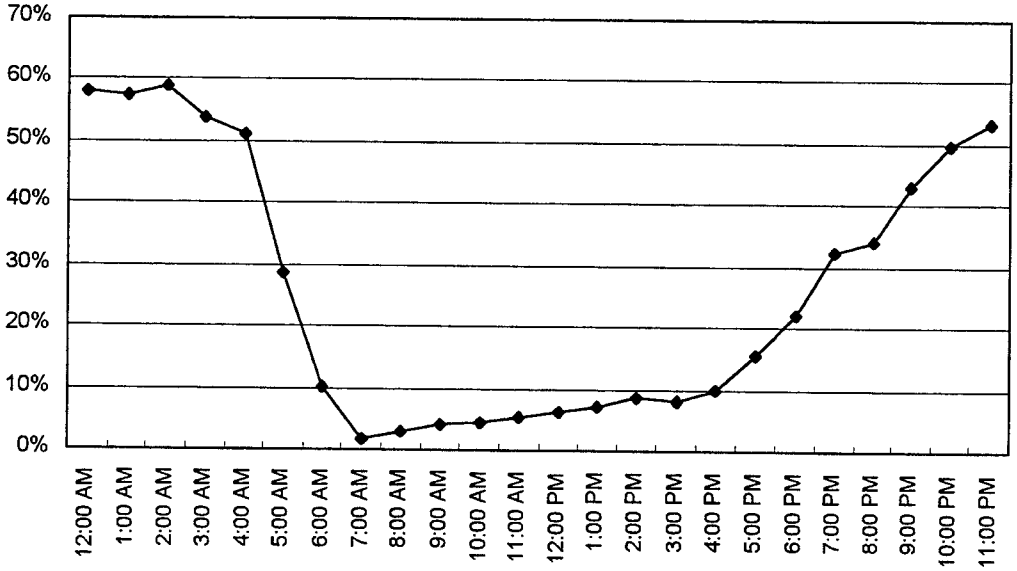
Source: Stein 1989

Figure 3-12: Calculated Relative Risk of a Single-Vehicle Fatal Crash Versus Time of Day - Driver BAC≥0.10%



Source: Stein 1989

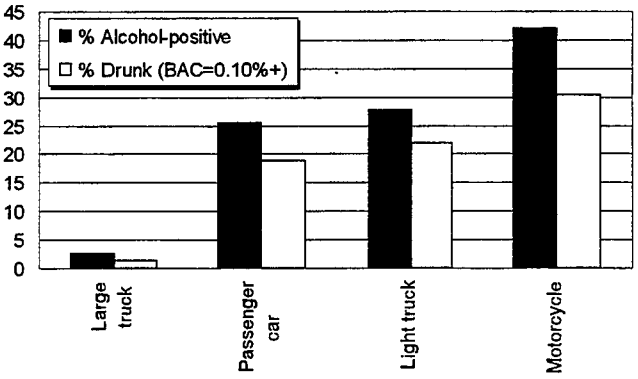
Figure 3-13: Time-of-Day Distribution of Fatally-Injured Involved Non-Occupants with a BAC ≥ 0.10%, FARS 1996



Stein also developed an estimate of the *relative risk* of a single-vehicle fatal crash versus time of day using these data combined with crash data from FARS (**Figure 3-12**). Interestingly, the highest relative risk for a driver with a BAC of 0.10% or more (238 times that of a sober driver) occurs during the evening rush hours, with a slight "blip" during morning rush hours. This supports the hypothesis that traffic density, and possibly fatigue, may play a potentiating role in alcohol-crash risk for this class of crash.

Vehicle Type. Prior updates have not found much useful information on the effect of vehicle type on the alcohol-crash problem. The FARS report on 1996 fatal crashes also contains data on the types of vehicles that were involved in fatal crashes. **Figure 3-14** depicts these data, showing for several vehicle types, the percentage of drivers who were alcohol-positive and the percentage who had a BAC at or above 0.10%. Drivers of motorcycles most often had been drinking (42% alcohol-positive and 30% ≥0.10), and drivers of large trucks least often had been drinking (3% alcohol-positive and 1% ≥0.10). Drivers of light trucks were slightly higher than passenger cars for both measures (28% alcohol-positive and 22% ≥0.10). Again, no comparable new data were available on vehicle types whose drivers were not involved in crashes.

Figure 3-14: Alcohol-Positive and Drunk Drivers As A Percentage of All Drivers of Various Types of Vehicles in Fatal Crashes



Source: US DOT, NHTSA 1997

Several studies at the state and local levels have examined the characteristics of motorcycle drivers who had been arrested for DWI or involved in alcohol-related crashes. The Texas study of DWI arrestees cited above (Watson and Garriott 1992) suggested that, because of the demands of operating a motorcycle, such drivers are impaired by alcohol at lower BACs than are drivers of other types of vehicles. Another study of injured motorcycle drivers admitted to a trauma unit in the Baltimore, Maryland area by Soderstrom, *et al.* (1991) found that drivers with a positive BAC were nearly twice as likely to have caused the crash in which they were involved as were drivers with a negative BAC (93% versus 43%). With respect to large trucks, Sweedler and Quinlan (1990) found that a larger percentage (13%) of *fatally injured* drivers in crashes investigated by the National Transportation Safety Board in eight states *circa* 1988 had measurable amounts of alcohol in their systems; 37.5% of the 56 drivers who tested positive for drugs of abuse also had measurable amounts of alcohol in their systems.

Drinking Location. Prior updates suggested that the drinking location preceding illegal drinking-driving was most frequently bars or taverns and other person's homes. Several recent studies have examined drinking location as a correlate of drinking-driving. A study of New York State DWIs by Wieczorek, Miller, and Nochajski (1992) 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.

A study of Vermont university students by Musty and Perrine (1990) 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 in Australia (Lang and Stockwell 1991) examined the effect of type of drinking location on crash involvement. 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 unlicensed 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.

Target Group Studies

NHTSA's Tier 1 Task Force (U.S. Department of Transportation, NHTSA, Unpublished) described the initial efforts of a working group to identify appropriate target populations for NHTSA's Traffic Safety Programs. The approach employed a conceptual model that included four components: crash involvement, crash risk, contribution to the overall problem, and countermeasure effectiveness. Two expert panels, one from inside NHTSA and one from outside NHTSA, then examined existing data, concluding:

> "This effort clearly revealed that existing national data bases will not provide the information we sought in order to better define high-priority target populations in terms of social, economic, demographic and behavioral characteristics."

Nevertheless, the panels eventually developed a synthesis that pointed toward two categories of *alcohol-crash* target groups:

1. High-risk target populations with high impact on national alcohol-related crash rates; and
2. High-risk target populations with low impact on national alcohol-related crash rates.

Priority targets in the first group were: young beginning drivers 15-25 years old, male; drivers with repeated moving violations, especially alcohol-related; drivers with risky lifestyles; and nonusers of seatbelts. Priority targets in the second group were: Hispanics, especially 21-35 year old males; probably of lower socioeconomic status; Blacks, especially 30-40 year old males of low socioeconomic status; Native Americans of low socioeconomic status in rural areas; and male motorcyclists of all age groups.

SUMMARY AND CONCLUSIONS

The identification of targets for alcohol-crash countermeasures requires information about the number of alcohol-related crashes, the extent of alcohol-impaired driving, and the relative risk of an alcohol-related crash. The literature examined in this update relates almost entirely to the first two of these areas, adding useful information about:

- The involvement of various groups of alcohol-impaired drivers in fatal crashes, and to a limited extent, serious injury crashes;
- The involvement of various groups of drivers in "non-crashes" (that is, stops at a roadside survey checkpoint); and
- DWI arrests or convictions of various groups of drivers as a percentage of all drivers arrested or convicted of DWI.

Nearly all of the useful fatal-crash data are from FARS, the only exception being data on involvement as a function of race which are from North Carolina. Information on serious injury crashes comes largely from studies emanating from trauma centers in the U.S. and Canada. Roadside survey data come primarily from the 1986 National Roadside Breathtesting Survey (conducted during weekend, nighttime hours). The data on DWIs are from a range of studies, including those whose subjects were DWIs who had been sent by the court to alcohol assessment or treatment.

Clearly, only the first of the three above areas (involvement in alcohol-related crashes) bears directly upon the measurement of a group's alcohol-crash incidence. The non-crash area is pertinent by providing an estimate of a group's involvement in the nighttime, weekend drinking-driving that may lead to a crash. The DWI indicator is at best an indirect, second-order indicator, to the extent that drivers with prior DWI convictions are over-represented among all alcohol-involved drivers in fatal crashes. Unfortunately, no satisfactory direct indicator of relative risk of a crash (that is, probability of a crash given alcohol divided by the probability of a crash given no alcohol) is available from recent research. This is because, as indicated above, there are no recent studies based on matched sets of crash data and non-crash data. Relative risk can only be discussed indirectly. For example, over-representation of a group in crashes relative to that group's representation in some non-crash measure, such as the roadside survey, would suggest high crash risk for that group.

With respect to *BACs at risk*, recent research adds little new knowledge about the role of a high BAC in alcohol-related crashes, but does reinforce the findings of prior studies indicating that a high BAC is strongly related to both high alcohol-crash incidence and high alcohol-crash risk. A recent examination of the BAC distribution of fatally injured drivers from FARS data underscores the strong role of the high-BAC driver in fatal crash incidence. Considerable new information regarding high BACs comes from studies of DWIs.

There is also new research to suggest that BACs in the 0.01%-0.09% range are associated with increased alcohol-crash risk and involvement. FARS data indicate that there were a sizable number of fatal crashes at these BACs in 1996 (3,507), but there are no comparable data from non-crashes to get a good estimate of relative risk. Instead, we have very rough estimates based on FARS data combined with data from unmatched roadside surveys. These estimates suggest a significant relative risk at BACs in the 0.05%-0.10% range, and a lower but still not insignificant risk in the 0.02%-0.05% range. Further, a study of fatal crashes in Texas found that, as BAC increased, there was a significant increase in the probability of the killed driver having *caused* a given multiple-vehicle fatal crash. This relationship held over the entire BAC range studied, from 0.05% to 0.20%, with the largest marginal increase occurring in the 0.00-0.05% range.

In the case of *people at risk*, a relatively large number of factors have been studied in the recent literature, but only driver sex, age, and to some extent, race, are based on hard epidemiologic data. Among drivers who are characterized by such factors, these data indicate that male drivers, drivers in the 21-34 age group, and drivers who are of the "white" race constitute the largest percentage of alcohol-impaired drivers in fatal crashes. It should be noted that recent data continue to indicate that the role of females in the alcohol-crash problem appears to be increasing. In 1982, 12.3% of drivers in fatal crashes with a BAC of 0.10% or more were female, and this percentage has grown steadily to 15.7% in 1996, an increase of 28%. There is also some evidence from recent data to support the prior hypothesis that the alcohol-crash risk of females is higher than that of males (see above discussion). Similarly, there is

some evidence to suggest that non-whites (including blacks, Hispanics, and Native Americans) are over-represented among alcohol-impaired drivers in fatal crashes even though their overall share of the alcohol-crashes is small in comparison to that of whites.

Data pertaining to the role of other people-related factors in the alcohol-crash problem are spotty, coming mainly from studies of DWIs, and from the 1986 National Roadside Breathtesting Survey. They suggest an *over-representation among weekend, nighttime drivers* of impaired drivers who are: unemployed, without a college diploma, moderate to very heavy drinkers, and whose trip purpose was visiting friends. Impaired drivers appearing in *relatively greater frequency among weekend nighttime drivers and/or DWIs* are those who: are employed, are married, have no college diploma, have a record of many traffic violations and prior DWI convictions, and drink in many rather than a single location. In addition, recent studies continue to confirm prior studies *that impaired drivers (especially young drivers) with certain personality/psychosocial characteristics appear more frequently among DWI populations.* These characteristics are relatively high levels of verbal hostility, assaultiveness, sensation-seeking, impulse expression, tobacco and drug use, and personal problems, and relatively low levels of responsible values and parental compatibility. Most of these findings are not new, but do add confirmatory evidence to the knowledge base.

Recent research on *environmental situations at risk* appears to have been limited to examination of the day of the week and the time of day of impaired driving incidents, and of the types of vehicle used by impaired drivers in fatal crashes. FARS data continue to show that weekend days have higher numbers and percentages of impaired drivers in fatal crashes than do week days. FARS data also show that late nighttime and early morning hours have *much* higher numbers and percentages of alcohol-impaired drivers (and also non-occupants) than do other hours. One study of the time of day of incidents involving alcohol-impaired drivers found that the greatest percentage of impaired drivers on the roads occurred during the 2 a.m.-3 a.m. period. The same study also calculated the time of highest relative risk of a fatal single-vehicle crash involving an alcohol-impaired driver, arriving at time period 5 p.m.-8 p.m. with a relative risk of 238.

The latest available FARS report provided data on the type of vehicles driven by alcohol-impaired drivers involved in fatal crashes. Passenger cars and light trucks were by far the most frequently used by such drivers, but motorcycle drivers in fatal crashes were more likely to have been alcohol-impaired than were drivers of any other type of vehicle. Drivers of heavy trucks in fatal crashes are the least likely to have been alcohol-impaired.

It should be noted the above discussion applies to variables treated one at a time as univariates rather than to combinations of variables examined through multivariate techniques. Very few recent studies have approached the problem from a multivariate standpoint, and most of these have not had hard data on many of the most important variables dealing with the crash-involved drivers (for example, BAC). Lack of such

data makes it impossible to identify confidently more detailed levels of alcohol-problem groups, for example, young, unemployed males without a college diploma who drive light trucks.

Nevertheless, some useful findings have emerged from recent multivariate studies. A study of interactions among driver age, sex, and race based on hard data from North Carolina found that alcohol-impaired *non-white* male drivers were significantly more frequent than were alcohol-impaired *white* males in alcohol-related crashes. This latter finding was apparently due to an age-sex interaction effect: in the over-24 years group, *non-white* males were significantly more frequent than were *white* males, while in the under-25 group, *white* males were significantly more frequent than were *non-white* males. For female drivers in North Carolina, the picture was more complex, with the frequency of whites outnumbering that of non-whites by a factor of almost 2 to 1. In the under-25 and over-54 group of alcohol-impaired drivers, white females were *less* frequent than were non-white females, while in the 25-54 group, the frequencies of white females and non-white females were about the same.

Another multivariate study by James (1990) profiled several "high-risk" groups of DWIs through factor analyses, but the crash involvement of such groups was not treated in the analysis, and so the profiles have limited utility in identifying target groups for countermeasures.

The most comprehensive of the multivariate studies examined in this review dealt with personality and psychosocial variables in combination with a variety of other variables, including biographical variables and variables available from driver records. These studies, while enlightening as to the directions of relationships among the variables and in supporting hypotheses about the underlying structure of the relationships, again do not provide much information for estimating the magnitude of the alcohol-crash problem due to groups having various combinations of characteristics.

Overall, we conclude that the currently available hard data on the nature of the alcohol-crash problem are adequate 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, to use the above example, that young, unemployed males without a college diploma who drive light trucks are an important subgroup to be singled out for special countermeasure action. At this juncture, it appears that such detailed levels of target identification can best flow from combination objective-subjective processes of the type employed by NHTSA's Tier 1 Task Force.

To help fill this data gap in the problem-identification state of knowledge, there is a need for new controlled studies of the role of alcohol in traffic crashes, preferably conducted periodically (say, every five years) in several different regions of the U.S. These studies should collect detailed information in the subject areas discussed in this update and be of sufficient magnitude to permit the multivariate analysis of pertinent study variables. At this writing, NHTSA has initiated a case-control study that would

constitute an important first step toward this goal. The controlled epidemiologic studies should be augmented by periodic national surveys of the driving population of the type recently completed by NHTSA.

These recommendations for research at the national level do not obviate the need for continued research on a more limited geographic scale. To the contrary, special studies at the state and local levels are probably the only economically practical way of obtaining more detailed information on some topics and should be continued. As indicated above, such studies can be useful when examined in the light of other studies, providing information that can be pieced together with other information to help in identifying potential target groups for alcohol-crash countermeasures.

GLOSSARY

ADS Alcohol Dependance Scale. Twenty-five item scale developed by the Addiction Research Foundation.

BAC Blood or breath alcohol concentration. The usual ratio standards are the number of grams of alcohol either per 100 milliliters of blood, or per 210 liters of breath.

BAL Blood alcohol level. The usual ratio standards are the number of grams of alcohol either per 100 milliliters of blood, or per 210 liters of breath.

BrAC Breath alcohol concentration. The usual ratio standards are the number of grams of alcohol per 210 liters of breath.

DIS Diagnostic Interview Schedule.

DSMIII American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders, a multiple criteria-based diagnostic system.

DSMIIIR A structured clinical interview devised by Spitzer and Williams to diagnose mental disorders, including substance abuse disorders, as directed by revised diagnostic criteria of the American Psychiatric Association.

DUI Driving under the influence. General term used to describe the criminal action of operating a vehicle while under the influence of alcohol or other drugs.

DWI Driving while intoxicated, or driving while impaired. General term used to describe the criminal action of operating a vehicle while intoxicated, impaired or under the influence of alcohol or other drugs.

FARS Fatality Analysis Reporting System. (Formerly Fatal Accident Reporting System.) A NHTSA system which has collected information on fatal crashes since 1975 in all states, including data on alcohol involvement.

GES The National Highway Traffic Safety Administration's General Estimates System, which uses data from many sources including police reported crashes and the National Automobile (formerly Accident) sampling system to generate national estimates of all types of crashes including all types of vehicles.

GGT Blood levels of Gammaglutamyltransferase. The enzyme has been found to be a relatively sensitive index of liver damage in clinical studies of alcoholics and heavy drinkers.

MAST Michigan Alcohol Screening Test. A 10-15 minute, 24 item (Yes/No) test; self or counselor administrated resulting in one of three categories: no drinking problem, possible problem, alcoholism.

MORTIMER-FILKINS A 45-90 minute, 58 item (True/False, Yes/No, and short answer) questionnaire plus a structured interview resulting in one of three categories: social drinker, presumptive problem drinker, problem drinker. Specifically designed for court assessment of DWI/DUI offenders.

N or **n** Mathematical term denoting sample size.

NIAAA National Institute on Alcohol Abuse and Alcoholism. One of 17 institutes that comprise the National Institutes of Health. NIAAA supports and conducts biomedical and behavioral research on the causes, consequences, treatment, and prevention of alcoholism and alcohol-related problems.

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