# ALCOHOL AND HIGHWAY SAFETY 1978: A REVIEW OF THE STATE OF KNOWLEDGE

Ralph K. Jones
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The University of Michigan
Highway Safety Research Institute
Ann Arbor, Michigan 48109

January 1978

Prepared for
U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, D.C. 20590

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16. Abstract

This report presents the results of a comprehensive review and analysis of the problem of alcohol and highway crashes in the United States. Both the nature of the alcohol-crash problem and societal responses to that problem are treated. Epidemiologic studies, experimental studies, and countermeasure programs are examined in the review. The short-term future of the alcohol-crash problem is projected and conclusions and recommendations relative to future research and action programs are developed.

Other reports produced under the contract include: *Alcohol and Highway Safety 1978: A Review of the State of Knowledge* (Summary Volume) and *Drugs and Driving: Information Needs and Research Requirements*.

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Early in the project we contacted some 450 practitioners and researchers in alcohol safety and related fields to identify relevant issues and literature. It is impossible to list here all of those who responded, but we are grateful for their help and hope that our report will prove useful to them.

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Other HSRI personnel also made important contributions. This report was edited by James E. Haney. Joyce V. Cassells was associated with the project as a research assistant. Her inputs to the sections on public information and education are particularly appreciated. Olga S. Burn supervised the production of the report. Arlene Chmielewski prepared the citations, bibliography, and index. Linda Throne and Susan Kornfield assisted in the collection of reference materials and the organization of the report for production. Jacqueline B. Royal, Patricia Whichello, and Anne L. VanDerworp typed the manuscript. Kathleen Jackson prepared all of the illustrations. Natalie Lenaghan read proofs.

The history of this project is interesting and unusual. The proposal was written and the contract awarded while the principal investigators, Kent B. Joscelyn, Ralph K. Jones, and Roger P. Maickel, were at Indiana University. Subsequently, each left Indiana University. Mr. Joscelyn joined the Highway Safety Research Institute of The University of Michigan. Mr. Jones formed his own company, Mid-America Research Institute, Inc. Dr. Maickel became Head of the Department of Pharmacology and Toxicology, School of Pharmacy and Pharmacal Sciences, Purdue University. The principal investigators continued to work together on this report and other work products of the study. Mr. Jones had principal responsibility for this report. Mr. Joscelyn assumed similar responsibility for other aspects of the project dealing with drugs and driving. Dr. Maickel served as a consultant principally in the drug area.

The movement of the principal investigators required the transfer of the contract from Indiana University to The University of Michigan. This transition was accomplished because of the willingness of a number of individuals to devote additional effort to the identification of the proper procedures to accomplish the transfer. We thank the following individuals who were most helpful in the transition:

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# 1.0 INTRODUCTION

This report was prepared under a National Highway Traffic Safety Administration contract (DOT-HS-5-01217) to assess the state of knowledge about alcohol and highway safety. It constitutes one of the two primary products of that contract and was developed during the period September 1975 to May 1977. The second, a set of priorities developed for research on the impact of drugs other than alcohol on highway safety is reported in a separate volume.

The primary objectives of this report are (1) to review, evaluate, and summarize existing knowledge about alcohol and highway safety in the United States, and (2) to identify priorities for research to help remedy or alleviate that problem.

## 1.1 BACKGROUND

Motor vehicle crashes rank as a major cause of death in the United States (National Safety Council 1976). During the period from 1972 to 1975 the average number of persons killed in highway crashes each year was more than 50,000. Like other major causes of death, such as heart disease and cancer, motor vehicle crashes have been the object of much public concern and of a great deal of research. Investigators in the field of accident research have categorized the factors that may contribute to the occurrence of motor vehicle crashes as vehicular, environmental, or human. *Vehicular factors* are those related to the design, construction, and operating characteristics of the vehicle; *environmental factors* focus on operating conditions, traffic conditions, time of day, etc.; *human factors* include any characteristics (physical, social, psychological, etc.) of the driver which may affect his ability to perform driving tasks. It has been estimated that 76%–90% of all motor vehicle crashes are caused largely by human factors. One of the human factors thought to have a significant impact on the incidence of motor vehicle crashes is the drinking behavior of the driving population (U.S. Department of Transportation 1968).

An early statement of scientific concern about the impact of the consumption of alcohol on highway safety appeared in a 1904 issue of the *Quarterly Journal of Inebriety* and is quoted in the U.S. Department of Transportation's 1968 report to Congress on the alcohol-highway safety problem. The quote reads as follows:

> We have received a communication containing the history of twenty-five fatal accidents occurring to automobile wagons. Fifteen persons occupying these wagons were killed outright, five more died two days later, and three persons died later. Fourteen persons were injured, some seriously. A careful inquiry showed that in nineteen of these accidents the drivers had used spirits within an hour or more of the disaster. The other six drivers were all moderate drinkers, but it was not ascertained whether they had used spirits preceding the accident. The author of this communication shows very clearly that the management of automobile wagons is far more dangerous for men who drink than the driving of locomotives on steel rails. Inebriates and moderate drinkers are the most incapable of all persons to drive power motor wagons. The general palsy and diminished power of control of both the reason and senses are certain to invite disaster in every attempt to guide such wagons. The precaution of railroad companies to have only total abstainers guide their engines will soon extend to the owners and drivers of these new motor wagons. The following incident illustrates this new danger: A recent race between the owners of large wagons, in which a number of gentlemen took part, was suddenly terminated by one of the owners and drivers, who persisted in using spirits. His friends deserted him, and in returning to his home his wagon ran off a bridge and was wrecked. With the increased popularity of these wagons, accidents of this kind will rapidly multiply, and we invite our readers to make notes of disasters of this kind (U.S. Department of Transportation 1968, p. 146).

Concern continued to increase throughout the years following this report, even to the extent of enforcement "crackdowns" (Stoeckel 1925), but there was little scientific basis for defining the nature and extent of the problem before the 1930s. One of the first of these early scientific studies in the United States was reported in 1934 by Heise (1934), who defined the four basic approaches to studying the alcohol-crash problem that are still being followed today (Perrine 1975):

- measurement of the amount of alcohol in the body,
- measurement of alcohol effects on human performance in a laboratory setting,
- measurement of alcohol effects on actual driving performance, and
- estimation of alcohol usage among various populations of drivers (i.e., epidemiologic studies).

The first approach obviously was the most crucial for establishing a basis for scientific inquiry into the effects of alcohol, which would most meaningfully be described in relation to the amount of alcohol present in the body. As it turned out, the most critical variable for this purpose was *blood alcohol concentration*, or BAC, which describes alcohol presence in terms of the weight of alcohol found in a given volume of blood.

The second and third approaches were consistent with the usual processes of scientific investigation, wherein cause-and-effect relationships are first investigated in the laboratory under controlled conditions and then gradually extended into the more complex and uncontrolled environment of the real world. Their ultimate purpose is to determine how alcohol affects human behavior so as to degrade performance of essential driving tasks and thereby increase the risk of a crash.

The fourth approach was essential for measuring the impact of drinking-driving on society, including the determination of whether there really is an "alcohol-crash prob-

lem." It involves the study of highway crashes and driver populations with respect to alcohol usage and is used in developing inferences about the role of alcohol in crashes. It is referred to as an "epidemiologic" approach because it employs techniques commonly used by scientists in the study of the incidence of diseases in populations. Like the laboratory experiments and driving performance tests used in the second and third approaches, the epidemiologic approach also seeks to relate alcohol usage to crash risk but does so through after-the-fact analyses of crashes.

Simultaneously with these attempts to better define the alcohol-crash problem, solutions have been sought for the problem as it was currently understood. Early efforts at prevention and control in the U.S. were, with few exceptions, nonscientific and noncomprehensive. Moreover, few alcohol safety programs in this country have been formally evaluated. However, the effectiveness of several alcohol safety programs in foreign countries has been examined with some care, so that there is at least an initial knowledge base on means of dealing with the problem.

During the more than 40 years of scientific study of alcohol and highway safety, numerous papers, articles, and reports on the four approaches to the problem outlined above have appeared. However, a comprehensive review of the state of knowledge of the alcohol-crash problem was not performed until the late 1960s, when the U.S. Department of Transportation published its landmark report on Alcohol and Highway Safety (U.S. Department of Transportation 1968). Since then, research on the role of alcohol in highway safety has accelerated rapidly, and this has been reflected in the growing literature on the subject. While there have been several excellent reviews in many of the separate areas addressed by this research, no single in-depth review has been conducted across all areas. The present report attempts to fill this gap by updating the current state of knowledge about alcohol and highway safety, from problem definition to problem solution.

## 1.2 SCOPE AND APPROACH

This report emphasizes research conducted since the 1968 Report on Alcohol and Highway Safety. However, several key studies conducted prior to 1968 are considered here to provide needed perspective and to present recent interpretations of their methods and findings. Conclusions and insights arrived at by considering more recent findings in light of those from earlier studies are also discussed in this report. In some cases the earlier studies have had to be cited simply because no comparable subsequent studies have been conducted.

The information needs of a wide range of potential users are addressed in the report. Workers in specialized areas of the field of alcohol and highway safety may find the discussion of other interacting areas beneficial to their own work. Scientists and researchers new to the field may find it useful to have in a single volume a discussion of major research findings in all areas, and persons who design and operate alcohol safety programs should find a more factual basis for decision-making.

Great care has been exercised in selecting the material to be emphasized in this report. An attempt has been made to present results from only the most scientifically

reliable studies and to avoid studies with serious methodological or analytical deficiencies. A clear trail to these data sources is provided in the form of citations to specific references listed at the end of the report. The literature referenced is of a type available to the general reader not having access to special or confidential files. Much of it can be obtained from the shelves of any reputable university library.

The emphasis in this report is on research findings that are supported by facts. The objective is to present these findings as clearly as possible and with minimum "interpretation." Speculations and conjecture are avoided, but conclusions based on reasonable, if not complete, evidence are stated. In general, it is left to the individual reader to determine the material's relevance to him and to make his own interpretations in light of his experiences and needs.

The main substance of the report is presented in five major sections. Section 2.0, *The Alcohol-Crash Problem*, describes the nature and extent of the highway safety problem thought to be due, at least in part, to drinking-driving. This section presents (1) evidence (primarily epidemiologic) linking alcohol presence in the blood to the various types of crashes, (2) a description of the risk posed by these crashes to drinking and nondrinking drivers, and (3) some measures of the societal costs of such crashes.

Section 3.0, *Alcohol Effects on People*, is a discussion of the state of knowledge with respect to the effects of alcohol on human behavior in general and driving performance in particular. In this section are brief descriptions of the biochemical, physiological, and behavioral effects of alcohol and their possible relationships to impairment of body functioning and driving performance. It (1) describes how alcohol is absorbed into the body, (2) describes how alcohol presence is measured, (3) describes the acute and chronic effects of alcohol on specific parts of the body, and (4) summarizes what is presently known about alcohol effects on the range of behavioral attributes, from simple neuromuscular functioning through complex motivational and cognitive processes and driving performance.

Section 4.0 of the report, *People Who Drink and Drive*, discusses the characteristics of people who are overrepresented in alcohol-related crashes. It attempts to shed more light on groups of people whose drinking-driving behavior seems to create abnormally high highway crash risk. The section (1) briefly describes worldwide patterns of drinking, (2) defines types of U.S. drinkers according to their drinking patterns, and (3) characterizes by various attributes drinking-drivers using the road and drinking-drivers involved in crashes.

Section 5.0 of the report, *Dealing With The Alcohol-Crash Problem*, describes and evaluates past efforts to reduce alcohol-crash risk. It presents the salient features and results of representative past programs in the U.S. and elsewhere.

Section 6.0 of the report, *Future Directions of The Alcohol-Crash Problem*, projects the alcohol-crash problem into the short-range future. It develops an estimate of the future nature and magnitude of the problem and discusses needed advancements for dealing with the problem.

The last section of the report (Section 7.0) presents the report's overall conclusions and a set of research priorities both for improving understanding of the problem and for developing measures and programs for dealing with it more effectively. Summaries are provided at the end of each section of the report.

## 1.3 BLOOD ALCOHOL CONCENTRATION AND DRIVING WHILE INTOXICATED

The terms *blood alcohol concentration* (BAC) and *driving while intoxicated* (DWI) are used so widely in the literature on alcohol and highway safety that no serious study of the subject can begin without first defining the terms.

BAC is a measure of the amount of alcohol present in a person's blood. It is stated in terms of the *weight* of a quantity of alcohol in a given volume of blood. In the U.S.A. it is common to use grams per *100* milliliters. The resulting measurement is then stated in terms of *percent alcohol*, weight per unit volume. For example, if a given measure showed .01 grams of alcohol in a 100 milliliter sample of blood, the result would be interpreted in the U.S. as ".01% w/v blood alcohol concentration (BAC)."

The body, on the average, requires about an hour to eliminate .015% w/v of alcohol, which is the amount contained in a typical "drink" (e.g., a shot of whiskey, a large glass of wine, a pint of beer). If a person drinks more than about one drink per hour, his BAC will rise, and he will become intoxicated.

When a person's BAC reaches .10% w/v, he will be *presumed* by law to be too intoxicated to drive in nearly all states. Different jurisdictions use different terms in describing drivers who are defined by law to be intoxicated by alcohol, for example, "Driving While Ability Impaired" (DWAI), "Driving While Intoxicated" (DWI). Sometimes, statutes use the term "impairment" to indicate a lower level of performance degradation than that associated with "intoxication." In this report, the term "Driving While Intoxicated" (DWI) is used generically to describe driving with an illegally high BAC.

A more detailed discussion of BAC and its relationship to impairment of driving performance and a discussion of legal factors related to drinking driving are presented in sections 3.0, 4.0, and 5.0 of this report.

# 2.0 THE ALCOHOL-CRASH PROBLEM

Determining whether drinking-driving is a significant societal problem and defining that problem is basically a four-step process. First, one must estimate how many crashes involve drinking drivers. If there are only a few such crashes nationwide, then there is no alcohol-crash problem. However, if many crashes involve drinking-driving, then there is reason for the second step, further analysis to determine if drinking drivers are more often involved in crashes than other drivers. If they are not, there is no basis for suspecting alcohol more than any other factor as a cause of the crashes involving the drinking drivers. If, however, one finds significantly higher percentages of drinking drivers among crashed drivers than among drivers who have not crashed, then one has real reason for concern and for suggesting that there is, indeed, an alcohol-crash problem.

The third step in the process is determining whether the overrepresentation of drinking drivers in crashes is actually due to alcohol impairment of driving performance rather than to some other coincident factor. Sufficient indication of alcohol impairment will justify the fourth and final step of the problem-identification process, which is the more detailed definition of drinking-driving and drinking drivers so that effective methods can be devised for dealing with the problem.

This section of the report is concerned with the first two steps of the above process, that is, whether there is good reason to suspect that an alcohol-crash problem exists and, if so, the likely magnitude of that problem. Relevant literature is examined to determine the likely range of values for variables most useful for this purpose. The variables utilize data collected after the crashes have occurred, and employ the epidemiologic approach alluded to in the previous section of this report.

## 2.1 METHODOLOGY USED IN ESTIMATING THE ALCOHOL-CRASH PROBLEM

The essential elements of the epidemiologic approach as applied to motor vehicle crashes are:

- field investigation of crashes *as they occur in the real world,*
- documentation of the nature of each crash and of the circumstances surrounding

it (for example, time of day and day of week crash occurred; probable cause of crash; extent of personal injury and property damage; indications that drivers involved had been drinking; biographical, social and psychological characteristics of drivers involved; etc.), and

- comparison of the behavior and characteristics of the crash-involved subjects with relevant conditions and behaviors of the larger driving population.

The element of comparison is especially important, because it allows the researcher to examine the differences in the distributions of characteristics between the crash-involved population and the larger driving population. In this way factors which contribute to crash-involvement may be identified. Ultimately, this approach will allow more exact definition of the population at risk, i.e., the population which is liable to behave in the same way under similar circumstances and thus is likely to suffer the same consequences.

The first drinking-driving study to compare crash-involved drivers with drivers using the road but not involved in crashes was conducted by Holcomb in a landmark study at Evanston, Illinois, in 1938 (Holcomb 1938). Specifically, Holcomb's study compared the blood alcohol concentrations (BAC) of a sample of drivers involved in personal injury crashes with those of a sample of drivers who were not involved in crashes but who had been using the same roads as the crash-involved drivers. As a result, Holcomb was able to measure not only alcohol involvement in crash-involved drivers but also the alcohol involvement of crashed drivers *relative* to drivers who had not crashed. This is a crucial comparison. Without it, Holcomb's finding that 25% of the crashed drivers were legally too drunk to drive by today's standards would have had little meaning, since it was possible that the same percentage of drivers who had not crashed were also legally drunk. Without this comparison it would have been impossible to determine whether drinking behavior had any influence on the likelihood of crash-involvement. Holcomb's findings that only 2% of the drivers who had not crashed were drunk when compared with the findings that 25% of the crash-involved drivers were drunk suggested that drunk drivers are more likely to be involved in crashes than sober drivers.

Holcomb's data were still not sufficient to conclude that consumption of alcohol "caused" the crashes. Rigorous statements about causation could only be made if the crashed and the non-crashed drivers and their driving situations were exactly the same in every respect except blood alcohol concentration (BAC). This means that if 10% of the non-crashed drivers were over 65 years old, then 10% of the crashed drivers would have to be over 65 years old; and that if 70% of the non-crashed drivers were males, then 70% of the crashed drivers would have to be males, etc. Because of the impossibility of meeting this condition, epidemiologic data can never prove causation, but can only imply it. The more closely the two groups match each other on relevant variables, the stronger the implication of causality.

In epidemiologic studies, information on crashes and on crash-involved drivers has been collected through the joint efforts of researchers and police officers. The usual arrangement is that as soon as possible after a crash has occurred, police officers or dispatchers inform the researchers, who then dispatch a trained accident investigator to the scene of the crash. In some cases, police reports have been relied on for data, but

this is not considered the ideal situation, since police departments are usually understaffed and the data needs of researchers and the traffic law system are not the same. These accident investigations have usually been conducted over a period of one or more years.

Information on the behavior and characteristics of the larger driving population has been obtained through roadside surveys. In epidemiologic studies, roadside surveys are designed so that the environmental conditions under which crashes occur are matched (i.e., controlled for). A sample of noncrash-involved drivers using the roads under these conditions is stopped (usually by a uniformed police officer) and asked to volunteer information to researchers. Information is collected on vehicular factors such as make, model and year of car and on such human factors as drinking and driving habits, origin and destination of trip, age, employment, etc.

In many roadside surveys conducted in recent years, no particular sample of motor vehicle crashes is controlled for, but general findings from other controlled studies contribute to the determination of the sites and the times of days and days of week to be used in selecting samples of drivers. The object of this kind of roadside survey has been to provide data useful in describing the larger driving population, especially the extent to which this population drives after drinking.

In determining the nature and extent of the alcohol-crash problem, an essential question is how do the patterns of alcohol consumption of crash-involved drivers differ significantly from those of noncrash-involved drivers? A number of variables have been defined which describe and measure elements of drinking patterns. Some of these measures focus on long-term patterns of drinking behavior (e.g., measures of problem drinking and alcoholism), and some emphasize drinking behavior immediately preceding the time of crash or of questioning during roadside survey. (Measures of long-term patterns of drinking behavior are discussed in Section 4.0 of this report.)

The most objective measure of immediate drinking behavior is blood alcohol concentration (BAC). The development of instruments and procedures allowing the accurate measurement of BAC has permitted researchers to define more exactly the relationship between alcohol consumption and impairment of human performance. Studies have shown that physicians' use of conventional psychomotor tests for intoxication may result in inaccurate diagnoses perhaps as much as 50% of the time (McCarroll and Haddon 1962). Use of such behavioral tests by police officers to identify intoxicated drivers is further complicated by the drivers' high motivation to avoid arrest. The result is often an increased ability to mask the influence of alcohol on body sway, walking a straight line, and other tests of coordination. Technically, BAC describes a chemical state of the body rather than a behavior. Its measurement is not dependent upon the driver's subjective self-report or upon the subjective judgment of a police officer or accident investigator.

A number of problems have been associated with the measurement of BAC in epidemiologic research. The measurement of BAC requires that the driver provide a sample of his body fluid or lung air for analysis. To ensure accuracy of measurement, this sample should be obtained for preservation as soon as possible after the occurrence of the incident, i.e., the crash or the interception for roadside interview. Difficulties are

encountered both in obtaining the necessary permission to take a sample and in obtaining a sample which is valid. Legally, unless the driver has been arrested for driving while intoxicated (DWI), no sample may be taken without his permission in most states. His refusal to provide a sample, especially if he also refuses to provide other information, may introduce unknown and uncontrolled bias into the results of the epidemiologic studies.

Even when the driver's permission has been obtained, actions must be taken to ensure that the sample taken for analysis will accurately reflect the BAC at the time of the crash or roadside interview. If the crash-involved driver is alive, the sample must be taken within a few hours of the crash before the BAC has been significantly affected by the metabolic processes of the body. This requires that researchers be quickly dispatched to the crash site, that the samples be quickly and adequately preserved, and that they be safely transferred to a laboratory for analysis.

If the driver has been injured seriously enough to require medical attention, the sample may be taken in the emergency room of a hospital without his explicit permission (or knowledge). In a recent review of epidemiologic studies of alcohol-related highway crashes, Perrine (1975) observed that while such an approach minimizes some types of bias, it opens the door for biases which may result from the failure of hospital attendants to obtain samples from all drivers who were treated, or from delay in obtaining a sample because a driver had already been treated by a private physician before his arrival at the emergency room.

The determination of BAC in fatally injured drivers is a relatively straightforward matter in jurisdictions where such measurements are routinely made by coroners or medical examiners. There are, however, two major problems in obtaining these measurements. The first occurs when not all of the deceased drivers are tested. A bias caused by the manner in which "samples" are selected may thus be introduced; i.e., certain types of drivers may be systematically eliminated (or selected) from the tests. For example, a medical examiner could decide on his own that a given victim was "obviously" not drunk and not bother with taking a sample. If the driver was drunk when he crashed, a bias would be introduced by the medical examiner's decision.

The second problem occurs when the victim does not die until many hours after the crash and continues to metabolize the alcohol while still alive. In such cases, the BACs taken after death will be much lower than they were at the time of the crash. This problem has been avoided in some studies by excluding samples taken from drivers who died more than four to six hours after the crash. However, the very fact that such drivers are excluded may cause still another bias if, as found in one study (Baker and Spitz 1970), drivers who survive for longer periods after their crashes are substantially different with respect to drinking-driving than those who survive for shorter periods.

The following discussion of the alcohol-crash problem is based on the most reliable data believed to be currently available and avoids data taken from studies where methodological problems of the types noted above appear to be significant. Data on nonfatal injury crashes are taken from studies where breath samples were obtained at the scene of the crash. Data on fatal crashes are from studies where nearly all of the deceased drivers were tested for BAC within six hours after the crash.

## 2.2 FINDINGS FROM EPIDEMIOLOGIC STUDIES OF MOTOR VEHICLE CRASHES AND DRINKING BEHAVIOR

This section of the report presents the results of several important epidemiologic studies of the alcohol-crash problem. The objective is two-fold:

- to determine approximately how many crashes of various levels of severity involve drinking drivers and
- to determine if drinking drivers are more often involved in such crashes than other drivers.

First, data describing the frequency of involvement of drinking drivers are presented. Fatal crashes, serious injury crashes, and crashes involving only property damage are examined in some detail. Automobile-pedestrian collisions involving fatal injuries are also considered, but in less detail. Next, the findings of studies of drinking-driving among drivers using the roads but not involved in crashes are discussed. Finally, controlled studies comparing the incidence of drinking among crash-involved drivers with the incidence of drinking among noncrash-involved drivers are presented and discussed to obtain an estimate of the risk of crash involvement after drinking.

### *2.2.1 Crash Involvement of Drinking Drivers*

*2.2.1.1 Fatal Crashes.* More useful data exist for describing alcohol involvement in fatal crashes than for other types of crashes. Figure 2-1 summarizes the findings of some studies selected for inclusion because they were well-designed and well-executed and because they obtained more than 100 subjects. The figure shows the percent of fatally injured drivers whose BACs exceeded a given amount. The data describe both single-vehicle and multi-vehicle fatal crashes in which no pedestrians were involved. The range of the data is indicated by the hatched area drawn around the data points.

The two California studies had the largest sample sizes—506 for the study conducted by Waller and associates (Waller et al. 1970) and 5,123 for the Neilson study (Neilson 1969). It was common practice in that state for coroners to measure BACs on all motor vehicle deaths occurring within 24 hours of the crash (Neilson 1969). The results shown in Figure 2-1 have excluded BACs for persons who died more than six hours after the crash. In the Vermont study, Perrine and associates (1971) obtained the BACs of 105 fatally injured drivers who survived less than six hours after the crash. The Wayne County, Michigan study, reported by Filkins and associates (1970; Zylman, Blomberg, and Preusser 1975), was conducted in the Detroit area and included BACs of 309 fatally injured drivers, about 96% of whom survived for fewer than six hours after the crash.

From Figure 2-1 it can be seen that 40% to 55% of all the fatally injured drivers tested had BACs of 0.10% w/v or more. These drivers were too intoxicated to drive a motor vehicle under the laws of most states. A large percentage of the drivers (29% to 43%) had BACs in the very high range of .15% w/v or greater and 16% to 28% had BACs of .20% w/v or greater. A 175-pound person would have to consume approximately six ounces of 86-proof liquor in an hour to reach a BAC of .10% w/v and eight ounces in an hour to reach .15% w/v.

Figure 2-1. Percentage of drivers fatally injured in crashes with BACs equal to or greater than given levels

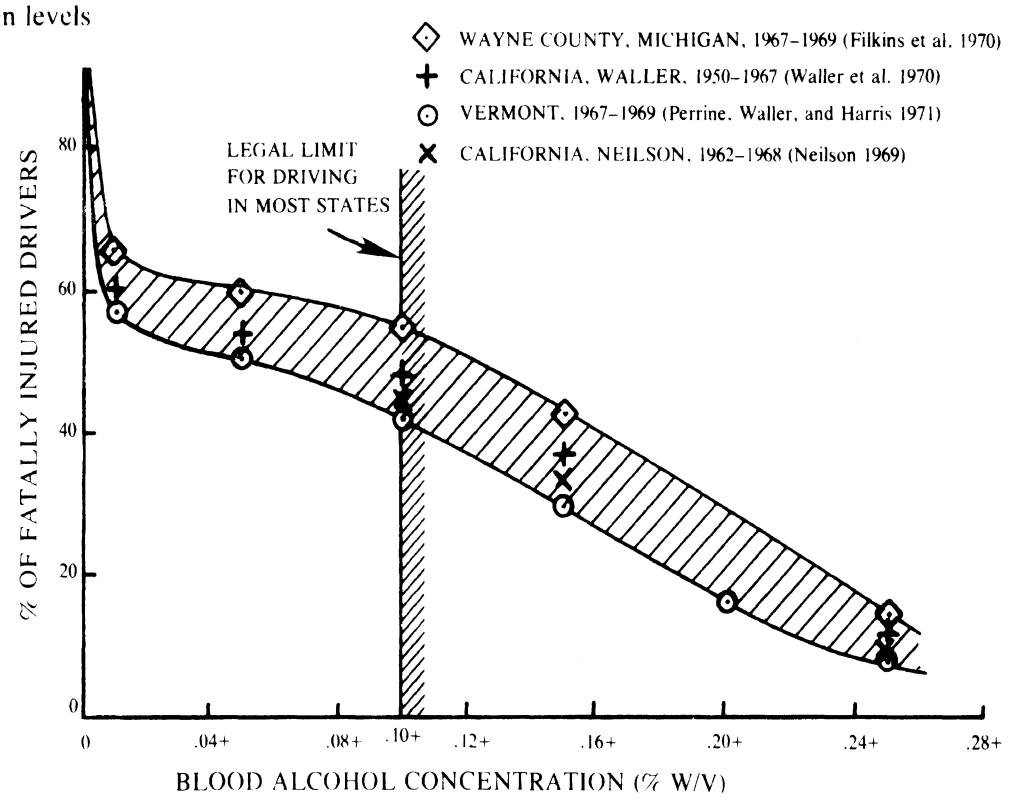



Figure 2-2 shows how data from several of NHTSA's Alcohol Safety Action Projects (ASAPs) (Clark and Clark 1973; Ellingstad and Estra 1974; Florendo 1975; Krause and Thomasson 1974; Phoenix, Arizona, Office of the City Manager 1975; Rosen, Mattson and Romslo 1974; Spencer and Ferguson 1975) compare with those from the selected studies of Figure 2-1. Available documentation on the ASAP studies does not allow a critical analysis of the validity of the data, but it is clear from several of the sources cited above that for a high percentage of fatally-injured drivers who had survived less than six hours after a crash, BAC data were often not available to the ASAP researchers. It seems, therefore, remarkable that there is such good agreement between the selected research studies and the ASAP findings. The range of BACs is slightly wider for the ASAPs, but the same trends are evident: many drivers were legally intoxicated before their fatal crash, and a considerable number of them had been drinking very heavily.

Extensive data collected in a nationwide survey in Canada indicate that this phenomenon does not stop at our northern border (Traffic Injury Research Foundation of Canada 1975). In Canada during 1973, 1,006 drivers out of 1,111 who died less than six hours after their crash were tested for BAC. It was found that 445 (44% of those tested) had BACs of .11% w/v or greater (Figure 2-3). Forty-nine percent had BACs exceeding the Canadian limit for legal impairment (.08% w/v). The percentages of drivers killed at given BACs fall well within the envelope described by the selected U.S. research studies shown in Figure 2-1.

The data on driver fatalities in single-vehicle crashes show even higher percentages of

Figure 2-2. Percentage of drivers fatally injured in crashes with BACs equal to or greater than given levels

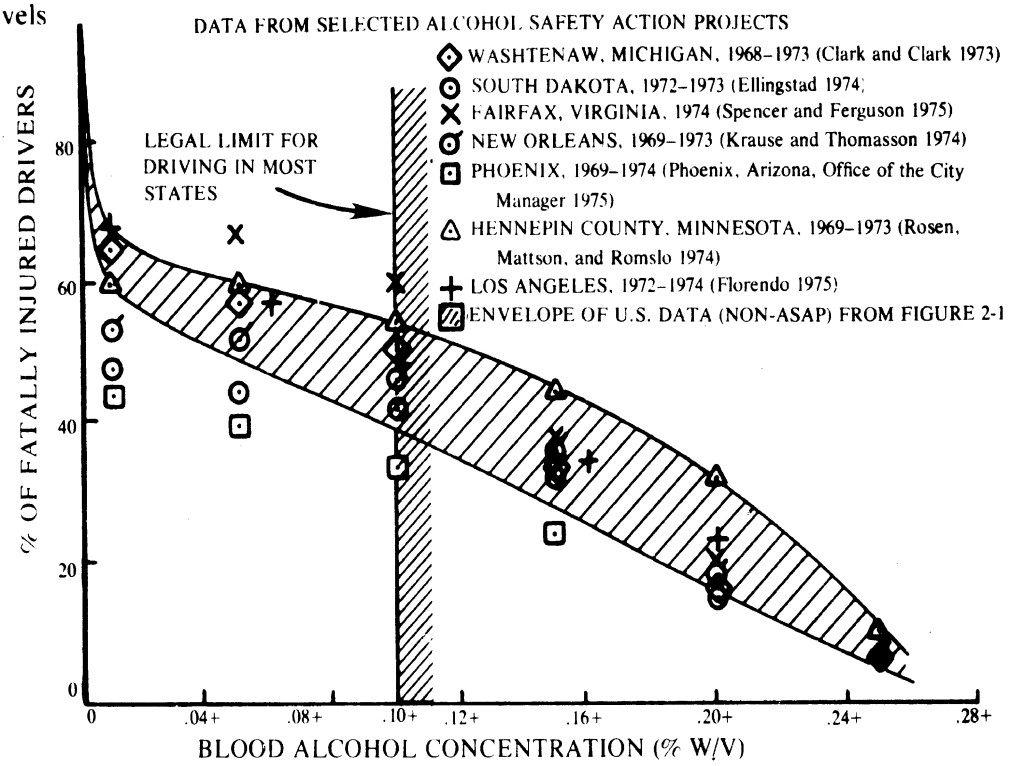



Figure 2-3. Percentage of drivers fatally injured in crashes with BACs equal to or greater than given levels

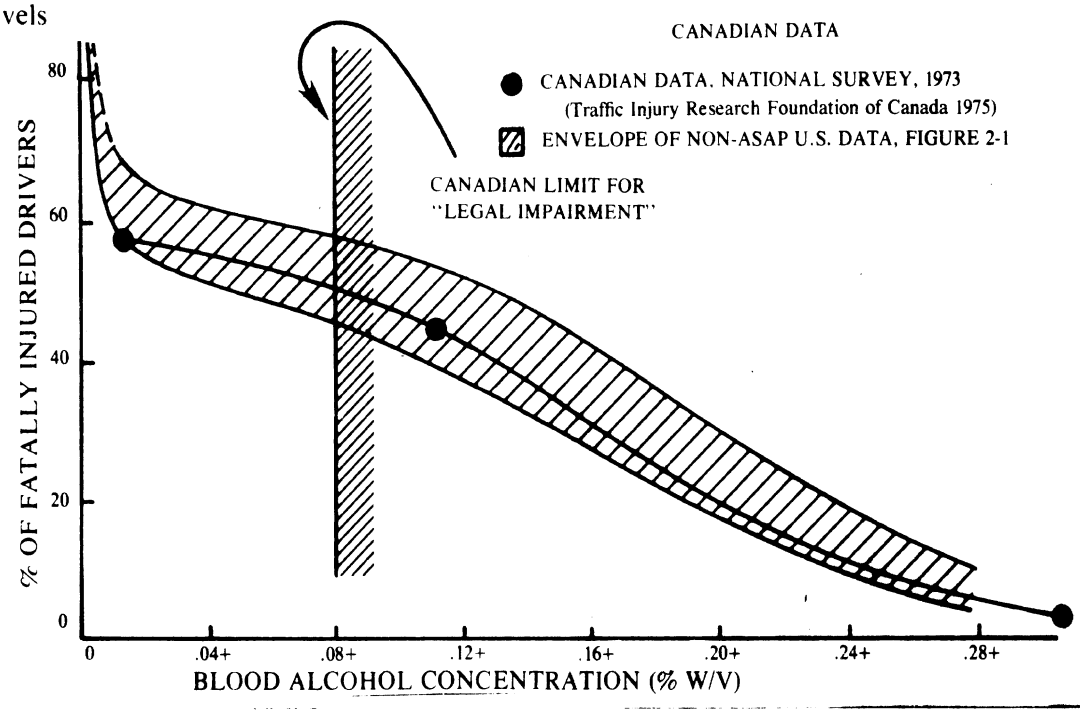
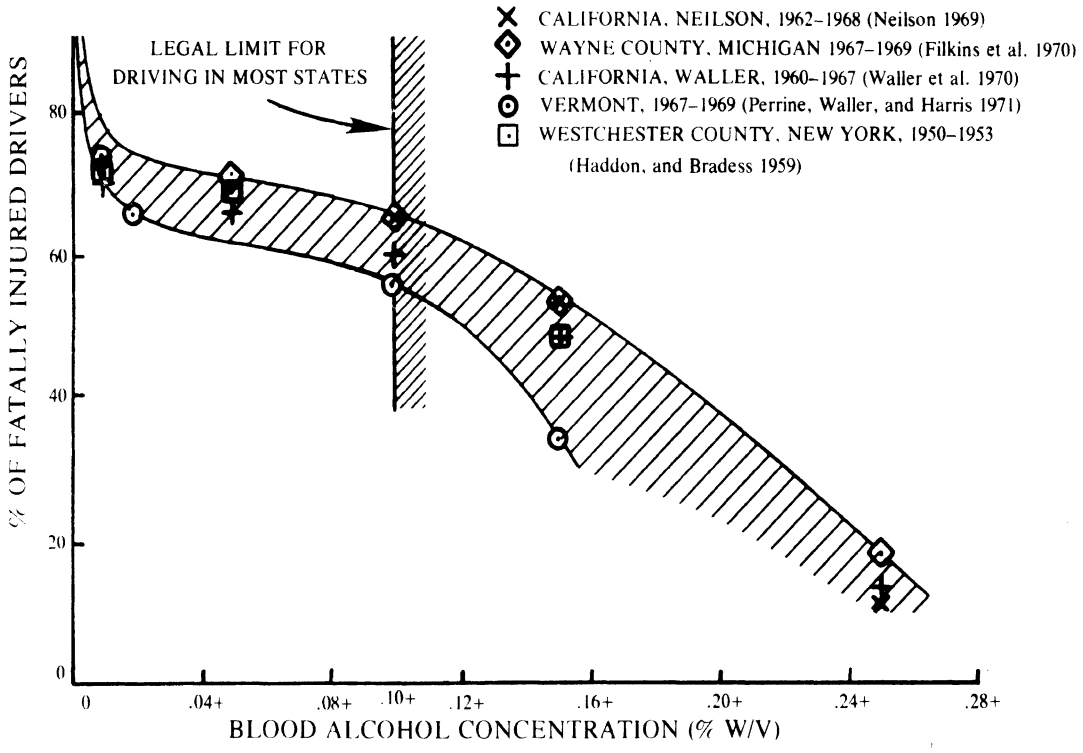


Figure 2-4. Percentage of drivers fatally injured in single vehicle crashes with BACs equal to or greater than given levels




individuals with BACs above the legal limit for driving (Figure 2-4). The data for Westchester County, New York, were obtained from a study by Haddon and Bradess (1959) of single-vehicle crashes. By legal standards, 55% to 65% of the sample were too intoxicated to drive, and 35% to 54% had BACs greater than .15% w/v. The variations in these data are quite small except at the higher BACs, where the Vermont data show a much lower percentage of drivers than the other four studies.

A wide variation exists throughout the BAC range for drivers killed in multi-vehicle crashes (Figure 2-5). The California data are quite consistent and closely grouped. The Wayne County data are generally much higher, and the Vermont data much lower, than those from either of the two California studies. The percentage of crashes involving illegal BACs is lower for multi-vehicle crashes than for single-vehicle crashes, but it is still impressively high at 25% to 50%.

The above figures on the BAC distributions of fatally injured drivers apply to motor vehicles in general. A recent study (Baker and Fisher 1977) of fatal motorcycle crashes in Maryland found that the BAC distributions of the motorcycle drivers were similar to those of fatally injured drivers of cars and trucks in that state.

*2.2.1.2 Nonfatal Crashes.* Since Holcomb's study, only three North American studies of nonfatal crashes have taken BAC measurements at the scene of the crash:

- the Toronto Study in 1951–1952 (Lucas et al. 1955),
- the Grand Rapids Study in 1962–1963 (Borkenstein et al. 1964), and
- the Huntsville Study in 1974–1975 (Farris, Malone, and Lilliefors 1976).

The Toronto Study by Lucas and associates was conducted in Toronto, Canada, during evening hours only (i.e., from about 6:30 p.m. to 10:30 p.m.). Data were collected on all days of the week except Sunday during the period from December 1951 through November 1952. A total of 433 drivers involved in personal injury crashes or property damage crashes were tested.

The Grand Rapids Study reported by Borkenstein and associates is the most extensive study of nonfatal crashes conducted to date. Its site was Grand Rapids, Michigan, and its time period was July 1962 through June 1963. BACs were taken at the scene from 5,985 drivers involved in crashes of all degrees of severity except crashes in which drivers were dead at the scene of the crash. Data were collected seven days a week, 24 hours a day.

In the study conducted by Farris and associates in Huntsville, Alabama, data were also collected seven days a week, 24 hours a day. BACs from 596 drivers involved in personal injury crashes were taken at either the scene of the crash (about 2/3) or hospitals. BACs measured at hospitals were carefully monitored by a researcher to avoid biases in sampling and inaccuracies due to time delays in taking the BACs (Farris, Malone, and Lilliefors 1976).

Figure 2-6 shows the BACs of drivers involved in all types of nonfatal crashes in Toronto and Grand Rapids. The Toronto data indicate about 15% of the crashed drivers were legally intoxicated by some U.S. standards (i.e., 10% w/v), but the Grand Rapids study showed only about 6% of the drivers at a BAC of .10% w/v or higher. One possible explanation for this difference is that the Toronto data were taken in the evening hours when drinking-driving is more frequent (see Section 4.2.2.1), while the Grand Rapids data were taken around the clock.

Figure 2-5. Percentage of drivers fatally injured in multi-vehicle crashes with BACs equal to or greater than given levels

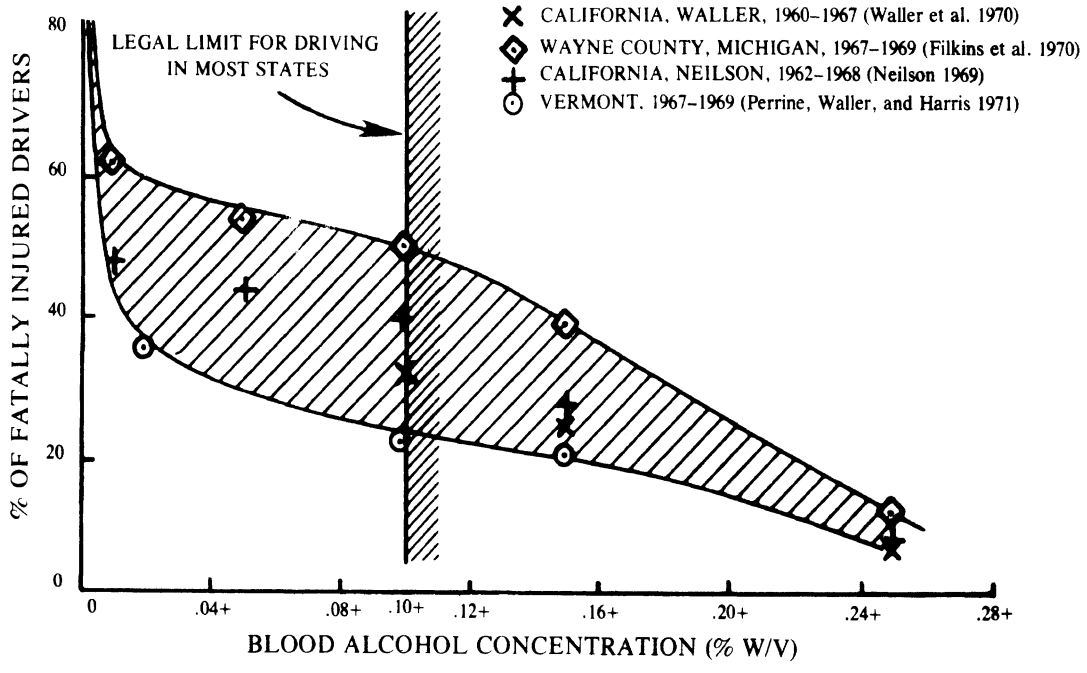


Figure 2-6. Percentage of drivers involved in nonfatal crashes with BACs equal to or greater than given levels

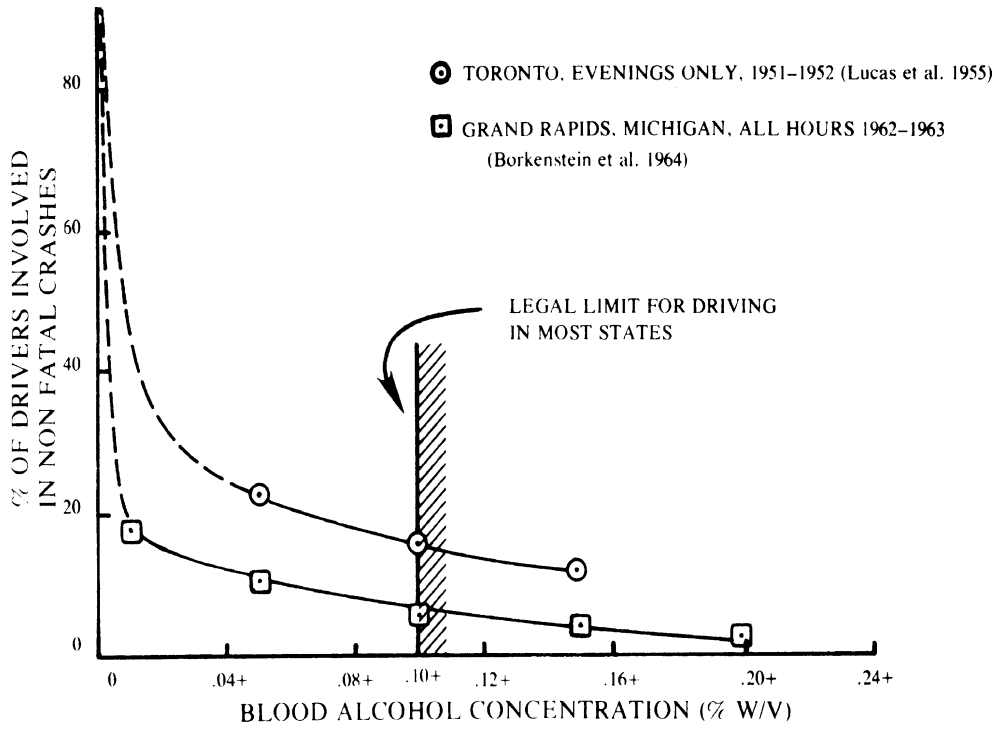
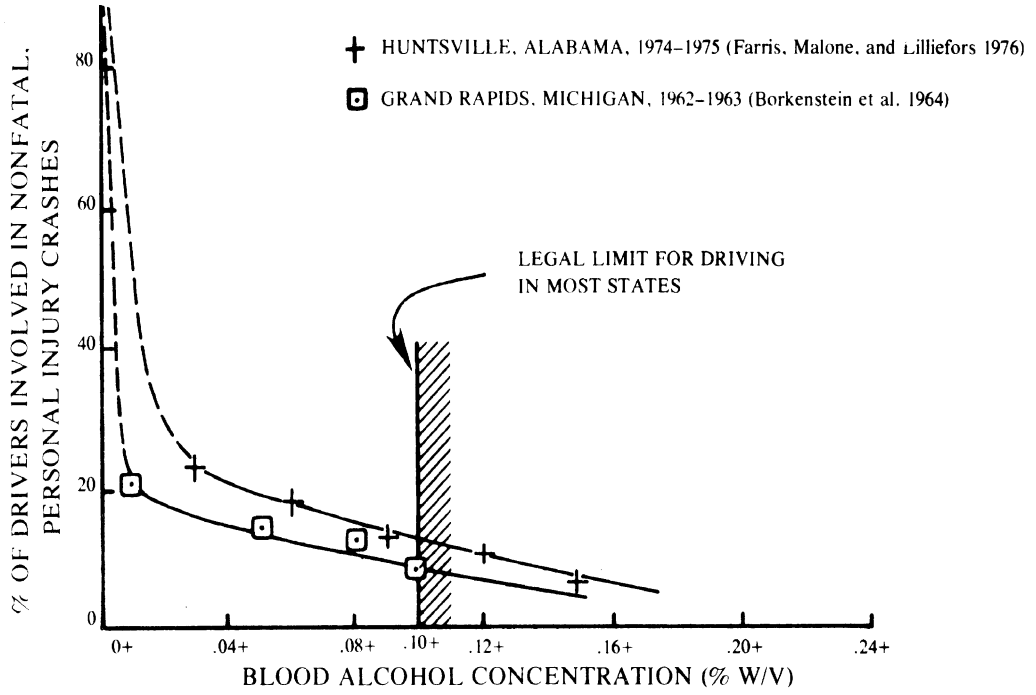



Figure 2-7. Percentage of drivers involved in nonfatal, personal injury crashes with BACs equal to or greater than given levels



The BACs of drivers in personal injury crashes are graphed in Figure 2-7. The Huntsville data show that about 13% were legally intoxicated (BAC ≥ .10% w/v) and the Grand Rapids data about 9%. Crashes classified as "fatals and driver injuries" (300 crashes) and "other visible injury" (404 crashes) are the basis for the Grand Rapids curve.

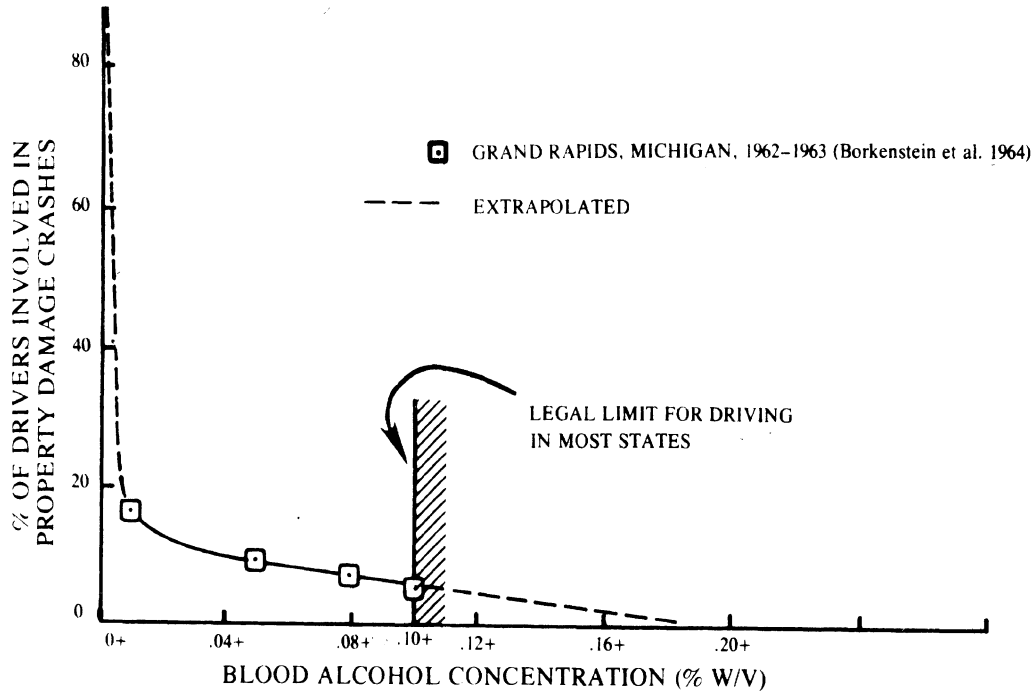
Finally, Figure 2-8 shows the BAC measurements taken in the Grand Rapids study for 4,570 drivers involved in crashes where there were "no indications of injury," i.e., property damage crashes. Only about 5% of these were at or above BACs of .10% w/v.

Figures 2-6 and 2-7 are of interest from another standpoint. A study employing a multidisciplinary team of accident causation researchers found that impairment by alcohol was a "prime cause" of 7% of crashes of all types that were investigated and a "prime or contributing" cause in 16% of its crashes (Joscelyn and Treat 1973). This is roughly the same range of percentages that was observed at BACs of .08% w/v or greater in the two studies of crash involvement shown in Figures 2-6 and 2-7.

With respect to crash culpability, a recent study found that about 40% of drivers said to be "responsible" for multiple vehicle crashes have BACs of .10% w/v or greater, but only 10% of the drivers deemed "not responsible" have such high BACs (Zylman 1974). A study by Waller (1972) using data from police reports found that 92% of fatally injured drivers with BACs of .10% w/v or more were "responsible" for their crashes. By contrast, only 64% of drivers with zero BACs were found to have been responsible.

The reader should note that most studies of crash causation and culpability have incorporated subjective judgments into their analyses. Thus, they do not provide objective proof that alcohol or any other factor actually "caused" or was "responsible" for

Figure 2-8. Percentage of drivers involved in nonfatal, no injury, property damage crashes with BACs equal to or greater than a given level



crashes. While the findings of such studies may be used in broadly defining the role of alcohol in crashes, such findings cannot be used to prove that alcohol is *responsible* for any given percentage of crashes.

*2.2.1.3 Adult Pedestrian Fatalities.* As is the case with driver fatalities, BAC measurements for pedestrian fatalities have been made by coroners or medical examiners. Thus, the same biases that plague driver fatality studies are also a threat for studies of the incidence of alcohol in pedestrian fatalities. Further, data on pedestrians may suffer from an additional bias due to the common practice among coroners of measuring BACs only of victims who were at least 15 years old. This will cause alcohol involvement to be overstated if the resulting percentages are erroneously applied to *all* pedestrian fatalities rather than to fatalities of pedestrians who are at least 15 years old.

Figure 2-9 presents the known pedestrian fatality data believed to be the least affected by measurement biases. (Two excellent studies conducted by Perrine and associates [1971] and by Haddon and associates [1961] are not shown because of the very small sample sizes, 14 and 19 respectively, they employed.) The figure shows that 31% to 43% of the pedestrians tested had BACs exceeding .10% w/v, the legal limit for driving. Test results showed that 25% to 37% had BACs in the very high range, i.e., greater than .15% w/v.

Data from two of the better ASAP surveys are in general agreement with this trend (Figure 2-10), although the Phoenix data show smaller fractions of alcohol involvement at all BACs exceeding .10% w/v.

Figure 2-9. Percentage of adult pedestrians fatally injured in crashes with BACs equal to or greater than given levels

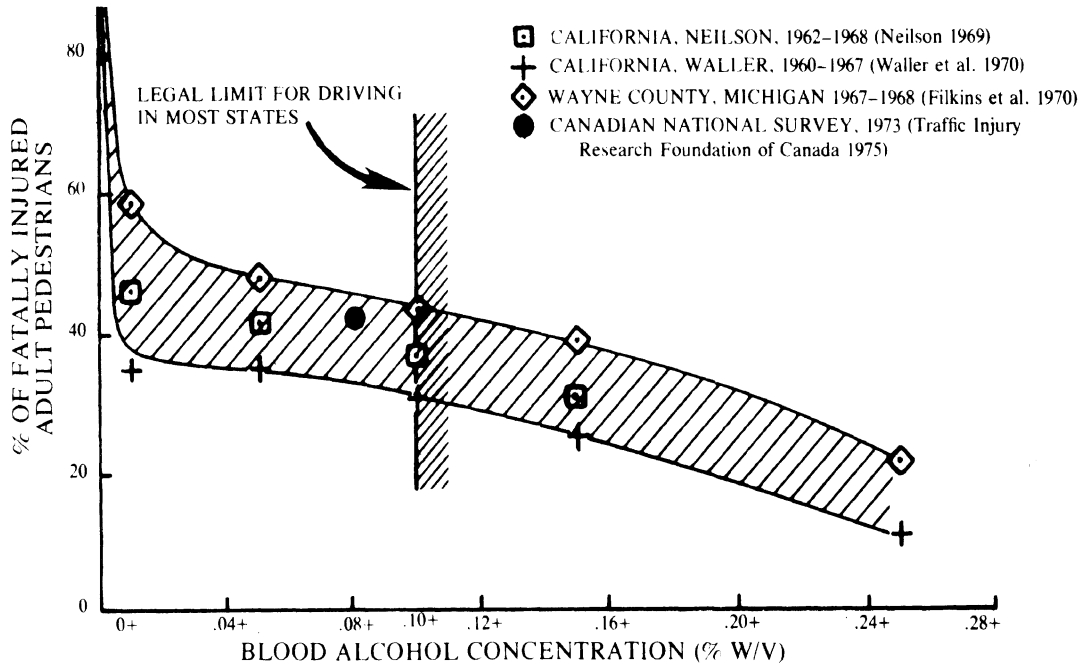
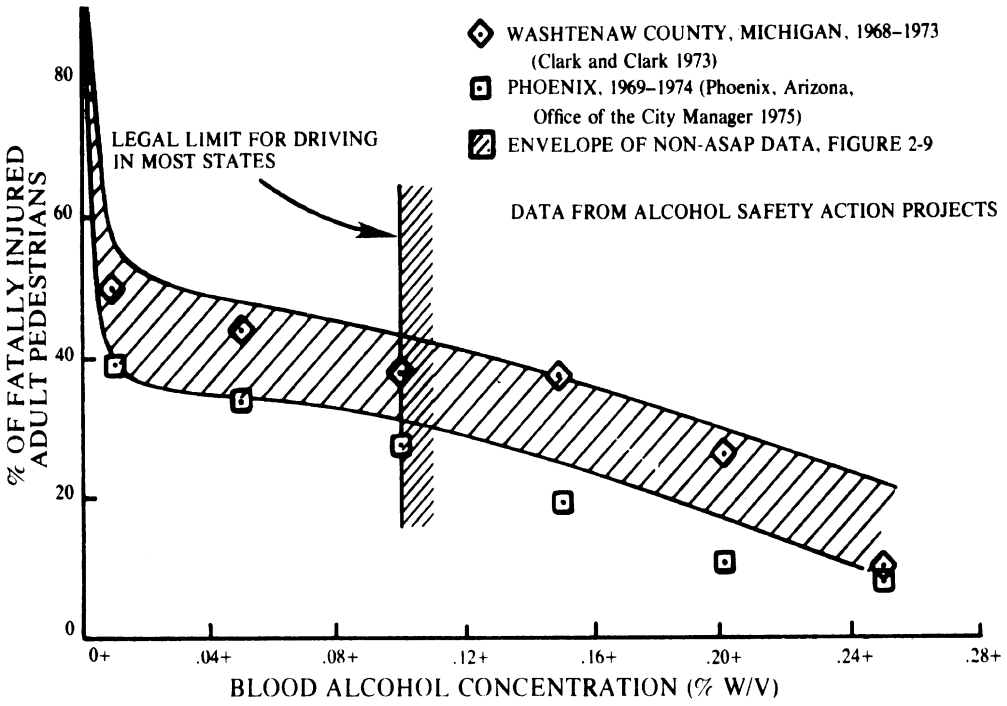


Figure 2-10. Percentage of adult pedestrians fatally injured in crashes with BACs equal to or greater than given levels




Unfortunately, there are no published studies* of the incidence of alcohol involvement in nonfatal pedestrian collisions. Meaningful analysis of this aspect of the alcohol-crash problem must be deferred until further data become available. Another gap in research on alcohol involvement in pedestrian collisions is the lack of data describing the BACs of the *drivers* of motor vehicles that have struck pedestrians. Such data would have the effect of raising the percentages of pedestrian collisions involving alcohol.

### *2.2.2 Drinking Behavior of Drivers Using the Roads*

Figure 2-11 summarizes the results of roadside surveys of noncrash-involved drivers conducted as a part of five controlled studies dating back to 1938. The first study was the previously cited effort by Holcomb. The control group for this study was only a rough approximation of a true control group because no attempt was made to "match" the experimental group with respect to time and place of crash (Holcomb 1938). The next study was conducted by McCarroll and Haddon in New York City in 1959 and 1960 and involved 258 "controls" taken at times and places of fatal crashes (McCarroll and Haddon 1962).

The Grand Rapids control group contained 7,590 drivers selected at random from drivers using the road at times and places of all types of crashes (Borkenstein et al.

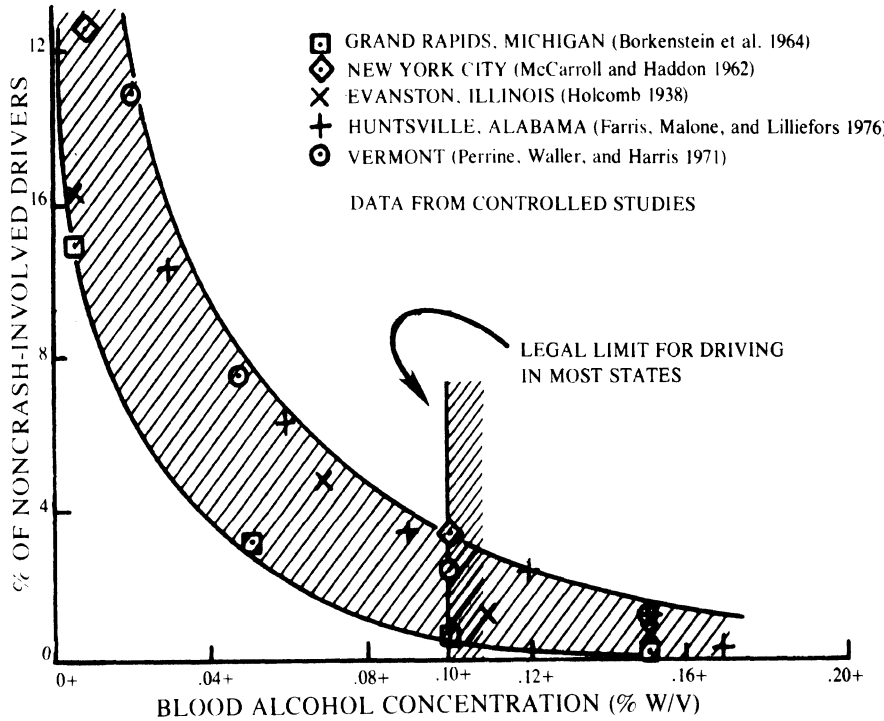
*Research on pedestrian accidents is currently being funded by NHTSA.

1964). The Vermont study (1967–1969) used 1,184 drivers selected from those using the road at times and places of fatal crashes (Perrine, Waller, and Harris 1971). The Huntsville study (1974–1975) is the latest controlled study. BACs were collected from 804 drivers using the road at times and places of 314 personal injury crashes (Farris, Malone, and Lilliefors 1976). Another excellent controlled study conducted in Toronto, Canada, in 1951–1952, is not included in Figure 2-11 because its data were collected only during nighttime hours (Lucas et al. 1955). All of the other studies cited collected their data 24 hours a day, seven days a week. Few drivers (i.e., less than 10%) refused to participate in the surveys.

The results from these controlled studies clearly show that the higher BACs were far less prevalent among drivers not involved in crashes than among drivers who had crashed. Only 1% to 3% of the noncrashed drivers had BACs as high as 0.10%, i.e., high enough to be classified in some jurisdictions as driving while intoxicated (DWI). The comparable range of BACs at this level or higher for crashed drivers is 5% to 50%. Noncrashed drivers having BACs in the very high range (i.e., over .20% w/v) were extremely rare. Only four drivers out of the 7,590 surveyed in the Grand Rapids study had BACs as high as .20% w/v, and only one was as high as .25% w/v (Borkenstein et al. 1964). Only two out of 1,125 drivers in the Vermont Study measured as high as .20% w/v (Perrine, Waller, and Harris 1971).

Figure 2-11 also shows that the BACs were lower in the Grand Rapids survey than in the other surveys. This may be reflective of a trend apparent in the following sections of this report where it is shown that drivers in the more serious crashes tended to have higher BACs than drivers in other crashes. The Grand Rapids survey took its BAC tests

Figure 2-11. Percentage of noncrash-involved drivers with BACs equal to or greater than given levels



from drivers stopped at times and places of *all* types of crashes, whereas the other surveys sampled at times and places of more serious crashes.

Considerable data have also been collected in recent years on drivers *not* selected to match any particular characteristics of crashes or crashed drivers. NHTSA's Alcohol Safety Action Project (ASAP) has been responsible for much of this activity, requiring each of the 35 ASAP sites in the United States and Puerto Rico to conduct roadside surveys to help evaluate the effectiveness of its project. Since 1970 there have been more than 100 of these surveys involving some 100,000 drivers (Wolfe 1975). The surveys were conducted during nighttime hours during weekends and, for some sites, weekdays as well. The data collection techniques were similar to those used in the controlled studies described above. The results of the ASAP surveys are being entered into a master computer file located at the University of Michigan's Highway Safety Research Institute (HSRI).

In 1973, HSRI was contracted by NHTSA to conduct a nationwide roadside survey of 24 cities and counties with populations over 20,000. The locations were chosen to represent all parts of the contiguous United States, and BAC data were collected on Friday and Saturday nights between 10:00 p.m. and 3:00 a.m. Of the 3,698 drivers who were stopped, 3,192 provided breath samples, a response rate of 86.3% (Wolfe 1975).

A summary of BAC data collected in the HSRI national roadside survey and BAC data from 77 of the ASAP surveys is shown in Figure 2-12. For purposes of comparison, the figure also shows a curve representing the mid-points of the range of data collected for noncrash-involved drivers in controlled studies. It can be seen that much higher percentages of drivers exceed any given BAC in these nighttime surveys than in the 24-hour surveys conducted in the controlled studies. For example, from 5% to 6% of the nighttime roadside survey drivers had BACs of .10% w/v or higher, compared to 1% to 3% of drivers sampled around the clock. Also, ASAP's practice of deliberately conducting roadside surveys in locations of relatively high incidence of drinking-driving undoubtedly contributed to its higher percentages of drinking drivers using the roads.

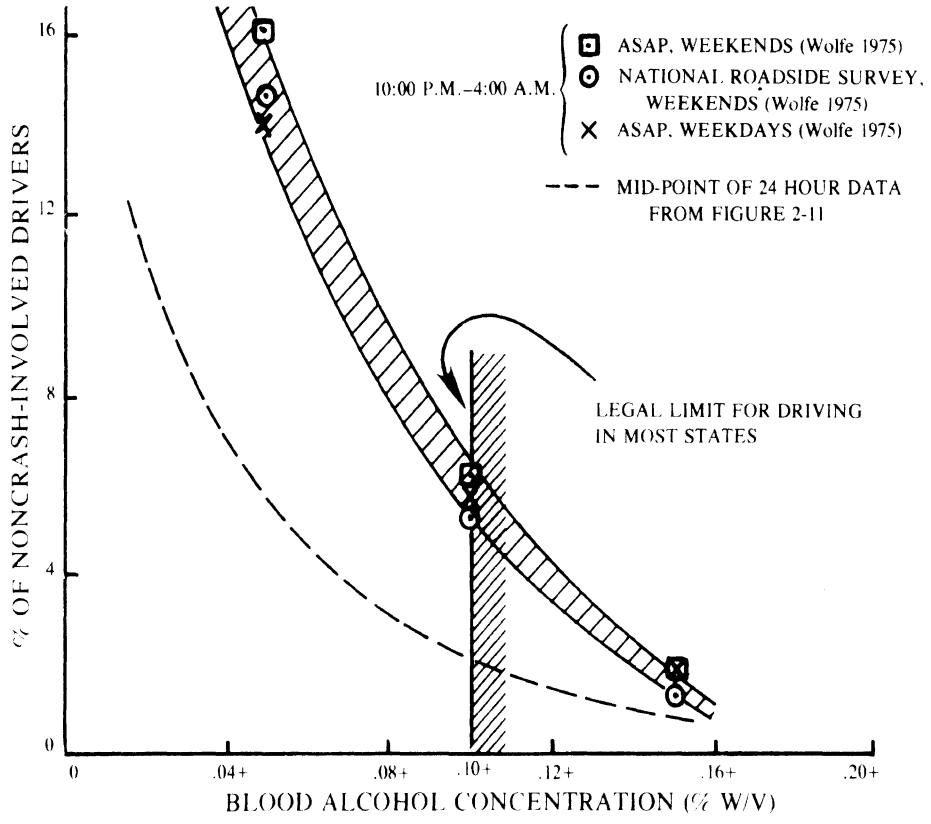
### *2.2.3 Crash Risk of Drinking Drivers*

As was noted previously in this report, meaningful inferences about the role of alcohol in highway crashes cannot be made without considering the incidence of drinking both in drivers involved in the various types of crashes and in drivers using the roads at approximately the same times and places of the crashes. If drivers with high BACs appear more frequently in crashes than in the traffic stream in the vicinity of the crashes, then there is reason to suspect high BAC as a causal factor in the crashes.

The data in the two preceding sections clearly indicate that drinking drivers are, indeed, highly overrepresented in crashes of all severities, especially at the higher BACs. Some 40% to 55% of drivers in the fatal crashes studied had BACs exceeding .10% w/v, but only 2% to 3% of the drivers using the roads at times and places of fatal crashes had BACs in this high range. Similarly, drivers with BACs exceeding .10% w/v were overrepresented by a factor of from three to five in personal injury and property damage crashes.

The controlled study provides a more rigorous method for estimating the relative involvement of drinking drivers in crashes. Various ways of summarizing the findings of

Figure 2-12. Percentage of noncrash-involved drivers with BACs equal to or greater than given levels




these studies have been used over the years. The first controlled study by Holcomb (1938) used the ratio of percentage of crash-involved drivers to percentage of non-crashed drivers to express the degree to which drinking drivers were overrepresented (or underrepresented) in crashes. Thus, on the basis of his data he was aole to say:

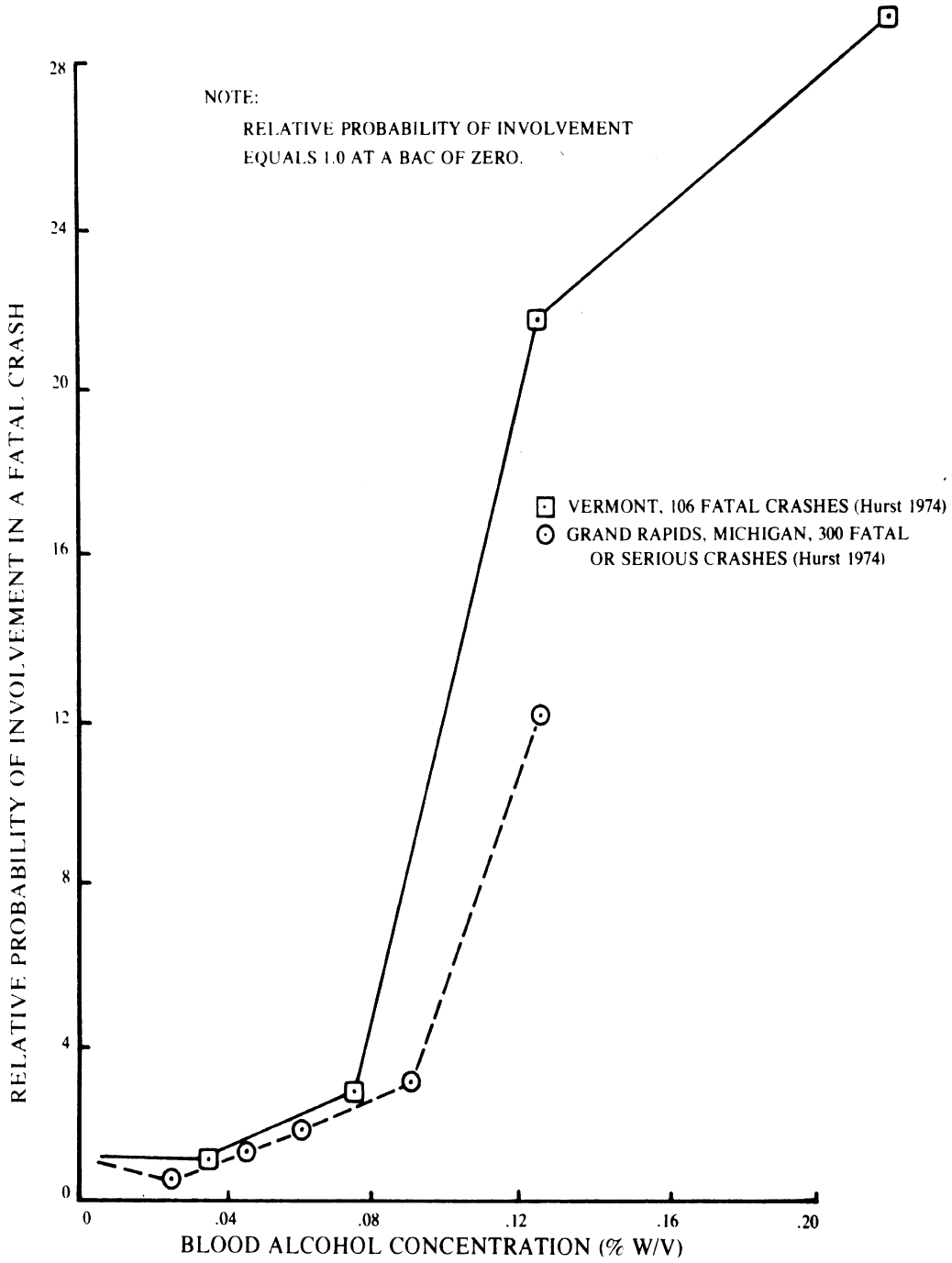
> There are thirty-three times as many drivers whose blood contains 1.5 parts per thousand of alcohol (.15% w/v) in a group of drivers involved in personal injury accidents as in the general population (Holcomb 1938).

The Toronto study in 1952 used this same measure plus an additional one described as the "hazard" associated with a particular BAC interval. The hazard was defined as the involvement of drivers in any BAC interval *relative* to the drivers in the lowest BAC interval measured (Lucas et al. 1955).

Most recently Hurst derived a more rigorous theoretical basis for this alcohol-crash hazard (Hurst 1970) and has applied it to relevant controlled studies up to and including the Vermont study (Hurst 1974). His interpretation is based on an application of an elementary principle of probability theory (i.e., Bayes' Law) and enables one to calculate the probability of being involved in a crash if a given BAC has been reached, *relative* to the probability of crash involvement at a zero (or lowest measured) BAC level.

Figure 2-13 depicts the results of applying Hurst's method to the Vermont study of fatal crashes and to a subset of "fatal or serious" crashes from the Grand Rapids Study.

Figure 2-13. Relative probability of involvement in fatal crashes for drivers with BACs at given levels



The calculations show that the probability of involvement in the Vermont fatal crashes for those with a BAC of .10% w/v was twelve times as high as for those who had not been drinking at all. The calculations for Grand Rapids' less serious crashes also indicate greatly increased crash risk for legally intoxicated drivers over nondrinking drivers but indicate the risk to be much lower than that calculated for the Vermont study. The figure shows that risk begins to increase very rapidly at BACs in the neighborhood of .08% w/v and becomes extremely high at the very high BACs, i.e., greater than 20 to 1 relative probability of involvement at BACs over .15% w/v.

The Grand Rapids curve shows a slight *decrease* in crash risk at very low BACs. Possible reasons for this "dip" are discussed in Section 4.0 of this report.

The data from the controlled studies also indicate increased risk of involvement in the less severe categories of highway crashes. At a BAC of .10% w/v, the relative probability of involvement in any kind of nonfatal crash on a year-round, 24 hours-a-day basis was about 3.5 in the Grand Rapids study (Figure 2-14). The Toronto study, conducted during evening hours only, indicates a smaller (but still important) relative probability of nonfatal crash involvement at a BAC of .10% w/v. The Huntsville study of personal injury crashes revealed relative probabilities of involvement somewhere in between those found in Toronto and Grand Rapids (Figure 2-14).

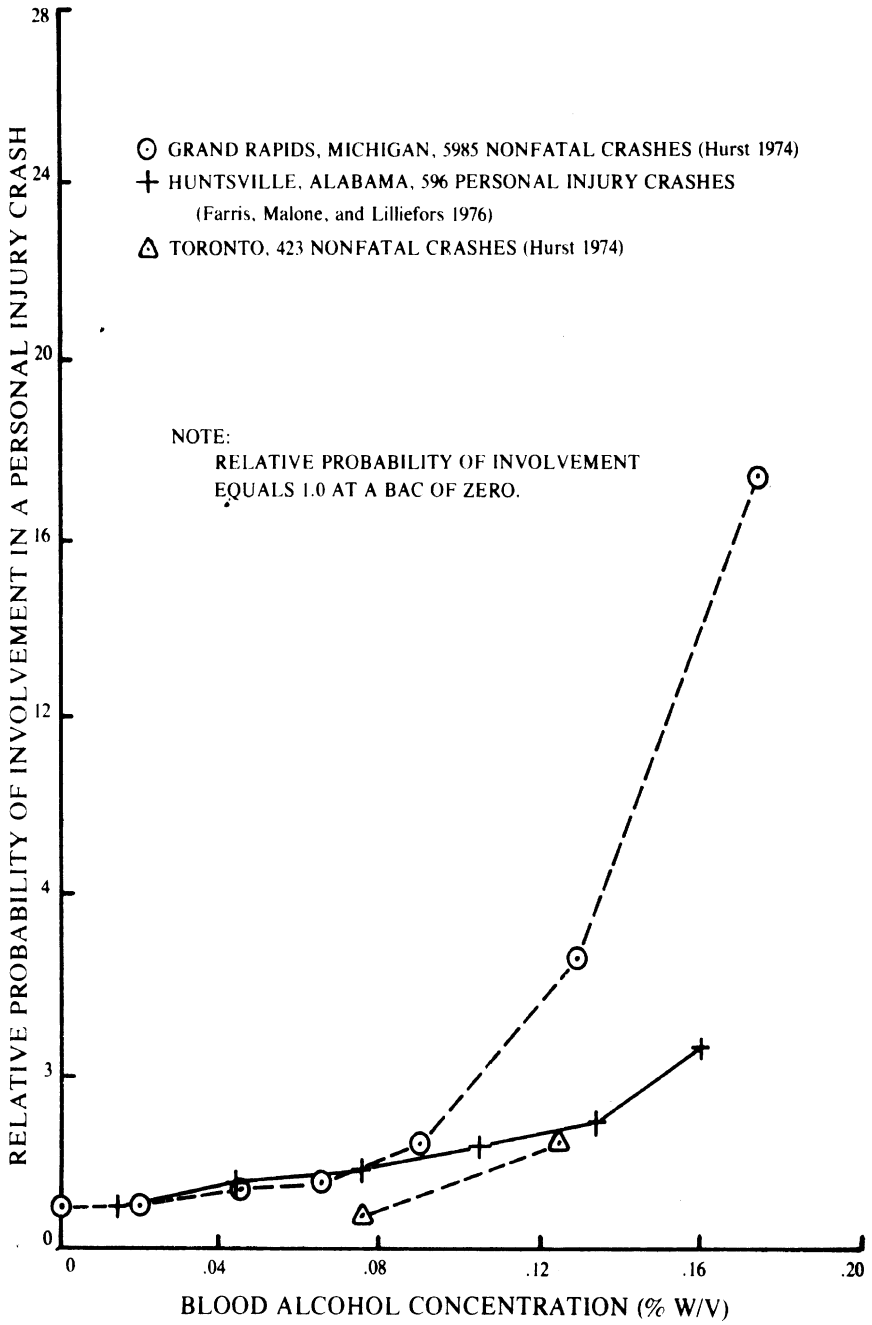
The Grand Rapids study also calculated the relative probability of *causing* a crash as a function of BAC. The analysis assumed that the non-culpable drivers involved in multiple-vehicle crashes had the same BAC distribution as the control group of drivers. A group composed of culpable crash-involved drivers was then constructed by subtracting the control group distribution from the distribution of all multiple-vehicle crashes and adding the distribution of single-vehicle crashes. As a result, it was estimated that the relative probability of *causing* a crash at a BAC of .10% w/v was about 6.0, or about twice the probability of being *involved* in a crash at that BAC.

In his 1970 paper, Hurst described another useful way of looking at the involvement of drinking drivers in highway crashes. He presented a method for using the relative probabilities of involvement to calculate the percentage of crashes that would be prevented if the drivers who had BACs above a given value were to lower their BACs and then were to experience the same involvement probability as other drivers in that lower BAC category (Hurst 1970). The results of applying this method to the Grand Rapids, Vermont, and Huntsville data are shown in Figure 2-15. If the BAC "limit" had been, for example, .10% w/v, then 32% of the Vermont fatal crashes would not have occurred, 8% of Grand Rapids' fatal and serious injury crashes would have been avoided, and 6% of the Huntsville personal injury crashes would have been prevented. Further, 3% of the Grand Rapids' crashes of *all* types would not have occurred. Lowering the BAC limit below .10% w/v would result in the prevention of additional crashes if Hurst's criteria were followed.

## 2.3 NATIONAL IMPLICATIONS OF EPIDEMIOLOGIC RESEARCH

The epidemiologic studies described above were, with the exception of the National Roadside Survey, designed as separate research projects to learn more about the alco-

Figure 2-14. Relative probability of involvement in personal injury crashes for drivers with BACs at given levels



hol-crash problem in specific locations around the United States. Yet, despite the wide differences in the study designs and in their geographical locations and dates, the same trends have consistently been observed:

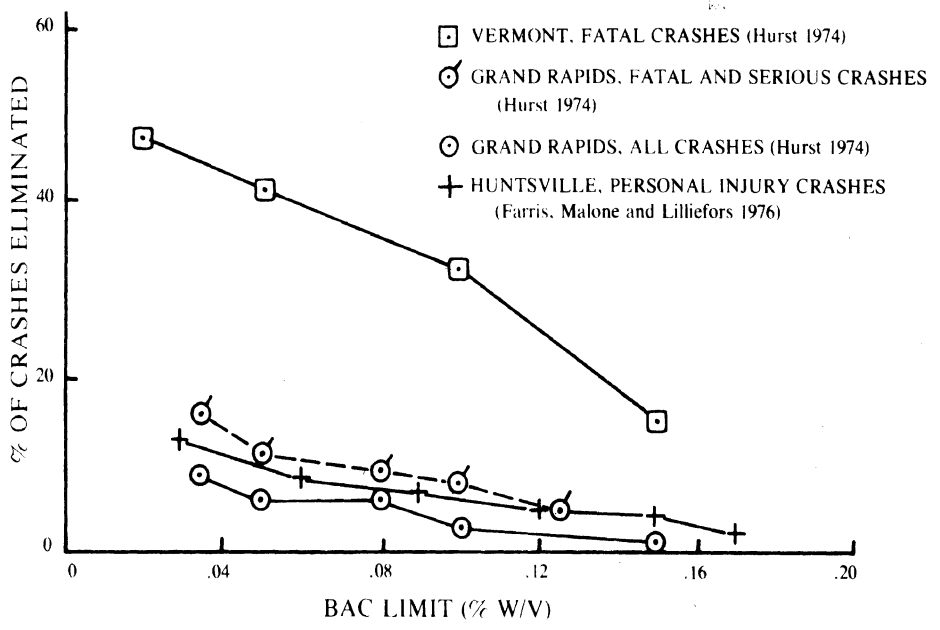
- Substantial fractions of the more serious crashes involve drivers whose BACs exceed the usual legal limit ($\geq$ .10% w/v) for driving.
- Smaller but not negligible fractions of "minor" crashes involve drivers who are legally too intoxicated to drive.
- The risk of being involved in any kind of a highway crash increases rapidly as the legal BAC limit for driving is exceeded.

Thus, there is ample scientific evidence to conclude that alcohol-crash is a nationwide problem, but existing data are insufficient to describe scientifically the exact nature or extent of the problem. Faced with this dilemma one can either make no further statements pending collection of additional data or make estimates and approximations based on existing data. This report follows the second course in the belief that a rational, if not precise, analysis of available information will be more useful than no analysis. In the remainder of this section such estimates are made with respect to percentages, number, and societal costs of U.S. crashes involving alcohol. In addition, various interpretations are made about the risks such crashes present to drivers with high BACs.

### *2.3.1 Alcohol in Crashes*

Table 2-1 summarizes the results of section 2.2.1 of this report and two other recent reviews of the epidemiology of alcohol involvement in highway crashes (Perrine 1975;

Figure 2-15. Percentage of crashes eliminated if given BAC limits had not been exceeded: Hurst criteria



Zylman 1974). This report's review and the Perrine review are in accord on the percentages of crash-involved drivers with BACs exceeding .10% w/v. The values arrived at by Zylman (1974) fall close to midpoints of the ranges indicated by this report and the Perrine review (Perrine 1975). Unfortunately, neither the Perrine review nor the Zylman review gave estimates of alcohol involvement at other BAC levels, and the latter review considered only fatal crashes.

The midpoints of the ranges of values shown in Table 2-1 have been used to develop some rough estimates of the national impact of alcohol-involved crashes. These values are plotted in Figure 2-16, which shows the resulting percentages of crash-involved drivers who would have BACs exceeding the amounts shown. The curves have been used to arrive at an idea of the number of crashes and associated deaths, injuries, and damages that could be "saved" by eliminating the crashes involving the drivers whose BACs exceeded given amounts. The resulting numbers represent an upper limit to savings that could actually be achieved by any real prevention program because (a) it is inconceivable that *all* such crashes could be prevented by any societally acceptable programs, and (b) persons who were removed from the higher-risk BAC categories by a prevention program would not cease being involved in crashes altogether but would, at best, only reduce their involvement to that associated with their lower BAC category.

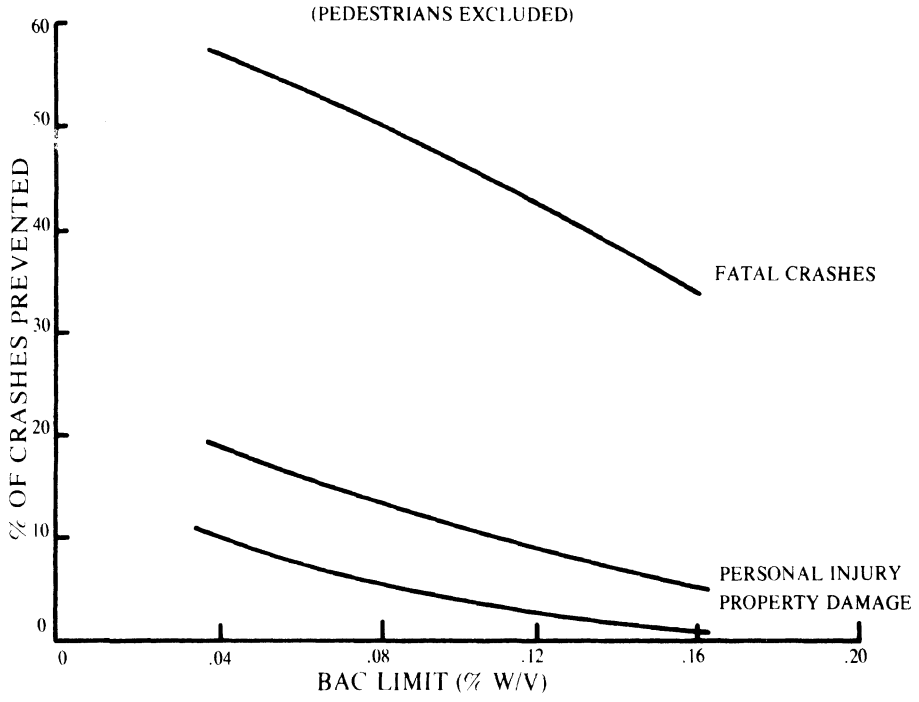
TABLE 2-1

*Estimated Percentages of Crash-Involved Drivers With BACs Exceeding Given Values*

| | | BAC, % w/v | | |
|---|---|---|---|---|
| *Type Crash* | *Source* | *.05* | *.10* | *.15* |
| All Fatal | This Report | 50–60 | 40–55 | 29–43 |
| | Perrine* | — | 40–55 | — |
| | Zylman** | — | — | — |
| Single Vehicle Fatal | This Report | 60–70 | 55–65 | 34–53 |
| | Perrine* | — | 55–65 | — |
| | Zylman** | — | 57 | — |
| Multi-Vehicle Fatal | This Report | 30–55 | 25–50 | 20–38 |
| | Perrine* | — | 25–50 | — |
| | Zylman** | — | 32 | — |
| Personal Injury | This Report | 14–19 | 9–13 | 5–7 |
| | Perrine* | — | 10–35 | — |
| | Zylman** | — | — | — |
| Property Damage | This Report | 9 | 5 | 1.5 |
| | Perrine* | — | 5–10 | — |
| | Zylman** | — | — | — |

*Perrine 1975
**Zylman 1974

Figure 2-16. Estimated percentages of U.S. crashes eliminated if all drivers with BACs exceeding a given amount did not crash




The reader is cautioned against concluding, purely on the basis of epidemiologic evidence, that all such prevented crashes would have been *caused* by alcohol.

The technique developed by Hurst (and described in Section 2.2.3) for calculating the maximum effectiveness of alcohol-related crash prevention programs allows this second factor (i.e., reduction of the risk of crash involvement as opposed to elimination of that risk) to be taken into account; and it results in a more realistic assessment of the costs of crashes involving drinking drivers. The only problem in using the technique for obtaining national estimates is the need for controlled studies to provide the input data. The only really valid controlled study of the most costly type of crash, the fatal crash, is the Vermont study, which was conducted in a predominantly rural setting. Nevertheless, it should be of interest, for purposes of comparison, to develop some estimates based on Hurst's criteria. The basis for these estimates will be Figure 2-17, which presents smoothed versions of the curves in Figure 2-15. The curve for personal injury crashes in Figure 2-17 is based on a composite of applicable Grand Rapids and Huntsville data.

Figure 2-17 may be used for estimating how many crashes would be eliminated by changing the crash risk of drivers with BACs *above* a given amount to a crash risk associated with *exactly* that BAC. For example, if one could by some means replace the crash risk of persons who drive with BACs *above* .10% w/v with the crash risk of persons who drive with BACs of *exactly* .10% w/v, approximately 29% of all fatal crashes would be eliminated. A BAC "limit" of .05% w/v would eliminate some 42% of all fatal crashes, etc.

Figure 2-17. Estimated percentages of U.S. crashes eliminated if alcohol-related crashes were reduced according to Hurst's criteria

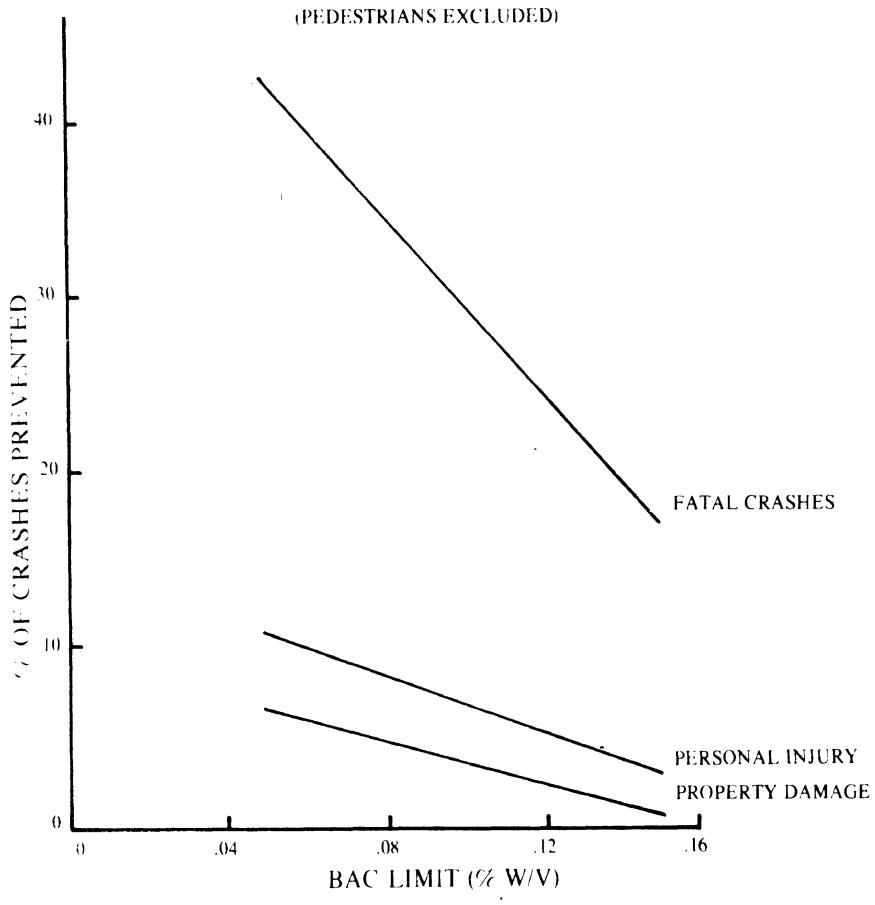



TABLE 2-2

*Estimated Reduction in Number of Crashes Due to Preventing Alcohol-Related Crashes: 1975*

*(Pedestrians Excluded)*

| | *HURST CRITERION: Lowered Probability of Crash Involvement for Those With Given BAC Levels** | | | *Probability of Crash Involvement Reduced to Zero for Those With Given BAC Levels*** | | |
|---|---|---|---|---|---|---|
| *BAC Limit (%w/v)* | *Fatal Crashes* | *Personal Injury Crashes* | *Property Damage Crashes* | *Fatal Crashes* | *Personal Injury Crashes* | *Property Damage Crashes* |
| .05 and above | 13,600 | 118,800 | 965,000 | 17,900 | 183,600 | 1,296,000 |
| .10 and above | 9,400 | 83,900 | 621,000 | 15,200 | 120,000 | 765,000 |
| .15 and above | 5,300 | 32,700 | 153,000 | 11,600 | 65,400 | 229,500 |

*The Hurst criteria are discussed in section 2.2.3 of this report.

**Numbers are based on percentages presented in Figures 2-16 and 2-17, and 1975 accident rates (National Safety Council 1976).

Table 2-2 shows the estimated number of fatal, personal injury, and property damage crashes (nonpedestrian only) that would have been prevented in 1975 if drivers who exceeded the BAC limits shown either had not crashed at all or had crashed at reduced rates in accordance with Hurst's criteria. The seriousness of the alcohol-crash problem is indicated by the fact that as many as 9,400 to 15,200 fatal crashes, 83,900 to 120,000 personal-injury crashes, and 621,000 to 765,000 property-damage crashes would not have occurred if the legally intoxicated drivers had not crashed at all or had crashed at the reduced rates indicated for nonintoxicated drivers. Still, it cannot be stated with certainty just how many of these crashes were actually *caused* by alcohol.

The societal costs associated with these alcohol-involved crashes may be estimated by applying cost factors developed by NHTSA (U.S. Department of Transportation 1976b). These cost factors permit one to calculate the long-term losses in societal welfare (a) to the individual (personal consumption loss, pain and suffering, assets consumption loss), (b) to society as a whole due to the distribution of resources away from welfare-*producing* activities and toward compensation for losses (medical care costs, property damage costs, legal and court resources, insurance costs), and (c) to society due to direct and indirect losses in the productivity of those involved in crashes (Faigin 1975).

The resulting societal costs are presented in Figure 2-18, which indicates that some $4 to $6 billion dollars in societal welfare losses could have been prevented in 1974 by reducing or preventing crashes involving illegally intoxicated drivers (BAC $\geq$ .10% w/v). Even greater savings could have been realized by reducing or preventing crashes with drivers' BACs exceeding .05% w/v ($6 to $8 billion). Large savings would have been possible even if only drivers exceedings the very high BACs had been prevented from crashing ($2 to $4 billion). Again, these represent the maximum possible savings that could be achieved by any real-world alcohol-safety program and are presented only to illustrate the upper bound to the problem.

### *2.3.2 Alcohol in Pedestrian Collisions*

In Table 2-3, the present report's estimates of the BACs of fatally injured adult pedestrians are compared with estimates developed in the Perrine (1975) and Zylman (1974) reviews. As was the case for BACs of drivers, there is accord among the studies for pedestrians with BAC $\geq$ .10% w/v, justifying the development, as in this report, of estimations of impact which use the midpoints of ranges of values.

TABLE 2-3

*Estimated Percentages of Fatally Injured Adult Pedestrians With BACs Exceeding Given Values*

| | *BAC (% w/v)* | | |
|---|---|---|---|
| *Source* | *.05* | *.10* | *.15* |
| Present Report | 35–48 | 31–43 | 25–37 |
| Perrine* | — | 28–43 | — |
| Zylman** | — | 36 | — |

*Perrine 1975
**Zylman, Blomberg, and Preusser 1975

Figure 2-18. Estimated maximum societal costs savings in the U.S. due to preventing alcohol-related crashes

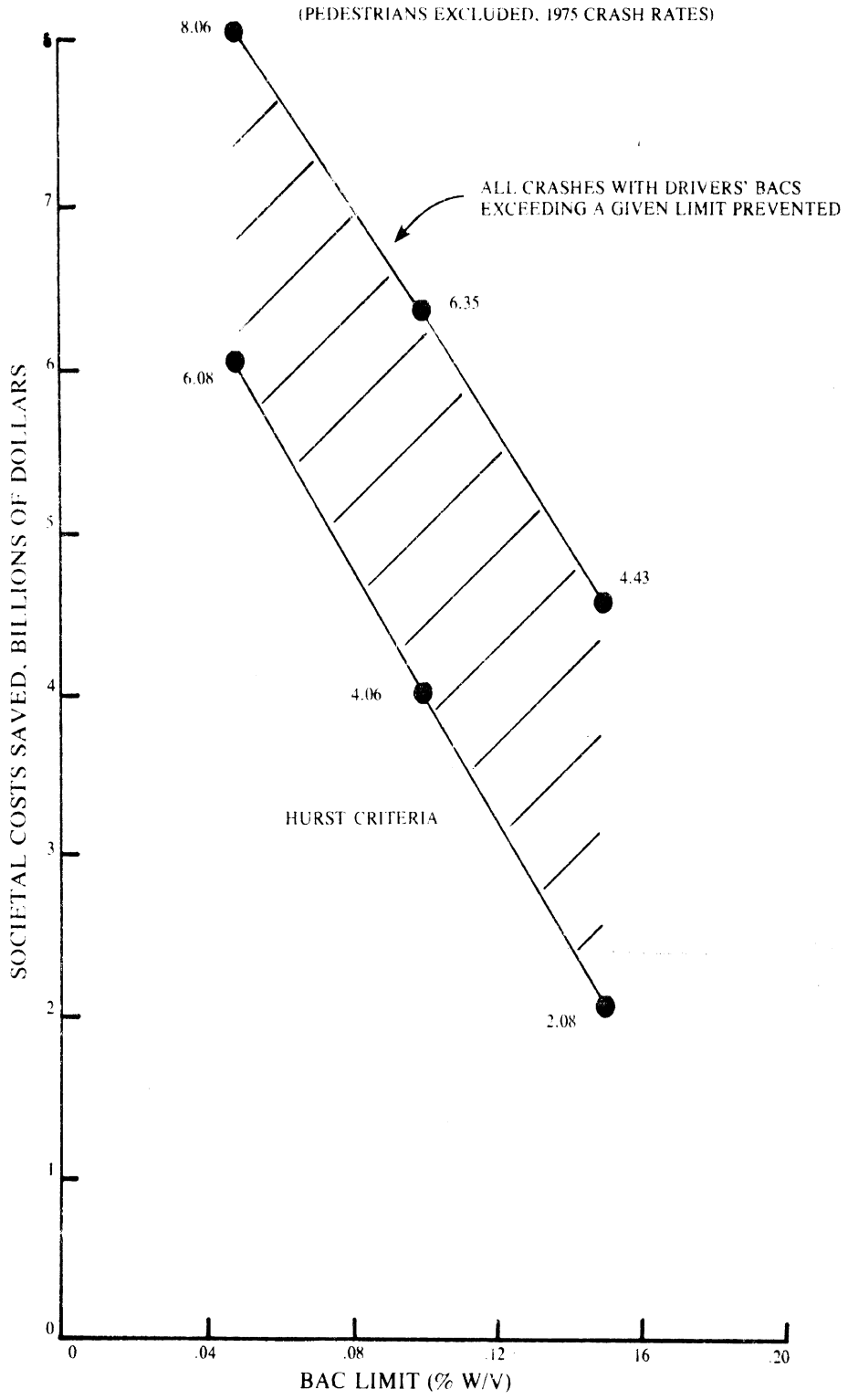


TABLE 2-4

*Estimated National Losses Due To Alcohol-Involved Adult Pedestrian Fatalities in 1975*

| *BAC (% w/v)* | *Number of Collisions* | *Societal Costs, ($ Million)* |
|---|---|---|
| .05 + | 2,700 | 775 |
| .10 + | 2,300 | 661 |
| .15 + | 2,000 | 574 |

Use of these percentages with national accident data (National Safety Council 1976) results in the finding that some 2,300 fatally injured adult pedestrians had BACs exceeding .10% w/v in 1975 (Table 2-4). The costs to society of these crashes are over a half-billion dollars. It is not possible to apply Hurst's criteria to these calculations because of the lack of applicable controlled studies of pedestrian collisions. Also, there are insufficient data to develop any useful estimates of alcohol involvement in pedestrian injuries which were nonfatal.

### *2.3.3 Risk of Involvement in Alcohol-Related Crashes*

The epidemiologic studies clearly show that high-BAC drivers face a much higher crash risk than low-BAC drivers. For example, the Grand Rapids and the Vermont studies indicate that illegally intoxicated drivers are six to twelve times more likely to be involved in fatal and serious injury crashes than nondrinking drivers (Figure 2-17). Data from the Toronto and Grand Rapids studies indicate that the involvement frequency of illegally intoxicated driver is 1½ to 3⅓ times that of nondrinkers for less serious crashes.

The alcohol-crash risk could be calculated for groups of drivers and nondrivers more sharply defined than those above. Unfortunately, the data for making such calculations on a national basis are so limited that the results would be little more than speculation and would probably serve more to confuse than to clarify. More will be said about the characteristics of drinking drivers in Section 4.0 of this report.

## 2.4 SUMMARY AND CONCLUSIONS

Public concern about a suspected alcohol-crash problem was expressed at least 70 years ago, and scientific investigations to determine the nature of that problem have been underway for over 40 years. A major tool for studying the role of alcohol in highway crashes is the epidemiologic study of the incidence of drinking among various population of drivers, particularly drivers who had crashed and noncrash-involved drivers who had been exposed to highway environments similar to those in which the crashes took place.

Epidemiologic studies have been conducted for many years in many different locations. Their objectives, designs, and executions have varied widely, for no national

program has existed for methodically investigating the many variables that describe the complex driver-vehicle-environment interactions surrounding highway crashes. For the most part, research has proceeded in the directions of greatest interest to individual investigators rather than along lines that would support the objectives of coordinated programs of risk reduction. Conversely, coordinated risk reduction programs based on a preliminary understanding of the problem have been unable, for the most part, to generate sufficiently rigorous data for wide application in improving understanding.

As a result, problem identification, the first step commonly taken in such programs, must be performed by piecing together bits of information gleaned from many exploratory studies never intended for global application. Such an approach is scientifically hazardous, but necessary, if further progress is to be made.

In many respects the picture that emerges is remarkably consistent. Some 40–55% of all driver fatalities in the studies had blood alcohol concentrations high enough to be considered, legally, too intoxicated to drive, in most states (i.e., BAC $\geq$ .10% w/v). An even higher percentage (55–65%) of drivers who were killed in single-vehicle crashes had BACs of at least .10% w/v. Smaller but still significant fractions of drivers involved in injury crashes (9–13%) and property damage crashes (5%) were illegally intoxicated.

The national impact of these figures is enormous. If one assumes that the national percentages lie at the midpoints of the ranges stated above, then, in 1975, the following numbers of crashes involved illegally intoxicated drivers:

- fatal crashes: 15,200;
- personal injury crashes: 120,000; and
- property damage crashes: 765,000.

The societal costs of these crashes are estimated to be in the order of $4 billion to $6 billion. The losses would be even higher if the thousands of crashes that involved lower but possibly impairing BACs were counted.

The studies also indicate that the risk of being involved in a crash increases as alcohol concentration in the blood increases. The relative probability of a crash starts to rise sharply as a BAC of .08% w/v is approached. At a BAC of .10% w/v the probability of a serious injury crash or a fatal crash is some 6 to 12 times as high as it is with no alcohol. At a BAC of .15% w/v, the relative probability of such a crash could be as high as 15 to 20. The risk of involvement in less serious crashes also increases after drinking but not to as great an extent.

Less can be said about the magnitude of the alcohol-pedestrian safety problem because of the paucity of reliable studies in the area. Indications are that about one-third of all pedestrian fatalities had BACs of .10% w/v or greater at the time of their death. No figures are available for nonfatal injuries of drinking pedestrians. Studies now in progress should help to fill this gap.

The above figures, while indicative of a large-scale national problem, do not, of course, prove that alcohol *caused* the crashes in which drinking was involved. Traffic accidents are probabilistic, with many factors entering into the probability equation. The most that can be said on the basis of epidemiologic evidence is that, on the average, alcohol, present beyond a certain amount, is associated with increased crash risk. In-depth analyses of the conditions surrounding the crashes would have to be made to

support stronger statements about causation. While such analyses have been made of the roles of many other factors, the role of alcohol has not been subject to the same close scrutiny in the studies. Only rough assessments have been made of alcohol as a causal factor in crashes. Nevertheless, these studies suggest that drivers who are responsible for crashes more often have high BACs (i.e., $\geq$ .10% w/v) than drivers who are not responsible for crashes.

# 3.0 ALCOHOL EFFECTS ON PEOPLE

Though epidemiologic studies have provided strong evidence that drinking is associated with increased risk of crash involvement, they are not an appropriate tool for addressing other fundamental questions about alcohol as a causal factor in crashes. For example, epidemiologic studies have not been able to rule out the possibility that other circumstances that just happen to be coincident with consumption of alcohol might be more significant causal factors than is alcohol consumption. (This issue will be discussed in detail in Section 4.0 of this report.) Nor can these studies indicate just *how* ingestion of alcohol results in impaired driving performance. Knowledge about the effects of alcohol on human behavior would help in determining the probability that alcohol alone (in given amounts) can sufficiently impair the driving performance of many people to be a primary causal factor in many highway crashes.

For the purposes of this report, the scientific study of alcohol effects on people has been divided into three categories:

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

The first two categories deal with the absorption and metabolism of alcohol in the human body, the measurement of alcohol presence in the body, and the acute and chronic physiological effects of alcohol on various parts of the body. This material is germane to the present report because of the need to describe the relationship between behavior and alcohol in quantitative terms, that is, in terms of amount of alcohol consumed. It is also important to understand some of the more basic interactions between alcohol and the bodily components, especially those interactions that influence behavior.

The third category of alcohol studies is of more direct interest here. It is concerned with alcohol's effects on human behavior, particularly behavior related to driving. Topics covered include the processes through which alcoholic intoxication is brought about, the specific site(s) of alcohol's effects in the body, and the effects of alcohol on the range of behavioral processes. Studies of alcohol influence on the simpler behavioral processes (e.g., interactions of nerves and muscles) are of special concern insofar as

they relate to driving performance. Studies of the effects of alcohol on the performance of simulated and actual driving tasks are of obvious interest.

The remainder of this section of the report discusses the findings of studies believed to be representative of some of the better research in the areas outlined above. No attempt is made at an exhaustive treatment of the literature, which in some areas is far too extensive for a complete review in a document such as this. However, references are presented which will enable the reader to engage in more in-depth study of topics of particular interest.

## 3.1 BIOCHEMISTRY AND PHYSIOLOGICAL EFFECTS OF ALCOHOL

### *3.1.1 Alcohol Absorption, Metabolism, and Measurement*

The active ingredient in distilled spirits, wine, and beer is ethanol, a member of a family of chemical compounds known as monohydric alcohols. Ethanol (also called ethyl alcohol, grain alcohol, and, more commonly, simply "alcohol") is simpler in chemical composition than any of the other alcohols except one, methanol. It is soluble in water, weighs a bit less than water (specific gravity = .79) and has a lower boiling point than water (78.3°C) (Wallgren and Barry 1970; Leake and Silverman 1971).

Although alcoholic beverages appear in a great variety of colors, flavors, and bouquets, their chief constituents quantitatively are ethanol and water. Other components appear to have only minor pharmacological significance (Wallgren and Barry 1970; AMA Committee on Medicolegal Problems 1970), although some studies (Katkin et al. 1970) indicate that primary alcohols other than ethanol (called "congeners") may increase risk-taking and decrease psychomotor performance. A "typical" drink (about 3/4 ounce of alcohol) is provided by the following amounts of alcoholic beverages (Hall 1974):

- a "shot" of distilled spirits (1½ oz. of 100 proof alcohol),
- a glass of fortified wine (3½ oz. of 20% alcohol),
- a larger glass of table wine (5 oz. of 12% alcohol),
- a pint of beer (16 oz. of 4½% alcohol).

Alcohol is most commonly absorbed into the body through the gastrointestinal tract, although it may also be absorbed through the membrane of other tissues, e.g., skin, bladder, oral cavity. Absorption occurs through the simple process of diffusion—alcohol does not have to be digested before entering the blood. When the route of absorption is through the gastrointestinal tract, approximately 25% of the dose passes through the stomach wall and the remainder through the intestines (Hall 1974).

The rate of absorption of alcohol, when taken orally, depends on the quantity taken, its concentration, and especially on the other contents of the gastrointestinal tract. Food delays absorption. When alcohol is taken with a heavy meal, up to six hours may be required for complete absorption (Wallgren and Barry 1970). The effect of the concentration of alcohol in the drink on the absorption rate is minimal for small doses but becomes noticeable at larger doses, peaking out at about 20–30% dilution for doses of

about two to three ounces (Wallgren and Barry 1970; AMA Committee on Medicolegal Problems 1970).

After absorption within the body, alcohol is distributed among the organs and tissues in proportion to their fluid content. The speed with which different organs reach equilibrium depends upon their blood supply (AMA Committee on Medicolegal Problems 1970). Organs such as the brain and liver will reach a given concentration faster than will, for example, bone.

Alcohol is eliminated from the body through the combined processes of oxidation and excretion. Conclusive evidence exists (AMA Committee on Medicolegal Problems 1970) that oxidation is by far the more important of the two, converting over 90% of the alcohol in the blood to carbon dioxide and water and releasing energy in the process. The first step of the metabolic process occurs mainly in the liver where an enzyme helps to convert the alcohol into another chemical compound, acetaldehyde. Other tissues assist in the further metabolism of this compound (von Wartburg 1971).

Researchers have found that the average rate of elimination of alcohol from the body is about .015% w/v per hour (Wallgren and Barry 1970). This rate of elimination is independent of the level of BAC except at very low concentrations (e.g., .01%). Roughly speaking, the average person eliminates, each hour, one of the "typical" drinks described above. No practicable means of significantly accelerating the elimination of alcohol has been discovered yet, although some research in this area has been conducted (see section 6.2.1).

There are many methods of measuring the amount of alcohol in the blood. Most of these test the blood directly, rather than some other fluid or tissue (for example, urine or saliva). Blood collected from a vein or from capillaries is usually preferred when a direct indication of alcohol concentration in the brain is required. Laboratory facilities are required to separate the alcohol from the blood and for the subsequent quantitative determination of the alcohol (AMA Committee on Medicolegal Problems 1970; Dubowski 1977).

In 1927, Bogen introduced breath-alcohol analysis as a medical tool in the United States (AMA Committee on Medicolegal Problems 1970). Since then a number of devices have been developed for use both in the laboratory and in the field. Moulden and Voas (1975) have reviewed techniques and instruments currently in use in the U.S.

Modern breath testers can be quite precise in their quantitation of breath alcohol. Tests of the Breathalyzer, a device which uses photometric methods, were conducted over a period of nearly 20 years and indicate high precision when compared to calibrated devices which measure blood alcohol directly (AMA Committee on Medicolegal Problems 1970). Other inexpensive and highly portable breath testers are available for screening purposes in the field where less precision is needed (Moulden and Voas 1975). More will be said (in Section 5.0) about the various types of breath alcohol testers and the problems of using them operationally in the section of this report which discusses ways of dealing with the drinking driver problem.

### *3.1.2 Acute Effects of Alcohol*

Evidence of alcohol intoxication is most commonly apparent through observation of the behavioral and emotional effects of alcohol consumption. (These effects are discussed

in some detail in Section 3.2). The gaiety of cocktail chatter, the staggering drunk, and the man who cries in his beer are easily recognizable stereotypes of the effects of drinking. These and other behavioral and emotional effects of drinking vary among individuals and among cultures. However, there is a universal pattern of reaction to drinking, beginning with feelings of relaxation and pleasure and progressing to heightened emotionalism and disturbances in psychomotor functioning. Though these effects are the most easily observable, they are secondary manifestations of the actions of alcohol on the human body. The primary effects of alcohol intoxication are physiological.

The physiological effects of alcohol intoxication have been categorized as acute and chronic. Acute effects are short term in that they result in only temporary behavioral changes; and they do not usually result in permanent damage to the human body, though impairment of certain physiological processes may extend beyond the time when alcohol has left the body (AMA Committee on Medicolegal Problems 1970; Wolkenberg 1975). Acute effects may begin to appear very soon after the ingestion of alcoholic beverages. As the amount of alcohol in the body increases, the depressant effect of alcohol increases, and the physiological processes of the body are increasingly impaired. The acute effects of alcohol intoxication on the human body include alterations in the functioning of the central nervous system, temporary swelling and inflamation of the liver, increased urinary output, increased heartbeat and blood pressure, irritation of the lining of the stomach, distortion of the water balance of the body through redistribution of water, impairment of the sexual function, and restless sleep (AMA Committee on Medicolegal Problems 1970; Carroll 1970; U.S. Dept. of Health, Education and Welfare 1971).

The most significant of these acute physiological effects is the impact of alcohol intoxication on the central nervous system. The behavioral and emotional effects of alcohol consumption are caused by the depressant effects of alcohol on the brain. The measurement of BACs is really an attempt to determine, indirectly, the amount of alcohol in the brain. Since it is not usually possible or practical to extract samples of brain tissue for this measure, materials from other parts of the body are employed. Thus, as discussed previously, the presence of alcohol in the body is most commonly measured through chemical tests performed on samples of blood, urine, and/or breath (AMA Committee on Medicolegal Problems 1970).

The sensory effects of alcohol consumption appear in response to very small doses of alcohol. Nystagmus, a condition involving rapid and involuntary movement of the eyeball from side-to-side, occurs as early as 15 minutes after ingestion of alcohol. Lesser effects occur with the other senses. Taste and smell become less acute. The use of alcoholic beverages to lessen pain compares well with that of other analgesic substances. There appears to be little effect of alcohol consumption on hearing (AMA Committee on Medicolegal Problems 1970; Levine, Greenbaum, and Notkin 1973).

Just how much alcohol must be ingested for acute alcohol intoxication to occur varies from person to person. Relevant variables are body weight, contents of stomach, physical health, and the tolerance which the individual has developed to the effects of alcohol. Researchers have found that at a BAC of 0.15% w/v, at least half of their subjects show signs of gross intoxication. Many people appear to be intoxicated at lower BACs (AMA Committee on Medicolegal Problems 1970). As stated above, acute alcohol intoxication

rarely results in permanent damage to the human body. However, it is possible for coma to result if a BAC of 0.40% w/v is reached. A comatose condition may last for 10–12 hours before death occurs as a result of the paralysis of the respiratory center.

### *3.1.3 Chronic Effects of Alcohol*

The effects of the consumption of alcoholic beverages on the human body become chronic when large amounts of alcohol are ingested over long periods of time. Among the possible chronic effects of heavy and sustained consumption of alcohol are nutritional imbalance, reduced sensitivity of the nervous system to the effects of alcohol, withdrawal symptoms when the intake of alcohol is abruptly decreased, increased risk among some groups of developing certain kinds of cancer, increased risk of heart disease among former drinkers, shorter life expectancy among heavy drinkers, muscle weakness, hormonal imbalance, and sustained irritation of the mouth, esophagus, and stomach, resulting in impaired functioning of the gastrointestinal tract (Lieber 1976; U.S. Dept. of Health, Education and Welfare 1971; U.S. Dept. of Health, Education and Welfare 1974).

Prolonged irritation of the gastrointestinal tract by alcoholic beverages, the possible presence in alcoholic beverages of carcinogenic substances, the enhancement of the effects of carcinogenic substances in those persons who both drink and smoke, and alcohol related nutritional imbalance are all factors which may contribute to the increased risk of cancer among some groups (U.S. Dept. of Health, Education and Welfare 1974).

However, there are at least two counterindications of the health problems believed to result from the use of alcohol. One counterindication is that moderate drinkers appear to be less prone to heart disease than either former drinkers or abstainers. A second counterindication is that though heavy drinkers have a shorter life expectancy than moderate drinkers, moderate drinkers have longer life expectancies than abstainers (U.S. Dept. of Health, Education and Welfare 1974).

Not all the issues related to alcohol and health have been resolved, as the preceding statements reflect. Of major concern to many researchers are the effects of alcohol on the liver. These effects are known but not completely understood. Many researchers believe alcohol to be a direct liver toxin, and others remain convinced that it is the malnutrition resulting from chronic use of alcohol rather than alcohol itself which leads to cirrhosis of the liver (U.S. Dept. of Health, Education and Welfare 1974). As a result of research conducted over a period of years on both humans and baboons, Lieber (1976) has concluded that even in those who maintain an adequate diet, heavy and prolonged consumption of alcoholic beverages can result in irreversible damage to the liver. Though diseases of the liver are commonly associated with alcoholism, Lieber points out that moderate ingestion of alcohol well below the legal limits of drunkenness set by most states has been shown to bring about liver damage.

## 3.2 BEHAVIORAL EFFECTS OF ALCOHOL

The preceding paragraphs have summarized the short-term and long-term physiological effects of alcohol. This section is concerned with the effects of alcohol on human

behavior, specifically, human behavior which could be related to driving a motor vehicle. The objective is to determine if the overrepresentation of drinking drivers in crashes that was found in section 2.0 of this report could be due to alcohol impairment rather than to some other coincident factor. Present theory on the mechanism of intoxication by alcohol is discussed very briefly, and what is known about alcohol effects on behavioral attributes is summarized.

*3.2.1 Effects on the Nervous System*

The most obvious and well-known acute effect of alcohol on behavior is intoxication. Yet, there is no generally accepted explanation of how intoxication is caused by alcohol. Hodgkin's theory, envisaging the nerve cell membrane as "pumping" ions in and out of cells until a change in voltage across the membrane causes a nerve impulse, is the basis for most modern theories of alcohol's effect on the brain (U.S. Department of Health, Education and Welfare 1974). It is known that many alcohols, including ethanol, can inhibit the transport of these ions into brain cells (Streeten and Solomon 1954), and it is believed by some that an enzyme is responsible, just as a different enzyme is responsible for metabolising alcohol in the liver (Albers 1967). A better understanding of this phenomenon awaits the development of a suitable theoretical formulation.

Lack of knowledge about the mechanism of intoxication seriously inhibits understanding alcohol's effects on human behavior. The U.S. Department of Health, Education, and Welfare's *Second Special Report to Congress on Alcohol and Health* (1974) noted:

> Existing knowledge of alcohol effects on brain metabolism, nerve cell transmission, synoptic function, and the biochemistry of membrane-bound processes is insufficient to elucidate the problem. The lack in knowledge handicaps treatment and perhaps blocks the fundamental understanding of the nature of alcohol addiction, and its possible prevention (p. 93).

Just as there is insufficient knowledge about the mechanism of intoxication, there is also an inadequate basis for pinpointing the components of the central nervous system which are most susceptible to the influence of alcohol. Some researchers believe that the reticular activating system (RAS) which forms the central core to the brain stem may be a major site of alcohol effects in the nervous system (Maling 1970). The RAS helps to control attention and arousal as well as to integrate the functions of the cortex. Impairment of RAS functioning would be expected to degrade the operation of both motor and thought processes. There is also evidence that alcohol affects the functioning of the cortex itself, but the exact nature of the effects is not known (Beck, Dustman, and Sakai 1969; Begleiter and Platz 1972).

There are indications that low concentrations of alcohol have opposite effects on the body than high concentrations. At low concentrations (i.e., BAC less than .05% w/v), alcohol seems to exert an excitatory influence on behavior, but higher concentrations cause depression and, ultimately, blockage. Some investigators believe that these so called "bi-phasic" effects can be explained by the hypothesis that alcohol is always a depressant and that its apparent stimulating effect at low concentrations is due to its depressing of some inhibitory mechanism (Perrine 1974b).

The major conclusion that can be drawn from existing research on the fundamental nature of alcohol effects on the nervous system is that there is insufficient knowledge to develop any practicable model for predicting specific behavioral effects. Lacking a general, unifying theory, it becomes necessary to turn to empirical data obtained through laboratory and field experiments to describe how alcohol affects behavior.

In a critical review of research on the effects of alcohol on human performance, Levine and associates (Levine, Greenbaum, and Notkin 1973) noted some problematic characteristics of the literature. Included in their critique of the literature were the following observations:

- Studies of the effects of alcohol on human performance differ greatly in the types of controls used.
- The subject populations have not always been well defined in terms of the variables (e.g., sex, weight, age, drinking patterns) which are known to influence alcohol-related behavior.
- The dosage of alcohol administered to subjects varies greatly across studies.
- The type of alcoholic beverage used varies, though it is known that different types of alcohol have different absorption rates.
- Time variables are not consistently defined or controlled for. These variables include time allowed to consume alcohol, time of day alcohol is consumed, and time between ingestion and start of testing.

Indexes of performance have not been standardized. These factors make it difficult to judge the validity of research findings and to replicate studies. Perrine (1974a) concurs in these observations and has made recommendations for alleviating some of these past deficiencies (Perrine 1974b).

Since the present report is concerned with alcohol and highway safety, the major interest here is behaviors that are related to driving performance. In the sections that follow, the continuous range of such behaviors is divided into three discrete parts for purposes of discussion:

- "simple" processes involving the ability to perform relatively uncomplicated tasks not requiring high degrees of motivation and understanding.
- "complex" processes involving verbal performance, problem solving, learning, memory, mood and emotions.
- processes believed to be directly involved in driving, as measured in driving simulators and actual driving tests.

The first two classes of behavior have been studied only in a laboratory setting. In most cases, the relationship between the behavior that has been studied in the laboratory and tasks that are performed in driving is tenuous. In some cases, considerable imagination is required to imply a relationship between the behavior and driving performance. In fact, no known study has explicitly stated such a relationship, leaving it to the reader to develop one of his own.

This lack of clear connection between laboratory behavior and driving tasks seriously limits the usefulness of all laboratory studies of the effects of alcohol on human behavior. Most of the laboratory tasks have been much simpler than those involved in driv-

ing, indicating that only gross effects on task performance could safely be interpreted as affecting driving performance. Obviously, in such cases, one cannot quantify any ultimate effects of alcohol on driving performance.

*3.2.2 "Simple" Processes*

Most of the scientific studies dealing with this group of alcohol effects fall into the following subject categories:

- interactions of nerves and muscles, such as would occur in moving the steering wheel of an automobile;
- the purely sensory aspects of vision, such as the ability to read a highway sign under given conditions;
- tracking, the ability to maintain an index marker at some predetermined or moving position, as might be required to keep an automobile on a roadway;
- time-sharing, the ability to perform two or more activities intermittently, such as keeping an automobile on the road while monitoring the speedometer to maintain a legal speed; and
- attention, such as the ability to maintain concentration on the roadway ahead while driving.

Certain interactions of nerves and muscles (i.e., neuromuscular effects) are among the most obvious manifestations of alcohol intoxication. Inability to stand upright without swaying is a classical symptom of intoxication that has been the subject of much study because it lends itself to quantification and is brought about by relatively low levels of blood alcohol concentration. A standard procedure for measuring body sway, the Romberg test, has been developed. This procedure allows some comparison of the results of the numerous laboratory studies of this phenomenon (Wallgren and Barry 1970). These studies showed that all of the individuals tested exhibited a significant amount of swaying at BACs over .10% w/v, that many were affected at much lower BACs (e.g., .075% w/v), and that the BAC at which their swaying began to significantly increase was between .04% w/v and .05% w/v (Franks et al. 1976; Fregly, Bergstedt, and Graybiel 1967; Goldberg 1943; Idestrom and Cadenius 1968).

Romberg tests of persons accused of drunken driving provide a much different picture from the results noted above. One study in the mid-1950's (Laves 1955) showed that only about half of such persons tested swayed perceptibly at BACs of .10% to .1[illegible]% w/v, and another study (Prag 1953) found that none of its subjects swayed at BACs lower than .20% w/v. The reason for this disagreement with laboratory tests of other groups is not known, but it has been speculated it may be due to the accused drinking drivers "mustering sufficient self-control to override the influences of alcohol on body sway" (Perrine 1974b). It could also be due to unknown fundamental differences between the groups of drinkers. Obviously, the results of Romberg tests cannot be directly translated into statements about degradation in the performance of specific driving tasks. The tests indicate that alcohol degrades neuromuscular functioning in some individuals; but of course they do not relate directly to driving performance.

Much research has been conducted on the influence of alcohol on vision. Indications are that many of the basic functions of the retina are not substantially impaired by

alcohol (Honneger, Kampschulte, and Klein 1970). For example, a person's ability to distinguish closely separated unmoving objects (i.e., *static visual acuity*) is virtually unaffected at BACs below .08% w/v (Mortimer 1963). However, at higher concentrations (e.g., above .10% w/v), almost everyone's static visual acuity becomes impaired (Newman and Fletcher 1941). By contrast, *dynamic visual acuity* (one's ability to distinguish closely separated moving objects) seems to be consistently impaired at much lower BACs, sometimes as low as .03% w/v (Honneger, Kampschulte, and Klein 1970). This finding could be significant for driving, in view of the positive (but low) correlation that has been found to exist between lower levels of dynamic visual acuity and poor driving records (Burg 1970).

Studies of alcohol effects on other modalities of vision show that there is little or no impairment at low to moderate BACs, but increasing impairment at the BACs above .08% w/v (Lewis, Dustman, and Beck 1969; Lewis 1972; Mortimer 1963; Moskowitz 1974; Newman and Fletcher 1941).

There is also considerable evidence to support the conclusion that alcohol does not significantly impair simple tracking performance and concentration attention, even at BACs of up to .10% w/v (Chiles and Jennings 1969) and higher (Colquhoun 1962; Newman 1949; Talland, Mendelson, and Ryack 1964). However, research indicates that more complex tracking tasks and tasks involving time-sharing or divided attention may be degraded at relatively low blood alcohol concentrations. For example, laboratory studies of pursuit tracking, where individuals are asked to maintain an index on a moving target, show that impairment occurs in the .05% w/v to .10% w/v BAC range (Binder 1971; Levine, Greenbaum, Notkin 1973; Mortimer 1963; Richter and Hobi 1975). Impairments in time-shared tasks, at BACs as low as .04% w/v, were reported among airplane pilots in a study of alcohol effects on flying (Billings and Wick 1972). Laboratory experiments in divided-attention tasks showed similar results (Gruner, Ludwig, and Domer 1964).

A possible explanation for alcohol degradation of time-shared activities is that a switching mechanism for alternately presenting information to the central processor might be impaired. It has been suggested that alcohol might impair the immediate memory system holding the information in line to be processed, or that the rate of processing by the brain might be reduced by alcohol (Moskowitz 1974). In any case, the relevance of these findings on time-shared activities to actual driving performance related to crashes cannot be explicitly stated.

### *3.2.3 "Complex" Processes*

Alcohol effects on the higher, more complex processes of the brain are more difficult to isolate and quantify than alcohol effects on the relatively simple processes discussed above. Relationships between alcohol effects on such processes studied in the laboratory and alcohol effects on complex tasks involved in driving are even more tenuous. A major source of difficulty in dealing with these intellectual functions is the pervasive and incompletely understood influence of emotional and motivational conditions which may also be influenced by alcohol. Thus, an experiment to learn the effect of alcohol on, say, verbal associations with certain stimulus words would, in general, be affected by the motivation (or lack of motivation) of the subjects to do well in the experiment. Con-

versely, understanding a situation may help to relieve or to increase anxieties or tensions, depending on the situation, the individual involved, and many other factors. Therefore, it is not possible, even in the most carefully controlled laboratory experiments, to say how a particular component of motivation or understanding is affected by alcohol. Only combined effects can be measured.

The literature is reflective of this methodological dilemma and of the fundamental constraint it imposes on the scientific analysis of alcohol impairment of human behavior. Only fragments of information are available to be pieced together informally to arrive at clues about the whole process. For example, there is a large body of literature describing the effects of alcohol on moods and emotions. The data in these studies are derived from direct methods employing self-reported and observer-reported descriptions, and from indirect methods using handwriting tests, inkblot tests, etc. Wallgren and Barry's review (Wallgren and Barry 1970) of pre-1970 laboratory studies of alcohol effects on mood and emotion indicates a dichotomy of effects. Some individuals are stimulated by alcohol and become exhilarated, cheerful, and friendly. Others are depressed and become quiet, relaxed, sleepy, and unable to think clearly. Post-1970 studies, conducted under a wide range of conditions, tend to confirm these findings. One such study (Warren and Raynes 1972) found that persons are more tired and less vigorous after reaching a BAC of .10% w/v than they were at .05% w/v; but another study, in which the subjects were policemen, found no depressant effects (Kelley, Myrsten, and Goldberg 1971).

In a review of the literature on indirect measurements of the effects of alcohol on moods and emotions, Barry (1974) found additional evidence of a "bi-phasic" effect, observing that "alcohol serves to depress any tendencies for organized meaningful expression of cognitive or emotional responses while showing a stimulant, disinhibitory effect on the style of responses." Other researchers have found increased expressions of aggression and of desires for power after consumption of moderate amounts of alcohol, as well as decreased inhibition (McLelland et al. 1972). However, it should be emphasized that most laboratory experiments on humans show little evidence of increased aggression as a result of alcohol intoxication (Barry 1974). At the same time, it should be kept in mind that the subjects of such studies usually have been college students, who are not representative of the general driving population.

A few laboratory studies have investigated the effects of alcohol on risk-taking. They indicate that alcohol may cause a small increase in willingness to accept risks in card games, money wagers, etc. (Wallgren and Barry 1970), one such study suggesting that introverts tend to engage in risk-taking more frequently than extroverts after consuming a moderate amount of alcohol (Cutter, Green, and Harford 1973). There are also indications that light drinkers may be more inclined to engage in risk-taking after drinking than heavy drinkers (Goodwin, Powell, and Stein 1973).

The depressant effects of alcohol are especially apparent in laboratory experiments involving integrated, skilled behavior and appear in the form of hasty, careless, and disorganized performances (Wallgren and Barry 1970). However, some studies have shown improved performance in certain intellectual activities after low doses of alcohol, especially among heavy drinkers and alcoholics (Mello 1972; Wallgren and Barry 1970).

A depressant effect of alcohol has also been noted in tests of a person's ability to perceive rapidly changing events (Buikhuisen and Jongman 1972). Also, time appears to pass more quickly for many individuals after drinking, an effect that is characteristic of persons who have taken a depressant drug (Ehrensing et al. 1970; Wallgren and Barry 1970). However, this is not always true. For some persons (including laboratory subjects who were depressed), small amounts of alcohol have had the opposite effect of slowing down the passage of time and inducing impatience, as might be observed after taking a stimulant drug (Cappell et al. 1972; Wallgren and Barry 1970). Further, a tendency of intoxicated persons to underestimate their performance impairment has been observed in some laboratory experiments (Goldberg 1943; Wallgren and Barry 1970).

Why a person's own estimate of the degrading effect of alcohol on his performance is sometimes less than the actual effect is not known. Behavioral research suggests that the tendency of alcohol to remove inhibitions (McLelland et al. 1972) may be a factor, but there may be other factors.

There are indications that alcohol may impair combined sensori-motor tasks (e.g., tracking) more than it impairs more intellectual activities (e.g., arithmetic calculations) (Sidell and Pless 1971). Experiments also suggest that one's performance in complex sensori-motor tasks (e.g., card sorting) is more impaired than in simpler tasks (Lewis 1975). Evidence that sensori-motor performance might be more impaired in light drinkers by moderate amounts of alcohol than in heavy drinkers is provided by one study (Goodwin, Powell, and Stein 1973).

Laboratory experiments provide evidence that alcohol impairs both short-term and long-term memory. Earlier experiments had indicated rather small effects on short-term memory, unless the material to be memorized was complex (Wallgren and Barry 1970), but more recent research has shown much larger detrimental effects, even for less complex materials (Ehrensing et al. 1970). Experiments with long-term memory have shown consistently larger effects, particularly on the retention in one state (drunk or sober) of information that was learned in another state (sober or drunk) (Walgren and Barry 1970). An extreme example of this effect is total inability to recall any events that occurred during intoxication (blackout). The exact relevance to highway safety of these findings cannot be stated at this time.

Most of the research conducted on the effects of alcohol on memory has employed alcoholics as subjects, thus limiting its general applicability. Experiments comparing alcoholics with nonalcoholics tend to show that both short-term and long-term memory effects are more pronounced among alcoholics (Weingartner and Faillace 1971a). One such study (Weingartner and Faillace 1971b) yielded the unexpected but highly relevant finding that alcoholics may be less sensitive to punishment than nonalcoholics. The nonalcoholics in this experiment had a poorer recall of words associated with punishment than other words, but the alcoholics showed no difference in recall with respect to punishment.

The studies cited above provide some clues as to how alcohol might affect driving performance. However, they do not show how the observed effects are explicitly related to crashes.

*3.2.4 Driving Performance*

Laboratory experiments on the effects of alcohol on human behavior are useful for developing a fundamental knowledge base from which basic concepts can be formed and valuable insights gained. However, they are seriously limited in their applicability to specific areas of human performance because of the difficulty of relating their abstract activities and conditions to those experienced in everyday life. It is difficult to understand, for example, exactly how the results of a Romberg test or an experiment in sorting playing cards conducted in a laboratory setting applies to the tasks that must be performed in driving an automobile on a busy expressway at night.

Attempts to get more realism into experiments on the effects of alcohol on driving performance have appeared in two basic forms:

- using driving simulators to approximate actual driving conditions in the laboratory and
- using an actual vehicle on a carefully controlled driving course.

While these two types of experiments provide a closer approximation to real life driving conditions than the laboratory experiments described in Section 3.2.3, the usefulness of the findings of these studies is limited. In simulator and closed course driving experiments the speeds which are achievable are much lower than average highway speeds and tests last for relatively short time periods. In addition, the tests require the use of much simpler skills than required in ordinary highway driving. Further, the driver is aware he is being tested and may react differently from how he would in an actual driving situation. These limitations exist because, legally and ethically, it is not acceptable to endanger the subject by exposing him (and the public) to the dangers of driving under the influence of alcohol for extended periods of time, at high speeds and on public roads (Huntley 1974).

The results of the driving simulator studies have been highly conflicting, leading one reviewer to observe that "there appears to be no driving behavior on which the effects of alcohol have been reported more than twice with complete consistency" (Heimstra and Struckman 1974). The authors of that study report that there was sufficient consistency among the studies to suggest that the impairment of the higher mental processes was a major contributor to reduced driving performance. This conclusion is supported by another simulator study that concluded that moderate amounts of alcohol impaired performance of complex, concurrent tasks more than simple tasks (Landauer and Milner 1971).

Two recent simulator studies, involving subjects with moderate BACs, indicated that braking response is degraded by alcohol (Rafaelsen et al. 1973) and that persons are more likely to continue through an intersection on a yellow light after drinking (Lewis and Sarlanis 1969).

In a study by Snapper (1973) on a closed course driving range, comparisons were made of the performance of light and moderate drinkers at BACs of 0.0, .05, .10, and .15% w/v. He found that psychomotor impairment is more relevant to accident causation than impaired decision-making. Snapper stated that this finding contradicts the earlier work in this area by Lewis and Sarlanis (1969), possibly because the driving task defined by them was not very sensitive to psychomotor impairment.

The extent to which a driving simulator is able to interject more realism into studies of driving performance is not known. In comparison of the performance of experienced taxi drivers on tests of psychomotor skills, simulators used in driver training, and actual street driving, no evidence was found that the laboratory methods commonly used to test driving performance are significantly related to on-the-street driving behavior (Edwards, Hahn, and Fleishman 1969).

Another study compared the effects of alcohol on perception of risk in a simulated and in an actual traffic situation. While the major finding of the study was that alcohol has no significant effect on subjects' perception of risk, the performance of subjects in the simulated situation was poorly correlated with their performance in the realistic traffic situation. The authors concluded that, if alcohol plays a role in risk-related behavior, the role must be to increase willingness to engage in risk. However, this is difficult to substantiate through simulation experiments, because psychological variables are not under the control of the researchers (Browning and Wilde 1975). The search for additional realism has led to a wide variety of studies on the influence of alcohol during actual driving.

One of the earliest of such studies was conducted by Bjerver and Goldberg (1950). It compared the performance of a group of drivers who had consumed distilled spirits or beer with a control group who consumed no alcohol. The driving tasks studied involved low-speed maneuvers (i.e., backing, parking, starting) to position a vehicle within an area defined by stanchions, and driving performance was measured in terms of the time required to complete all maneuvers perfectly. BACs of the experimental group ranged from .016% w/v to .07% w/v, with an average of .048% w/v. The study showed that the alcohol group took about 28% longer to complete the maneuvers than the control group. Individual differences were greater: impairment was noted at BACs as low as .035% w/v, and lack of impairment was noted at BACs as high as .060% w/v.

Another earlier study of driving performance at low speeds suggested that impairment is significant at a BAC of about .08% w/v for most people, but also found that some drivers were not impaired at BACs up to .10% w/v (Coldwell et al. 1958). There were also indications that heavy drinkers were less impaired at a given BAC than light drinkers.

Driver performance studies at higher speeds also indicate increases in driver errors in stopping and lane changing at BACs in the .10% w/v range (Chastain 1961; McLelland 1968). One study conducted at speeds of 45 mph showed an increase in braking reaction distance of 28% at a BAC of .10% w/v (Lovibond and Bird 1970). Another study showed more subtle signs of performance degradation (e.g., steering reversals, rough shifting) at BACs as low as .05% to .07% w/v (Seehafer, Huffman, and Kinzie 1968).

Some recent studies of driver performance at the University of Vermont have indicated that moderate amounts of alcohol (i.e., BAC of .07% w/v to .10% w/v) increase accelerator reversals and, possibly, steering errors (Huntley and Centybear 1974; Perrine and Huntley 1971). Few studies of the effects of alcohol on the driving performance of heavy drinkers have been performed. One Vermont study, conducted at night on only two heavy drinkers at BACs of approximately .10% w/v, showed statistically significant increases (24% to 33%) in brake response times to lights presented in the center and on the periphery of the visual field, respectively (Huntley, Kirk, and Perrine

1972). The Vermont studies also suggest that the driving performance of extroverted persons may be more degraded by alcohol than the performance of other drivers.

The latest reported Vermont study (Damkot et al. 1977) suggests that drivers with high BACs (i.e., .08–.149% w/v) may drive faster and have less smooth stopping behavior than other drivers. The latter study is also of interest because it measured speed and stopping performance in a real-world setting as drivers approached a roadblock. Its findings with respect to reaction time and stopping performance are in general agreement with a recent review of the subject by Perrine (1976).

## 3.3 SUMMARY AND CONCLUSIONS

Detailed investigations of the effects of alcohol on human behavior related to driving have been conducted along a wide front, ranging from laboratory experiments on animals to driving tests in automobiles. There are significant methodological problems with much of this research, making it difficult to arrive at scientifically justifiable conclusions at almost any level of detail. Thus, results must be discussed in terms of what may reasonably be inferred rather than in terms of what can be proved. The findings and conclusions presented in this section should be read in this context.

There is general agreement in the literature that absorption of alcohol by the body occurs through the process of diffusion (not requiring digestion) at a rate that is largely determined by the other contents of the gastrointestinal tract. Elimination of alcohol occurs almost entirely through metabolism (i.e., "burning up" by the body) at a relatively constant rate for most persons. Attempts to increase substantially the rate of metabolism by artificial means have not been successful.

The universal measure of alcohol presence is *blood alcohol concentration* (BAC) which, stated in terms of weight of alcohol per unit volume of blood, can be measured with high precision by a number of means, including breath testing devices. It is the most useful parameter known for relating alcohol consumption to human behavior.

The most obvious behavioral effect of alcohol is intoxication, but there is no satisfactory theory to explain how this occurs in the body. Some scientists believe that an important site of action is that portion of the brain which helps to control attention and arousal, as well as to integrate cortical functions. The cortex itself may also be directly affected by alcohol.

Research indicates that alcohol may have opposite effects at low BACs than it does at higher BACs. It appears that, at BACs of less than about .05% w/v, alcohol exhibits an excitatory influence on behavior, but that the effect is reversed and becomes depressant at higher BACs. This effect has been observed across a wide spectrum of behaviors, from those involving simple neuromuscular processes to those produced through complex cognitive and emotional processes.

With respect to the simpler behavioral processes, there is evidence that neuromuscular responses may be impaired in some individuals at BACs as low as .04% to .05% w/v and that many more individuals suffer such impairment at BACs in the range of .10% w/v. However, studies indicate that experienced drinkers can, if motivated, overcome these impairing tendencies at BACs as high as .20% w/v. Vision *per se* is not greatly

affected by alcohol at BACs of less than .10% w/v, but above that it becomes impaired in most persons. "Simple" tracking performance does not apper to be seriously degraded at BACs of less than .10% w/v, but the performance of "complex" tracking tasks has been degraded in many individuals at BACs in the .05% to .10% w/v range. The ability to divide attention between tasks can be impaired at very low BACs (i.e., .02% w/v) and is often impaired at BACs above .08% w/v.

Studies of the more complex behavioral processes indicate that risk taking may be increased at moderate BACs for introverts and light drinkers. Moreover, low doses of alcohol have been observed to improve the intellectual performance of heavy drinkers and alcoholics while having the opposite effect on lighter drinkers. Alcohol has been found detrimental to memory, particularly the long-term memory, of heavy drinkers.

The applicability of the laboratory studies of the effects of alcohol on human behavior is severely limited by the lack of a clear relationship between the various behavior studied and driving tasks. Degradations of such behavior have been observed, but there is no way of stating these degradations in terms of crash risk.

Simulator studies of behavior thought to be related to driving have shown highly conflicting results, but seem to indicate that one's ability to perform complex tasks is more impaired by alcohol than for simpler tasks. The relationship between simulator tasks and street driving has been seriously questioned in the literature.

Closed course driving experiments indicate that the ability of many drivers to perform parking maneuvers becomes impaired at low BACs (i.e., .04% to .06% w/v). Closed course driving performance at low speeds appears to be degraded for average drinkers at BACs of .08% to .10% w/v, but less so for heavy drinkers. Closed course driving performance at moderate speeds has been shown to be impaired at BACs as low as .05% to .07% w/v.

Thus, there is evidence that some behavior that appears to be related to driving performance is impaired by alcohol. The exact nature and extent of these impairments and their frequency of occurrence among different individuals at given BACs cannot be stated. Lacking explicit relationships between the behavior studied and critical driving tasks, it cannot be said precisely how these impairments affect one's probability of being involved in a crash. What emerges, however, is that behavior that has been studied is consistently and significantly impaired in virtually all individuals as BACs approach .10% w/v. Many persons, particularly lighter drinkers, have shown impairment at much lower BACs. Only a relative few of the heaviest drinkers appear to suffer little impairment at BACs much greater than .10% w/v.

# 4.0 PEOPLE WHO DRINK AND DRIVE

In the preceding sections of this report, data have been presented which indicate, when taken together, that consumption of alcohol does, in fact, impair driving behavior and is a major factor in a large number of highway crashes. The focus of this section is on the behavior and characteristics of people whose patterns of drinking and driving appear to create abnormally high risk of involvement in crashes. Research findings which describe two groups of drivers—drinking drivers involved in crashes and drinking drivers using the roads but not involved in crashes—are examined.

Two basic types of research activity provide the data used here. The first type is the epidemiologic study which was used extensively in Section 2.0 to develop broad statements describing the drinking-driving problem. These studies are examined in more detail in this section to provide sharper definitions of groups of drinking drivers. The second type of research activity involves surveys and testing of selected groups of people in order to learn more about the demographic characteristics, drinking and driving habits, physical and psychological attributes, and attitudes of drinking drivers. Studies which attempt to relate such survey and test data to findings from epidemiologic studies are also considered here.

The specific findings on people who drink and drive are preceded by a more general discussion of drinking and drinking patterns in the U.S. and elsewhere. Current statistics on alcohol consumption are provided along with some of the more widely used definitions of types of drinkers. Such information is essential to viewing the alcohol-crash problem in its proper perspective, that is, within the context of the larger societal problem of which it is a part.

## 4.1 DRINKING AND DRINKING PATTERNS

### *4.1.1 Estimated Consumption of Alcohol**

Over the last several decades, consumption of alcoholic beverages has increased in the U.S.A. among members of the drinking-age population (15 years and over). This

*The data presented below on apparent consumption of alcohol are taken from publications of the Rutgers Center of Alcohol Studies. The sources of possible error in deriving these data have been described in the Center's annual reports of alcohol-related statistics.

finding holds for distilled spirits, wine and beer and in almost every state in the Union. The pattern of increase has also resulted in an increase in the volume of absolute alcohol consumed per capita of the drinking age population. It is estimated that during 1947 the per capita consumption of absolute alcohol for the drinking age population was 2.03 gallons. During 1975 it was 2.69 gallons (Keller and Gurioli 1976). In Table 4-1, below, the figures show that in 1947, over half of the absolute alcohol consumed in the U.S. was ingested through beer drinking. The 1975 figures show that distilled spirits and wine are now in relatively more frequent use as sources of absolute alcohol. Because not every member of the drinking age population drinks, the average quantity of absolute alcohol consumed by the drinking (as opposed to drinking age) population is no doubt higher than these figures reflect.

TABLE 4-1

*Apparent Consumption of Absolute Alcohol in the United States*[a]

| *Year* | *Type of Beverage* | *Annual Per Capita Consumption*[b] | | |
|---|---|---|---|---|
| | | *Gallons* | *Litres* | *% of All* |
| 1947 | Spirits | .76 | 2.88 | 37.4 |
| | Beer | .16 | .61 | 7.9 |
| | Wine | 1.11 | 4.20 | 54.7 |
| | All | 2.03 | 7.69 | 100.0 |
| 1975 | Spirits | 1.11 | 4.20 | 41.3 |
| | Beer | .32 | 1.21 | 11.9 |
| | Wine | 1.26 | 4.77 | 46.8 |
| | All | 2.69 | 10.18 | 100.0 |

a. Source of data: Keller and Gurioli 1976
b. Based on drinking-age population (15 years old and over).

TABLE 4-2

*Apparent Consumption of Absolute Alcohol in the United States and Other Countries*[a]

| *Type of Beverage* | *Country* | *Year* | *Ranking of Country*[b] | *Annual Per Capita Consumption of Absolute Alcohol, Litres*[c] |
|---|---|---|---|---|
| Spirits | Peru | 1970 | Highest | 5.68 |
| | Portugal | 1974 | Lowest | .78 |
| | U.S.A. | 1975 | 5th | 4.31 |
| Wine | Portugal | 1974 | Highest | 20.80 |
| | Peru | 1970 | Lowest | .27 |
| | U.S.A. | 1975 | 19th | 1.26 |
| Beer | Belgium | 1973 | Highest | 9.27 |
| | Spain | 1971 | Lowest | .22 |
| | U.S.A. | 1975 | 12th | 4.91 |
| All | Portugal | 1974 | Highest | 23.43 |
| | Israel | 1974 | Lowest | 3.25 |
| | U.S.A. | 1975 | 16th | 10.48 |

a. Source of data: Keller and Gurioli 1976.
b. Ranking among 26 countries with respect to annual per capita consumption of absolute alcohol in indicated beverage.
c. Based on drinking-age population (15 years old and over).

TABLE 4-3

*Ratios of Apparent Annual Per Capita Consumption of Absolute Alcohol in Selected Countries*[a]

| *Type of Beverage* | *Countries Compared* | *Ranks Compared*[b] | *Ratios of Annual Per Capita Consumption of Absolute Alcohol*[c] |
|---|---|---|---|
| Spirits | Peru/Portugal | Highest/Lowest | 7.28 |
| | Peru/U.S.A. | Highest/U.S.A. | 1.32 |
| | U.S.A./Portugal | U.S.A./Lowest | 5.53 |
| Wine | Portugal/Peru | Highest/Lowest | 77.04 |
| | Portugal/U.S.A. | Highest/U.S.A. | 16.51 |
| | U.S.A./Peru | U.S.A./Lowest | 4.67 |
| Beer | Belgium/Spain | Highest/Lowest | 42.14 |
| | Belgium/U.S.A. | Highest/U.S.A. | 1.89 |
| | U.S.A./Spain | U.S.A./Lowest | 2.32 |
| All | Portugal/Israel | Highest/Lowest | 7.21 |
| | Portugal/U.S.A. | Highest/U.S.A. | 2.24 |
| | U.S.A./Israel | U.S.A./Lowest | 3.22 |

a. Source of data: Keller and Gurioli 1976.
b. Ranking among 26 countries with respect to annual per capita consumption of alcohol in indicated beverage.
c. Based on drinking-age population (15 years old and over).

Keller and Gurioli (1976) present data showing apparent consumption of absolute alcohol, per capita of population aged 15 years and over, for 26 selected countries. Almost all of these countries are Western and most of them are industrialized. In Tables 4-2 and 4-3, comparative data are shown for the U.S.A., the highest ranking country, and the lowest ranking country for each type of alcoholic beverage and for all alcoholic beverages. The figures presented show that the drinking-age population in first-ranking Portugal consumes more than twice as much absolute alcohol as the drinking age population of the U.S.A.; while the U.S.A.'s drinking age population consumes more than three times as much absolute alcohol as the drinking age population of least-ranking Israel. The corresponding ratio for Portugal and Israel is about seven to one.

In the 17 of the 20 countries for which historical data were available, Keller and Gurioli (1976) found an increase in the apparent per capita consumption of absolute alcohol over the time period beginning roughly in the mid-1950s to the early 1970s. The increases ranged from 20% for Switzerland to 170.9% for the Netherlands. The increase for the U.S.A. during this time period was 41.5%.

### *4.1.2 Patterns of Consumption of Alcoholic Beverages*

Patterns of alcohol consumption in the U.S.A. vary among members of the drinking age population on the basis of a number of socio-cultural variables which appear to influence the reasons why people drink, the types and amounts of beverages they consume, and the settings in which the drinking occurs. Using data collected in a national survey conducted in 1964–1965, of the drinking patterns of adults (21 years and

older), Cahalan and associates (Cahalan, Cisin, and Crossley 1969) classified respondents into the following types of drinkers: heavy (12% of all respondents), moderate (13%), light (28%), infrequent (15%), and abstainers (32%).

The data used to classify respondents described the quantity and type of alcoholic beverage consumed and the frequency of consumption of any type of alcoholic beverage. Because the data collected were in the form of self-reports of respondents, quantity of consumption was defined, not as absolute alcohol content, but as number of drinks, whether mixed or straight. Quantity of alcoholic beverages consumed was measured by the average number of drinks consumed per occasion and by the frequency and amount by which this average was exceeded, i.e., the variability of consumption.

This system of classification lumps together people with quite disparate patterns of alcohol consumption. For example, the range of respondents classified as heavy drinkers includes both those who consume any type of alcoholic beverage three or more times a day and those who may drink only two or three times a month but consume five or six drinks during those occasions. The researchers on the Cahalan study note that a more adequate index of relative drinking behavior would more exactly measure the spacing or bunching of consumption of alcoholic beverages over time and would result in a more sensitive index of drinking behavior than an index based only on frequency and quantity of drinking (Cahalan, Cisin, and Crossley 1969).

The findings of the Cahalan study and of more recent studies reveal that men and young adults drink in greater quantity and more frequently than women and older people; that among both men and women, the higher the socio-economic status the more likely they are to drink moderately and the more likely they are to drink heavily; that city dwellers drink more than residents of rural settings; and that the higher the level of education, the greater the proportion of heavy drinkers. Studies of drinking behavior among Italian, Irish, and Jewish groups reveal that social customs influence the type of alcoholic beverage usually consumed, the frequency and quantity of consumption, and the occasions on which drinking occurs. Most Americans usually drink in their own homes or in the homes of friends. They drink more when with friends on informal occasions than when with neighbors or colleagues on more formal occasions.

The types of drinkers identified in the national survey described above were defined in strictly behavioral terms, i.e., the amount and frequency of alcohol consumption. However, many researchers have found this type of definition to have limited usefulness because it does not include information about the setting in which drinking occurs and about the social, psychological and physiological consequences of different drinking patterns. This is especially true for researchers associated with social action programs which require the identification of target groups whose drinking patterns have been defined as problematic. These researchers have been concerned with defining drinking behavior in terms of the social and psychological functions it serves.

Researchers have been unable to reach agreement on functional definitions of significant types of drinkers and drinking patterns. Thus, there are many definitions in current use in the literature on the effects of alcohol on human behavior. Three categories of drinkers are commonly of concern to researchers: the social drinker, the problem drinker, and the alcoholic. Social drinkers and problem drinkers tend to be seen as mutually exclusive categories at a given point in time. However, a single individual may

be a problem drinker at one time in his life and a social drinker at other times. There is considerable overlap between the problem drinker and alcoholic categories. Not every problem drinker is an alcoholic, but the alcoholic is certainly a problem drinker. As presented below, the definitions of social drinkers, problem drinkers, and alcoholic illustrate what is commonly meant by the terms (Joscelyn and Jones 1971).

"Social drinkers" are those whose consumption of alcohol is part of their socially defined interactions with family, friends, neighbors, and co-workers. For the social drinker, use of alcohol enhances the occasions associated with it. Alcohol consumption in this context is both a symbol of shared feeling and, for some, a means of relaxing just enough to be comfortable in sharing feeling. The health and social functioning of the social drinker are not impaired by his pattern of alcohol consumption.

"Problem drinkers" is a term used to describe those whose pattern of alcohol consumption either contributes to or is symptomatic of the disruption of their relationships with family, friends, neighbors, and co-workers. Alcohol has not been identified as a cause of the problems of the drinkers in this category. It is just one element of behavior displayed by people with interpersonal problems who also drink immoderately.

The "alcoholic" is a person whose nervous system has developed a tolerance to alcohol, i.e., over a period of time more and more alcohol is required to achieve a given effect. The alcoholic is likely to drink in order to cope with social interactions. Thus, he may drink before, as well as during, the party or ceremony. Yet, in spite of his priming, he fails to cope because he cannot control his drinking. He is unable to act upon evidence that he has reached a point in his consumption of alcohol at which the benefits of drinking begin rapidly to decline and drinking itself becomes a problem. For the alcoholic, however, in contrast to the problem drinker, drinking is not just one of an array of problems. The drinking patterns of alcoholics clearly contribute to problems of poor health, social disruption, and economic instability.

## 4.2 CHARACTERISTICS OF DRINKING DRIVERS

The objective of this section of the report is to define in more detail, the nature of drinking drivers and drinking-driving as a precursor to the discussion, in Sections 5.0 and 6.0, of methods for dealing with the problem. The material presented here constitutes the last step of the four-step problem definition process described at the beginning of Section 2.0, i.e.:

- estimation of the number of crashes nationwide involving alcohol,
- determination of the involvement of drinking drivers in crashes relative to that of drivers as a whole,
- determination of whether any over-representation of drinking drivers among crashed drivers is due to alcohol, and
- further definition of drinking drivers and drinking-driving to support the development of methods for dealing with the problem.

Researchers contributing to the literature on alcohol and highway safety have generated a number of ways of categorizing variables for describing drinking drivers. Among

these, the three categories used by Perrine in his recent review (Perrine 1975) appear to be the most useful for describing the results of epidemiologic research, and will be adopted here.

The first category contains variables that are primarily *biographical*, including such demographic descriptors as sex, age, race, etc. The second category is composed of *driving* variables, such as number of previous crashes, driving experience, amount of driving, interactions with law enforcement agencies, etc. The third category contains variables most descriptive of an individual's *drinking* practices, for example, quantity and frequency of intake, and type of beverage consumed.

In addition, a fourth category of variables which have been analyzed in various psychometric studies (i.e., studies where surveys and tests have been used to measure certain psychological variables) will be examined below. These variables are classified here as *personality and stress* variables. Interactions between the above four categories of variables relative to drinking-driving are also discussed in this section (for example, alcohol-related crash involvement of male problem drinkers who have been arrested for driving while intoxicated).

Ideally, one would like to know two things about sub-groups of drinking drivers described by these four categories of variables:

(1) the extent to which each sub-group contributes to the total alcohol-crash problem.
(2) The alcohol-crash risk (i.e., relative probability of a crash after drinking) of each sub-group.

The first piece of information requires statistics on the BACs of *crash-involved* drivers broken down in sufficient detail to describe the contribution of each variable. For example, if one wishes to determine relative contributions of male drivers and female drivers to the alcohol-crash problem, then data giving the BACs of *males* and the BACs of *females* involved in crashes are required. Even then, such epidemiologic evidence will, as pointed out in section 2.1, be insufficient to "prove" that alcohol caused the crashes associated with any level of BAC. Behavioral studies showing the extent to which critical driving tasks of each sub-group (for example, males and females) were degraded at each BAC would be needed to reinforce the epidemiologic data.

The second piece of information (i.e., alcohol-crash risk of each sub-group) requires an additional set of statistics, the BACs of *noncrash-involved* drivers in each sub-group. For example, to determine the alcohol-crash risk of males relative to that of females at any BAC would require roadside survey data showing percentages of male drivers and female drivers with that BAC using the road at times and places of the crashes. In other words, controlled studies in sufficient detail to permit break-down of the data by sub-group would be needed.

It will be seen in this section that a number of reliable epidemiologic studies can provide useful data for answering questions about the contributions of various sub-groups of drivers to the alcohol-crash problem, but that there are few controlled studies for determining the alcohol-crash *risk* of such drivers. In the literature, two approaches are often followed when data from controlled studies are insufficient to estimate the alcohol-crash risk of a particular sub-group of drivers.

First, and most commonly, the incidence of the sub-group (or trait) among drivers in alcohol-related crashes (i.e., where drivers had been drinking) is compared to the incidence found among drivers in non-alcohol-related crashes or in all crashes. A second approach is to compare the incidence of the trait among drinking drivers using the roads with the incidence among non-drinking drivers using the roads.

Clearly, neither of these two approaches can replace the controlled study for estimating alcohol-crash risk. Their findings can be helpful in making subjective judgments about risk, but they will never be sufficient for making explicit quantitative statements about relative probability of a crash after drinking. Moreover, even controlled studies will not provide an adequate basis for societal action against the individual, but can only be used for screening more specific target groups from the general population.

Considerable care is required in interpreting the findings of studies of the characteristics of individuals who drink and drive. The reader is alerted to two pitfalls that are common in such interpretations. First, it is sometimes assumed that the finding that a given characteristic is associated with a higher than average alcohol-crash risk means that *all* individuals possessing that characteristic are high-risk drivers. A second pitfall is the assumption that different characteristics that have been found to be associated with increased alcohol-crash risk can be combined to form a composite picture of a high-risk driver and that *all* individuals matching that profile are high-risk drivers.

Both pitfalls are to be avoided since they will lead to erroneous conclusions. No characteristic or combination of characteristics can safely be used to identify a given *individual* as a certain alcohol-crash threat, but can only be used for identifying the alcohol-crash risk of entire *groups* of drivers. Moreover, the usefulness of simplistic "profiles" for underscoring common characteristics of high-risk drivers can be outweighed by the danger that such a profile may erroneously be assumed to describe the highest risk group of drivers as priority targets for countermeasures.

In the following discussion of variables that have been used to describe drinking drivers, data on crash involvement are presented first (when available) to estimate the importance of the variable to the overall alcohol-crash problem, and to get a rough idea of the alcohol-crash risk associated with that variable. Next, available data on drivers using the road but not involved in crashes (i.e., data from roadside surveys) are presented to further refine the initial subjective estimate of alcohol-crash risk. Lastly, any data from controlled studies are provided as a final basis for assessing alcohol-crash risk.

### *4.2.1 Biographical Variables*

*4.2.1.1 Sex.* Past research has consistently shown that males are highly overrepresented in drinking-driving populations, as well as among crash-involved drivers who have not been drinking. For example, the National Safety Council (1976) estimates that in 1975, some 55% of all registered drivers were male, but that 83% of drivers in fatal accidents were male. Similarly, 70% of drivers in all accidents were said to be male. The previously cited studies in California (Waller et al. 1970) and Wayne County, Michigan (Filkins et al. 1970) showed even greater percentages of males in crashes in which the drivers were fatally injured—86% and 90%, respectively. Those two studies

also found that about 90% of fatally injured drivers who had been drinking were males, compared to 81–88% of those who had not been drinking.

Similar results have been reported in studies of less serious crashes. For example, the Huntsville study of personal injury crashes (Farris, Malone, and Lilliefors 1976) found that 63% of all drivers in such crashes were male and 81% of all crashed *drinking* drivers were male. The Grand Rapids study of crashes of all types (most of which were of the less serious "property damage" variety) showed 78% of its drivers to be male and 88% of its *drinking* drivers to be male (Borkenstein et al. 1964).

Roadside surveys conducted in controlled and noncontrolled studies have shown a predominance of males among both drinking and nondrinking drivers (Table 4-4). The Vermont study found that 79% of its control group of noncrashed drivers were male and 83% of those with BACs exceeding .10% w/v were male (Perrine, Waller, and Harris 1971). The Grand Rapids survey and combined results of the National Roadside Survey and the ASAP surveys showed almost identical percentages of males at BACs approaching zero, but much higher percentages of males among drivers whose BACs were .08% w/v or above (Borkenstein et al. 1964; Wolfe 1975).

TABLE 4-4

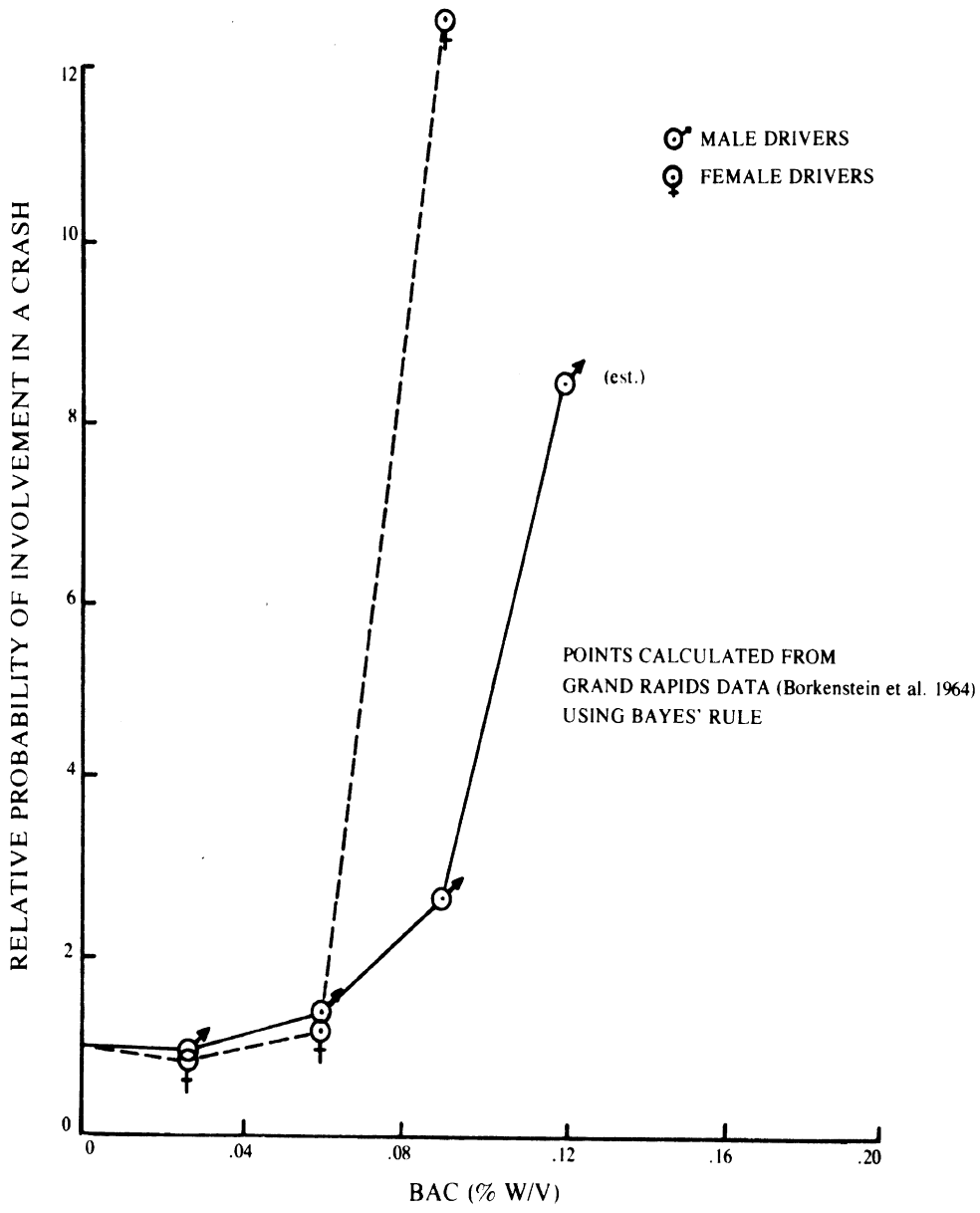
*Percentage of Males among Low-BAC and High-BAC Drivers in Roadside Surveys*

| *Survey* | *BAC* | |
|---|---|---|
| | *Negative* | *≥ .10% w/v* |
| Vermont (Perrine, Waller, and Harris 1971) | 79[1] | 83 |
| Huntsville (Farris, Malone, and Lilliefors 1976) | 71[2] | — |
| Grand Rapids (Borkenstein et al. 1964) | 78 | 95[4] |
| National Roadside Survey & ASAP (Wolfe 1975) | 79[3] | 91 |

[1]BAC < .02%
[2]BAC < .03%
[3]BAC < .05%
[4]BAC ≥ .08%

None of the studies cited above (or others which have investigated this variable) found any evidence to suggest that the reason for the higher incidence of male drivers in alcohol-related crashes was that males were somehow poorer drivers after drinking than females. On the contrary, data from the Grand Rapids study indicate the opposite may be true. Seventy-eight per cent of the study's crash-involved drivers were male, whereas 79% of its drivers using the road at the times and places of the crashes were male. At BACs exceeding .08% w/v, the study found that 88% of the crash-involved drivers were male, compared to 95% male for the controls. The over-involvement of females at the higher BACs is further indicated by their higher *relative* probability of involvement during the Grand Rapids study. The data show that a male's crash risk at a BAC of .08% w/v was about twice his crash risk at zero BAC (Figure 4-1). The relative crash probability of females at a BAC of .08% w/v was *nine*, or about 4½times as high

Figure 4-1. Relative probability of crash involvement of drivers, by sex, at given BAC levels



as that calculated for males. The figure indicates that there was little difference between the relative probability of crash involvement of males and females at the lower BACs, and that, if anything, females experienced slightly less risk at such BACs. A recent study of nighttime drivers (Carlson 1972) found drinking females to be more frequently involved in crashes than drinking males, even at the lower BACs, and suggested that inexperience with drinking may have been the cause.

In short, research shows that there are far more male drivers involved in alcohol-related crashes than female drivers. This is due more to the fact that the men drive more than women (especially after drinking), than to any inherent difference between sexes in tolerance to alcohol.

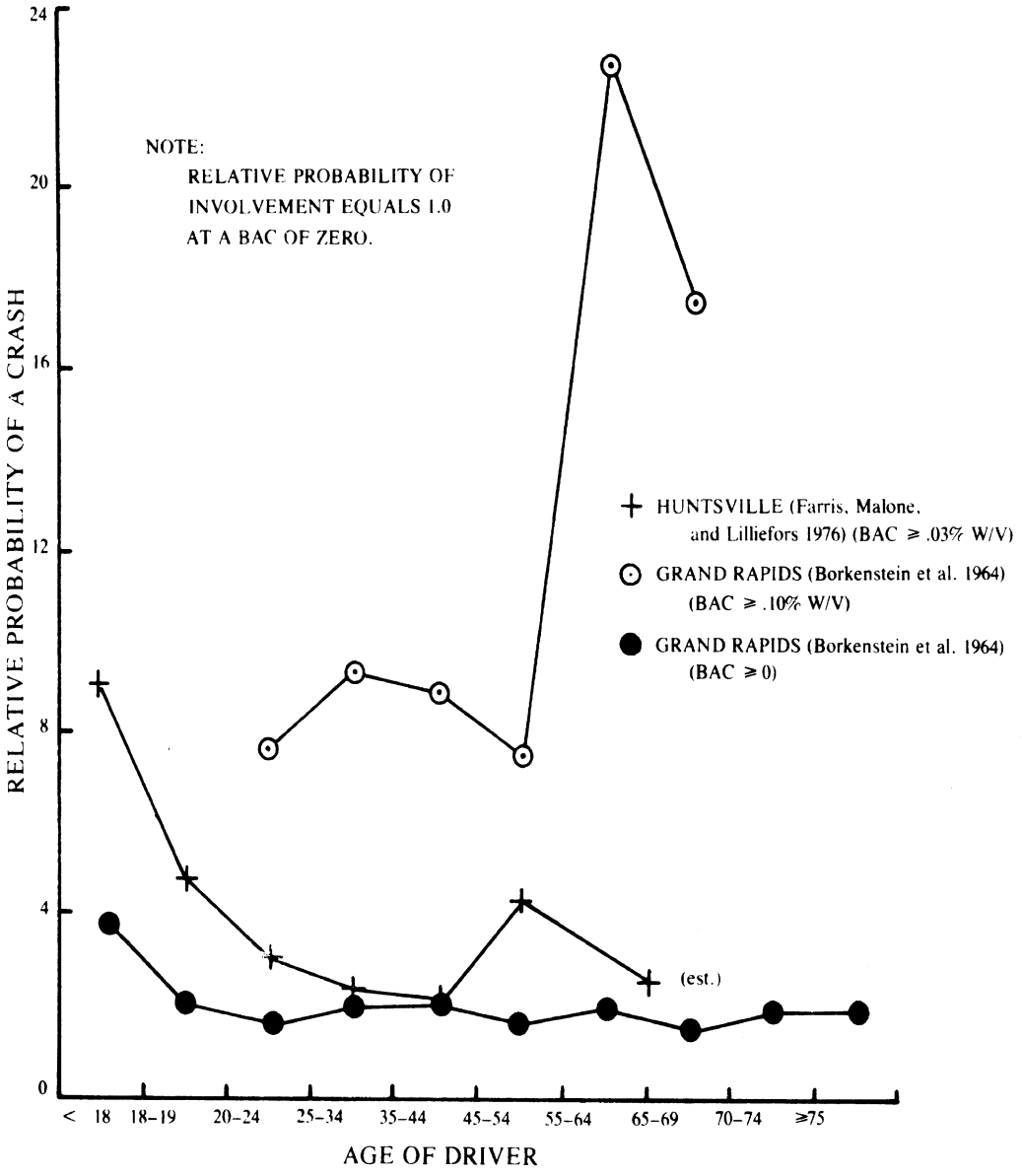
*4.2.1.2 Age.* Many studies have investigated the effect of a driver's age on his chances of being involved in an alcohol-related crash. The studies have consistently found that different age groups face different risks of such crashes. For example, in the study by Waller et al. (1970) of fatal crashes in California, 49% of fatally injured drivers under age 20 had been drinking, compared to 61% of those over 20. In the same study "only" 18% of fatally injured drivers under age 20 were legally intoxicated by today's standards (BAC $\geq$ .10% w/v), but 50% of those killed who were over 20 were intoxicated. The study also found that the percentage of fatally injured drivers over 60 years old who had been drinking and the percentage of such drivers who were legally intoxicated were both considerably less than the corresponding percentage of drivers *under* 60 years of age.

These findings have been repeated again and again to various degrees in studies of all types of crashes (Borkenstein et al. 1964; Cosper and Mozersky 1968; Farris, Malone, and Lilliefors 1976; Filkins et al. 1970; Perrine, Waller, and Harris 1971). All of the more carefully designed and conducted studies have found the youngest and the oldest crash-involved drivers less likely to have been drinking or legally drunk than crash-involved drivers as a whole. Of course, the less severe the crash, the less likely it is that a given driver of any age will have been drinking or intoxicated.

Studies of drivers not involved in crashes (i.e., roadside surveys) have observed the same general trend with regard to age, but the differences are usually more exaggerated. For example, the Vermont study of drivers surveyed at times and places of fatal crashes found that 9% of drivers under 20 years of age had been drinking, compared to 14% of drivers who were older than 20. Of drivers under 20, 1.6% were legally intoxicated, compared to 2.2% of drivers over 20 (Perrine, Waller, and Harris 1971). The Huntsville study of drivers using the roads at times and places of injury crashes found that about 4% of its under-20 drivers had been drinking (BAC $\geq$ .03% w/v) but 11% of its over-20 drivers had been drinking (Farris, Malone, and Lilliefors 1976). The combined results of the National Roadside Survey and the ASAP nighttime surveys showed 6% of its under-20 drivers had BACs of at least .05% w/v compared to 14% of drivers over the age of 20 (Wolfe 1975). Similar results with regard to drivers over 60 years of age were obtained in all of the above studies, i.e., older drivers were less likely to have been drinking than drivers as a whole (Farris, Malone, and Lilliefors 1976; Waller et al. 1970; Wolfe 1975).

A totally different and unexpected finding results from examination of the probability

Figure 4-2 Relative probability of crash involvement for drivers, by age



of a crash for drinking drivers *relative* to that for nondrinking drivers. Data from the Huntsville study (Farris, Malone, and Lilliefors 1976) and the Grand Rapids study (Borkenstein et al. 1964) indicate that crash risk of very young drivers is much higher after drinking than it is for drivers from other age groups (Figure 4-2). However, no increase in relative crash probability is noted for the oldest age groups except at the higher BACs. The usual reason given in the literature for the higher alcohol-crash risk faced by young drinking drivers is their relative inexperience with driving after drinking (Carlson 1972; Organization for Economic Cooperation and Development 1975; Voas 1974b; Zylman 1972b), but there are few behavioral data on the differential effects of alcohol on various age groups to support this conclusion.

Thus, studies show that the youngest and oldest crash-involved drivers are less likely to have been drinking. However, when younger persons do mix drinking and driving, their risk of a crash is higher than that of drivers as a whole. Older drivers have a higher crash risk at *higher BACs* than most other age-groups of drivers with similar BACs.

In view of the epidemiologic evidence of the increased crash risk faced by young drinking drivers, it might be expected that the recent lowering of the legal drinking age in some states would be accompanied by an increase in the number of alcohol-related crashes involving young drivers in those states. Analyses of alcohol-related crashes in several states indicate that, indeed, such an effect does exist but leave some question as to the amount of the effect (Douglas, Filkins, and Clark 1974; Whitehead et al. 1975; Zylman 1976b; Smart and Schmidt 1976; Ferreira and Sicherman 1976; Douglass and Freedman 1977).

*4.2.1.3 Marital Status.* Studies of alcohol involvement in fatal crashes have consistently shown that divorced or separated drivers who were fatally injured in such crashes were more likely to have been drinking or legally intoxicated than married, single, or widowed drivers. For example, the Wayne County, Michigan study of 309 fatally injured drivers found 87% of its divorced or separated drivers had been drinking and 73% surpassed legal standards of intoxication (BAC $\geq$ .10% w/v) (Filkins et al. 1970). By comparison, 71% of fatally injured single drivers had been drinking and 49% had BACs of .10% w/v or higher. The California study by Waller et al. reported a similar trend (Waller et al. 1970).

Although these findings indicate that divorced or separated fatally injured drivers are more likely to have been drinking than other fatally injured drivers, this group makes up a relatively small percentage of *all* fatally injured drivers. Less than 13% of the fatally injured drinking drivers in the Wayne County study were divorced or separated compared to 34% who were single and 52% who were married (Filkins et al. 1970). In the California study, 17% were divorced or separated, 16% were single, and 61% were married (Waller et al. 1970). The Vermont study found that out of 18 fatally injured drivers, age 25 or older and with BACs of at least .10% w/v, only one was "widowed, divorced, or separated," thirteen (72%) were married and four were single (Perrine, Waller, and Harris 1971). Thus, past studies indicate that married persons comprise a larger percentage of fatally injured drinking drivers than persons of other marital statuses. At the same time, fatally injured married drivers are less likely to have been drinking or intoxicated than other drivers.

The Grand Rapids data on less serious crashes show many of the same trends noted above. Again, separated and divorced drivers in such crashes were more likely to have been drinking than drivers of any other marital status, but married drivers appeared most frequently among crashed drinking drivers (Borkenstein et al. 1964, Table 39).

The Grand Rapids data also show that the marital status/BAC characteristics of drivers using the road at times and places of nonfatal crashes were similar to those of drivers who were actually involved in such crashes. For example, 22% of such separated and divorced drivers had been drinking, but only 11% of married drivers and 9% of single drivers had been drinking (Table 4-5a). Further, of all control drivers who had been drinking, 69% were married, 18% were single, and 10% were separated or divorced (Table 4-5b).

The data from the National Roadside Survey/ASAP survey followed the same patterns as the Grand Rapids data, but showed fewer married drivers (51%) and more single drivers (33%) among its drinking drivers (Table 4-5b). This is very possibly an age effect because of the greater percentage of young drivers using the roads during the nighttime hours when the two nationwide surveys were conducted.

The Grand Rapids data also showed that separated or divorced drivers with BACs of at least .05% w/v had a slightly higher relative crash probability than married drivers who, in turn, had a slightly higher relative crash probability than single drivers (Figure 4-3). However, no significant differences between the three groups were found for drivers in the very low BAC range. All marital status groups showed essentially no increase in relative crash risk at BACs of .01% w/v to .04% w/v.

It is difficult to make strong statements about the effects of marital status alone on alcohol-crash risk because many of the studies which have investigated this effect have not attempted to account for interactions between marital status and age. Thus, it is usually not clear whether an observed difference in crash risk is due to marital status or age. Future research efforts can help remedy this problem by presenting their results so that the separate effects of the two variables can be analyzed. Certainly, research conducted to date does not prove that marital status is strongly related to alcohol-crash risk.

TABLE 4-5a

*Drinking Drivers as a Percentage of Drivers of a Given Marital Status*

| *Marital Status* | *Source* | |
|---|---|---|
| | *Grand Rapids** | *National Roadside Survey and ASAP*** |
| Single | 9 | 11 |
| Married | 11 | 12 |
| Separated or Divorced | 22 | 20 |
| Widowed | 12 | 15 |

*Borkenstein et al. 1964, BAC greater than zero
**Cahalan 1970, BAC = .05% w/v or more

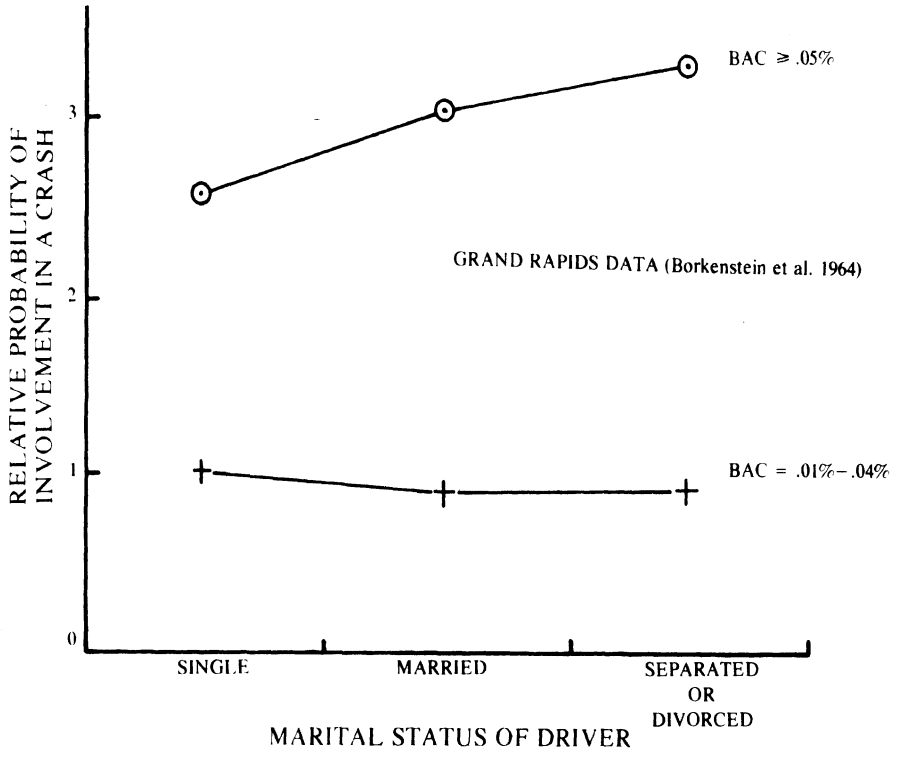
TABLE 4-5b

*Drivers of a Given Marital Status as a Percentage of All Drinking Drivers*

| *Marital Status* | *Source* | |
|---|---|---|
| | *Grand Rapids** | *National Roadside Survey and ASAP*** |
| Single | 18 | 33 |
| Married | 69 | 51 |
| Separated or Divorced | 10 | 14 |
| Widowed | 3 | 2 |

*Borkenstein et al. 1964, BAC greater than zero
**Wolfe 1975, BAC = .05% w/v or more

Figure 4-3. Relative probability of crash involvement for drinking drivers by marital status




*4.2.1.4 Occupational Level and Race.* The Grand Rapids study provides the largest data base with which to study the effects of a driver's occupation and race on drinking-driving. An analysis of these data conducted by Zylman in 1972 (Zylman 1972a) found that drivers engaged in low status occupations made up more than 51% of the drivers on the road with BACs of .08% w/v or higher, but less than 33% of all drivers on the road were in such occupations. The National Roadside Survey/ASAP Surveys of nighttime drivers show a similar trend: 69% of its drivers with BACs of .10% w/v or higher were classified as blue collar workers, compared to 56% blue collar workers among all drivers

stopped (Wolfe 1975). NRS/ASAP data also show a larger percentage of black drivers in the high BAC group than in the group containing all drivers (15% vs. 11%). Non-white drivers of low status were particularly overrepresented among the high BAC members of the Grand Rapids control group. Low status non-whites represented less than 5% of all drivers in the control group but were 21% of control group drivers with BACs of at least .11% w/v. Also, non-whites were found to represent about 9% of all crash-involved drivers but were more than 27% of crash-involved drivers with BACs of .15% (Borkenstein et al. 1964).

The Grand Rapids data also show that the relative probability of a crash increased with BAC for all occupation statuses and races studied (Figures 4-4 and 4-5). The data do suggest that at low BACs non-whites may face a higher crash risk than whites but that the opposite may be true at high BACs.

Occupational variables are closely related to age and sex, so that it is difficult to measure the extent to which the effects noted above are due to occupational status alone. The Vermont study attempted to separate these effects by limiting its analysis of occupation to control group males aged 25 to 59 (Perrine, Waller, and Harris 1971). The study found no significant difference in proportions of persons with given BACs by occupational level. All in all, there is no epidemiologic evidence of a strong relationship between occupational status/race and alcohol-crash risk.

*4.2.1.5 Education.* The Grand Rapids study also collected data on the years of education of drivers involved in crashes and drivers using the road at times and places of crashes. The data showed that 37% of all control group drivers (i.e., those not involved in crashes) had not completed high school but that 49% of control group drivers with BACs of at least .05% w/v had not completed high school (Borkenstein et al. 1964). The effect was reversed for drivers having more years of education. Persons who had completed high school or college were less frequent among drivers with BACs of .05% w/v or higher than among the driving population as a whole.

A similar effect was found for the Grand Rapids drivers who had crashed. In addition, there was a higher percentage of the least educated drivers among the crash-involved population than among the control group drivers. This difference between the crash-involved and control groups also held true when only drinking drivers were examined.

Other studies, however, have failed to show these trends so consistently. The Vermont study found no significant difference at all between drinking drivers and nondrinking drivers with respect to education (Perrine, Waller, and Harris 1971). The Huntsville study data showed that the least educated of its drivers were found more frequently among control group drivers who had been drinking, but indicated no difference in this respect among drivers who had crashed (Farris, Malone, and Lilliefors 1976). The National Roadside Survey/ASAP Survey of nighttime drivers found no great differences in educational backgrounds between drivers as a whole and drivers who had been drinking, but observed considerable differences when drivers with very high BACs (i.e., $\geq$ .15% w/v) were compared to the group containing all drivers (Wolfe 1975). Again, it was found that the least educated drivers were more frequently represented in the drinking group (see Figure 4-6).

Figure 4-4. Relative probability of crash involvement for drinking drivers, by occupational level, at given BAC levels

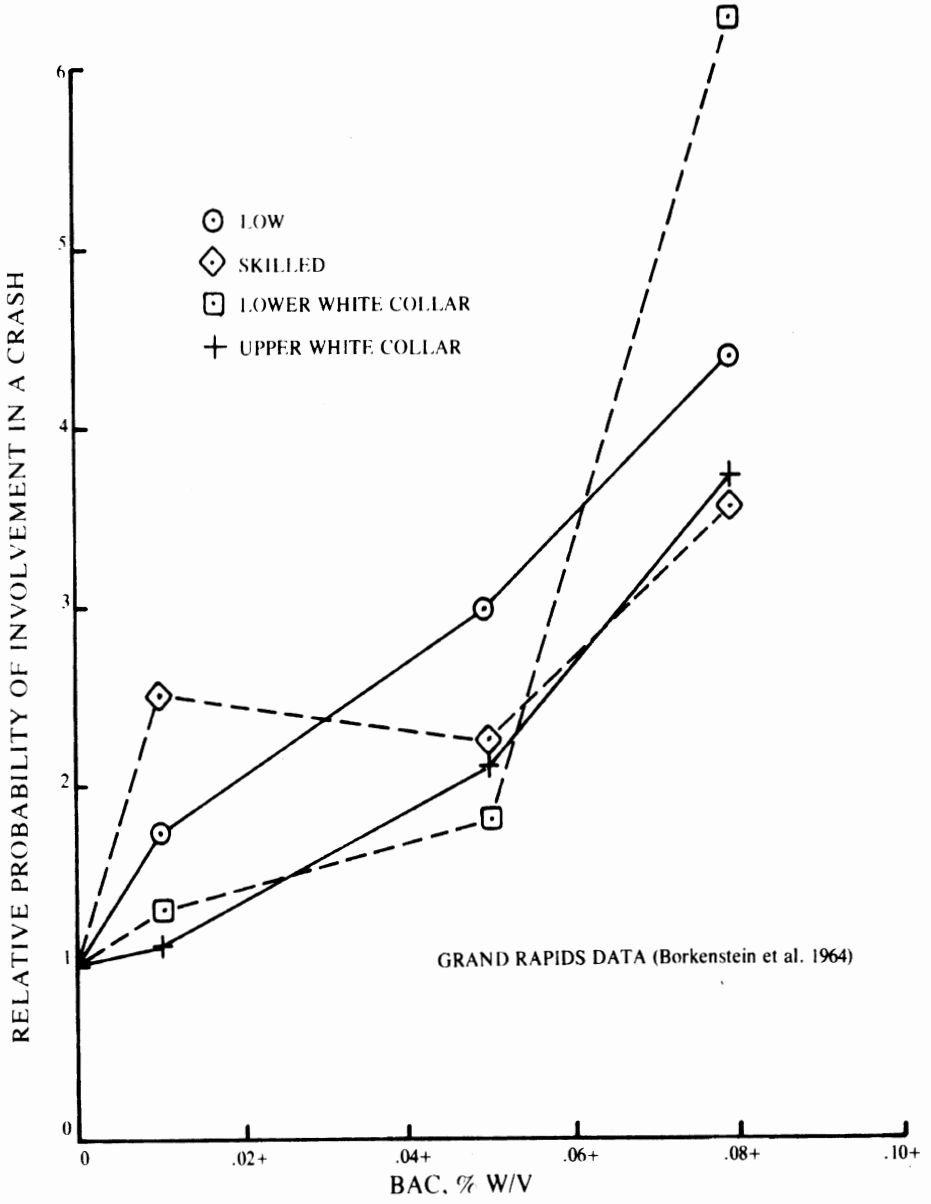


Figure 4-5. Relative probability of crash involvement for drinking drivers by race, at given BAC levels

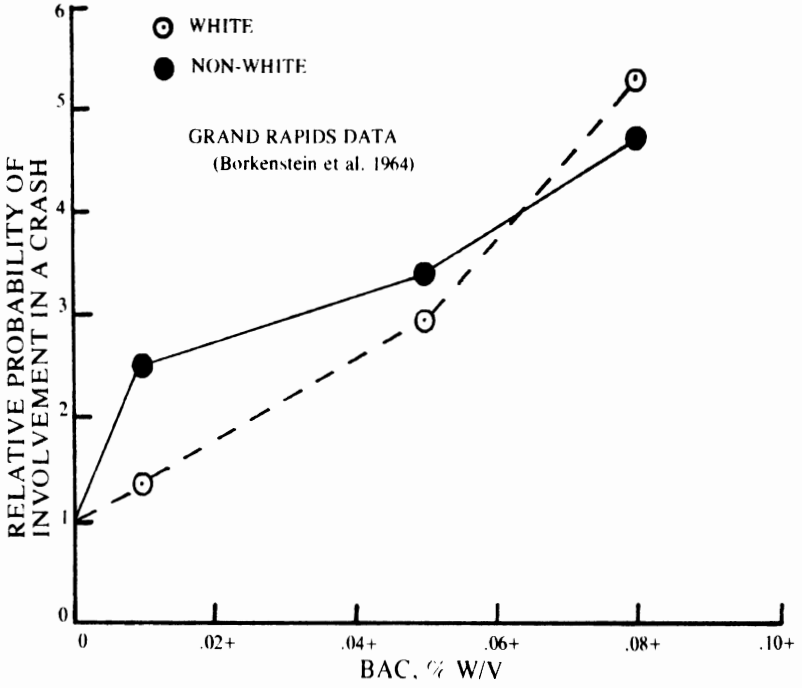
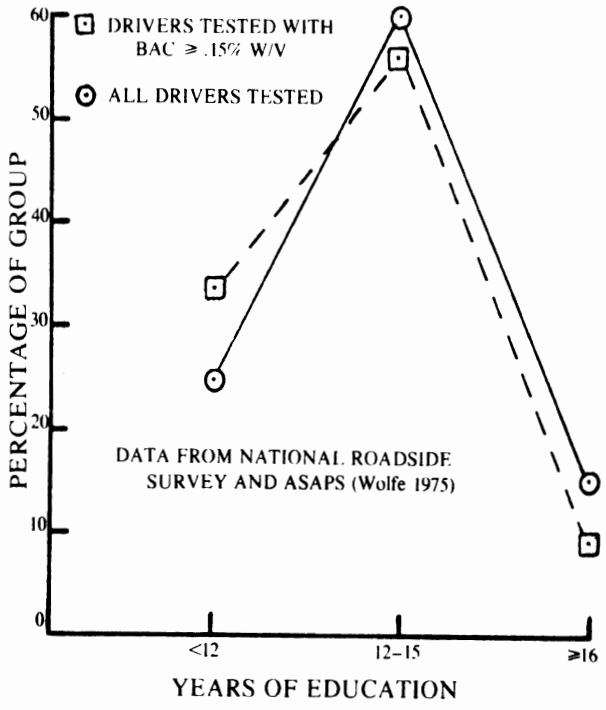



Figure 4-6. Comparison of drivers with high BACs (.15% w/v or more) with all drivers tested, by years of education



Research does not indicate that number of years of formal education has any relation to the relative probability of a crash after drinking. The data from the Grand Rapids study show little difference in this respect until a BAC of .08% w/v is reached (see Figure 4-7). At that point, the least educated group had a much lower relative crash probability than the other groups, but the difference was not statistically significant (Borkenstein 1964). Likewise, the Huntsville data indicate no significant trend in relative crash probability with respect to years of education (Farris, Malone, and Lilliefors 1976).

As was noted for the biographical variables discussed in the previous sections, it is necessary to use extreme caution in making general statements about the effect of a driver's education on his drinking-driving behavior. In addition to the confounding effects of other variables (particularly age), there is the problem of maturation to contend with. Educational patterns have a strong tendency to change over time, so that many conditions that existed, for example, during the Grand Rapids study in 1962–63 no longer exist today. In 1960, 41% of all persons over age 25 had completed high school, compared to 61% in 1974 (U.S. Department of Commerce 1975b). In short, there is little convincing evidence of a strong relationship between education and alcohol-crash risk.

*4.2.1.6 Other Biographical Variables.* The effect of a driver's *annual income* on tendency to drive after drinking was studied in the National Roadside Survey/ASAP Survey (Wolfe 1975). The data collected show that persons in the lowest income group were less than 20% of all nighttime drivers but more than 30% of nighttime drivers with BACs of at least .10% w/v (Figure 4-8). Further, the data show that the percentage of low-income drivers increased steadily with increasing BAC and that the reverse was true for high-income drivers (Figure 4-9). The proportion of drivers earning less than $5,000 per year and of drivers earning more than $15,000 per year was about equal in the group containing all drivers. However, there were nearly three times as many low-income drivers as high-income drivers in the group containing drivers with BACs of .15% w/v or higher. These findings do not, of course, prove that drivers in different income groups have different alcohol-crash risks, since there have been no controlled studies of this effect.

Three studies have collected data on the *religion* of drinking drivers. The National Roadside Survey/ASAP Survey found no clear differences in drinking-driving patterns among persons of different religious preferences (Wolfe 1975). The Grand Rapids study found a slightly larger percentage of drinking drivers among persons who never attended church than among persons who attended church weekly (Borkenstein et al. 1964). The latter study also found that drivers with BACs of .10% w/v or higher were three times as frequent among non-attenders as among persons who said they went to church weekly. By contrast, the Vermont study found no statistically significant differences in drinking patterns accorded to religion or church attendance (Perrine, Waller, and Harris 1971).

The Vermont study also investigated the effect of *place of residence* (i.e., country, small towns, cities, suburbs) on presence of alcohol among drivers not involved in crashes. It found that higher BACs were more frequent among rural drivers than among

Figure 4-7. Relative probability of crash involvement for drivers at given BAC levels, by educational level

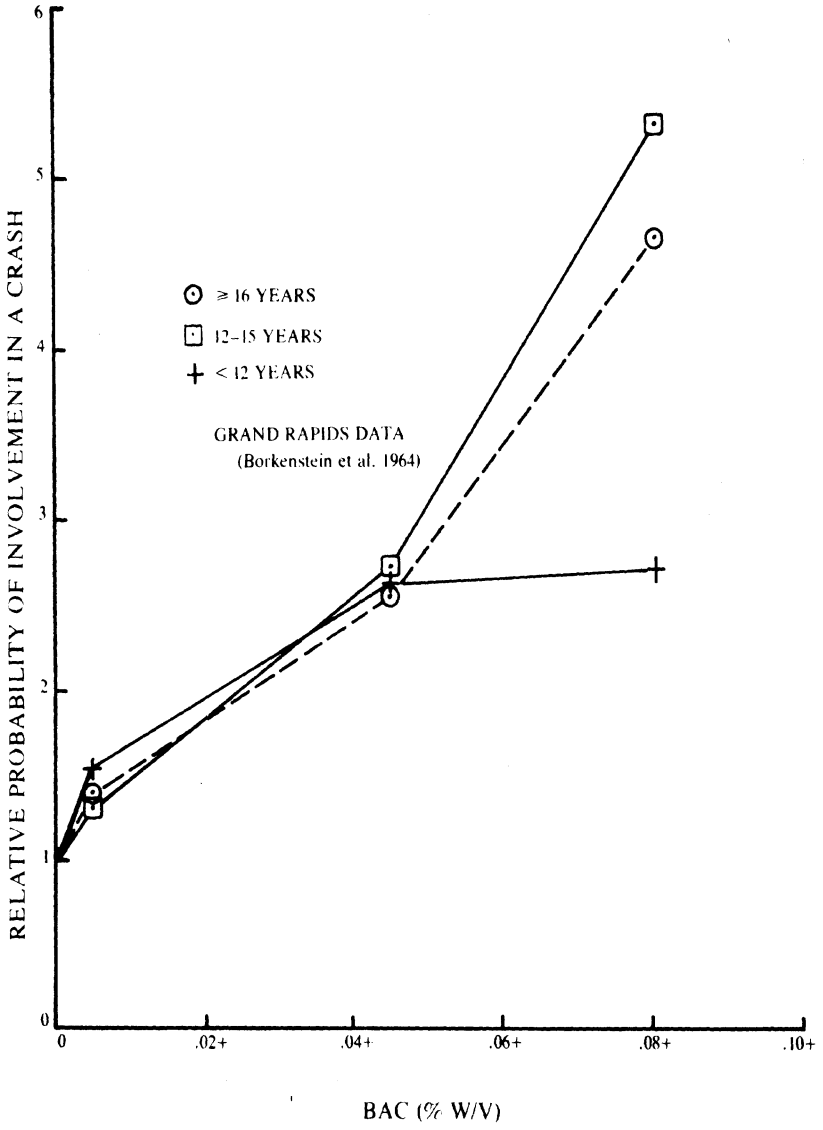


Figure 4-8. Comparison of drinking drivers (BAC of .10% w/v or more) with all drivers tested, by annual income

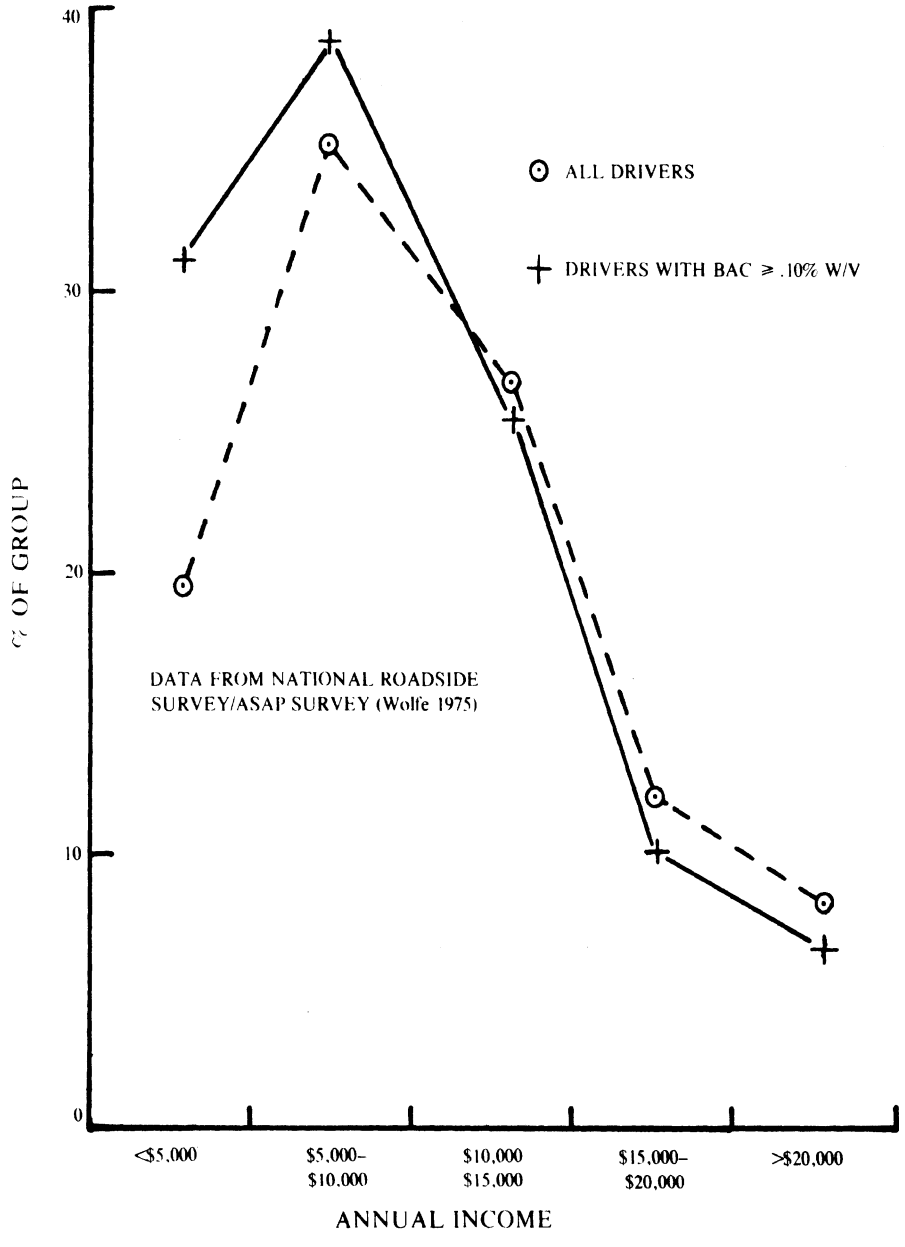
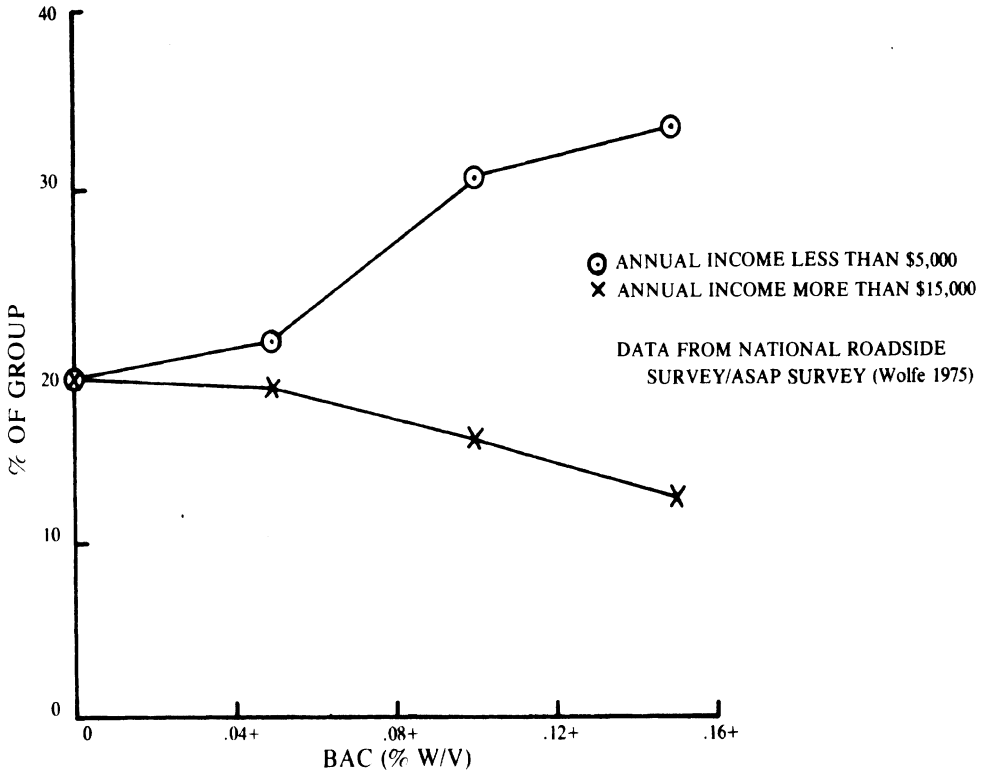


Figure 4-9. Comparison of drivers with high and low annual incomes, by given BAC levels




drivers from the urban areas (Perrine, Waller, and Harris 1971). This is especially interesting in light of the finding by Cahalan and associates that city dwellers drink more than rural residents (Cahalan, Cisin, and Crossley 1969).

### *4.2.2 Driving Variables*

*4.2.2.1 Time of Day and Day of Week.* It would be logical to expect that crashes involving alcohol occur with higher relative frequency at times of day when people tend to drink more, i.e., the evening hours. The findings of past studies are in general agreement with this expectation. For example, data on crashes in California indicate that over 85% of all drivers fatally injured in single-vehicle crashes occurring in the hours between 9:00 p.m. and 6:00 a.m. had BACs of at least .05% w/v (see Figure 4-10) (U.S. Department of Transportation 1968). By contrast, only about 40% of such drivers in the 3:00 p.m. to 9:00 p.m. period had such high BACs. The Wayne County, Michigan study produced similar statistics for drivers killed in either single-vehicle or multi-vehicle crashes. The Wayne County study also showed that 75% of drivers killed in crashes occurring between midnight and 6:00 a.m. were legally too intoxicated to drive, but that less than 30% had such high BACs between 6:00 a.m. and 6:00 p.m. (Figure 4-11).

Less serious kinds of crashes exhibit this same trend. The Huntsville study showed that 73% of all drivers involved in personal injury crashes occurring in the midnight to 3:00 a.m. period had been drinking (BAC $\geq$ .03% w/v), but that less than 20% of such drivers had been drinking in the 6:00 a.m. to 6:00 p.m. period (Figure 4-10). The Grand

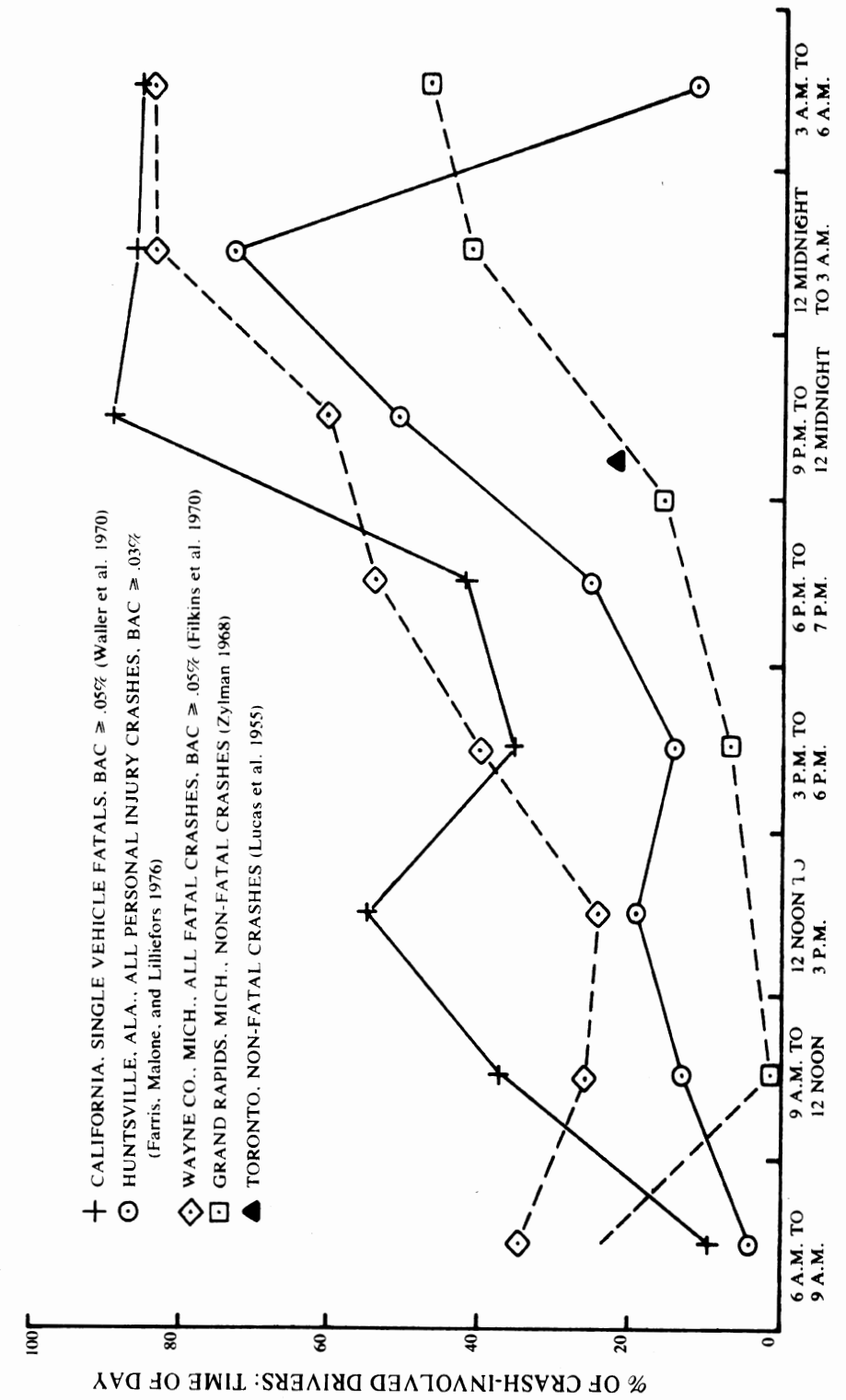



Figure 4-10. Percentage of crash-involved drivers who had been drinking, by time of day

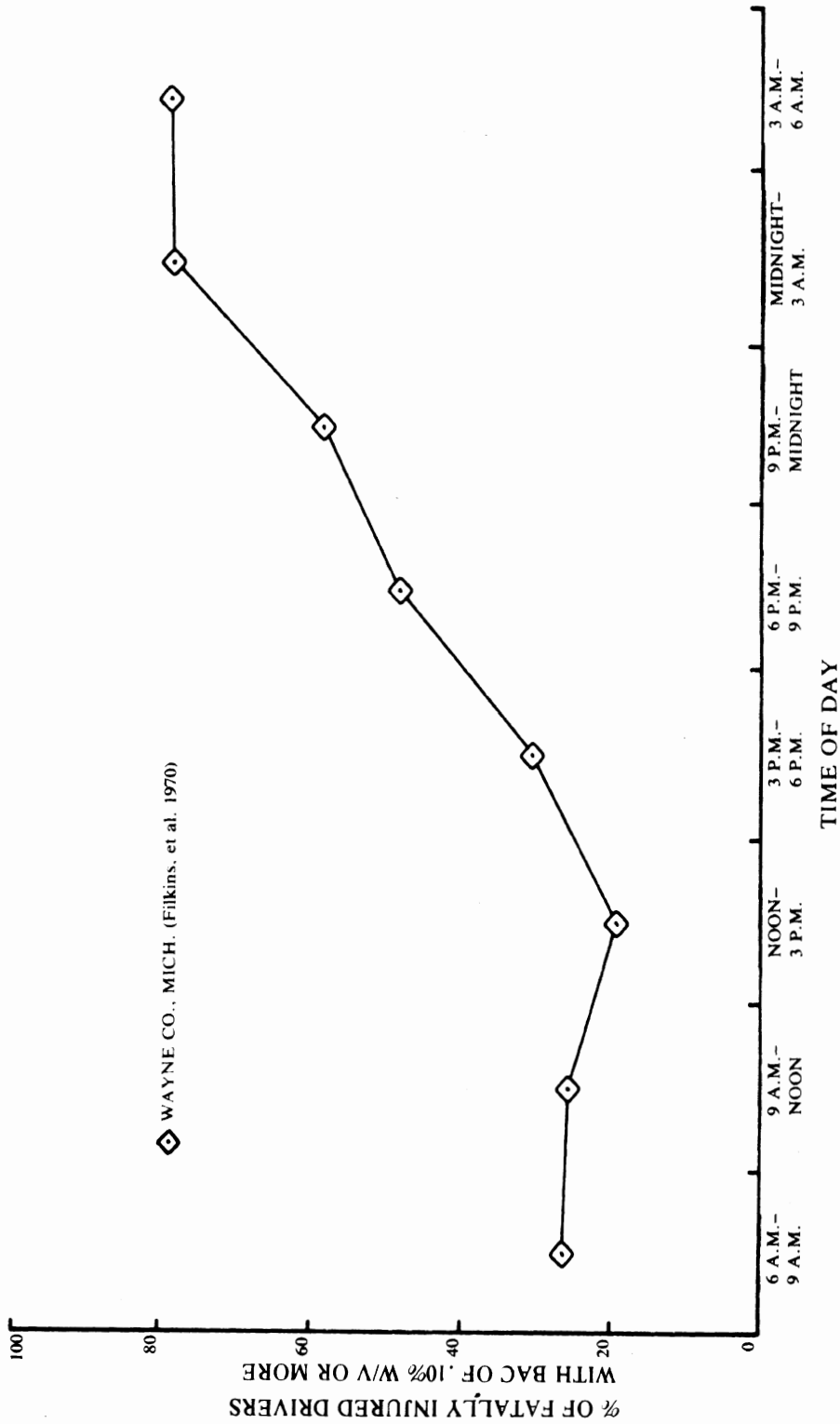



Figure 4-11. Percentage of fatally injured drivers who had been drinking (BAC of .10% w/v or more), by time of day

Rapids study found that nearly half of the drivers in *all* nonfatal crashes occuring from 3:00 a.m. to 6:00 a.m. had BACs of .05 w/v or or higher (Figure 4-10), compared to an average of only 9% over the 24-hour period.

A similar trend might be expected with respect to weekend versus weekday crashes. Such a trend has, in fact, been noted in several studies, but is much less pronounced than that observed for nighttime hours versus daytime hours (Figure 4-12). The largest differences were found in Wayne County, Michigan, where 65–75% of drivers killed in crashes occurring on Fridays, Saturdays, and Sundays had BACs of at least .05% w/v, compared to about 50% of those killed in crashes on Mondays, Tuesdays, Wednesdays, and Thursdays. A similar result was observed in Wayne County for crashes involving fatally injured drivers who were legally intoxicated by today's standards (Figure 4-13).

The effects of time of day and day of week on alcohol involvement in fatal pedestrian collisions have been found to be quite similar to those shown for alcohol involvement in driver fatalities. For example, the Wayne County study showed some 60–80% of adult pedestrians involved in fatal collisions occurring between 9:00 p.m. and 6:00 a.m. had BACs of at least .10% w/v (Figure 4-14). By contrast, less than 20% of such victims who were fatally injured between 6:00 a.m. and 6:00 p.m. had BACs so high. The same study also showed that alcohol was more frequently a factor in such pedestrian collisions on weekends than on weekdays (Figure 4-15).

The trend toward higher frequencies of noncrash-involved drinking drivers in the nighttime driving population is illustrated in Figure 4-16. The very late nighttime period has a particularly high percentage of drinking drivers: as high as 40% in the Huntsville study and over 20% in the Grand Rapids and ASAP surveys. The studies also provide some evidence that drinking-driving occurs more frequently on weekends than on weekdays, but the effect is not as noticeable as for nighttime versus daytime drivers (Figure 4-17).

Only one study (Grand Rapids) has collected sufficiently detailed data to estimate the effect of time of day on crash risk. Zylman (1973b) states that these unpublished data show that the risk at BAC $\geq$ .05% w/v was more than three times as high during the hours between 9:00 a.m. and noon as it was during the hours between 3:00 a.m. and 6:00 a.m.! He speculated that this could have been due to the higher traffic density during daytime hours which caused increased demands on drivers even at low BACs, resulting in increased crash probability. An implication of this finding is that time periods other than nighttime and weekends should not be ignored when alcohol safety programs are designed.

*4.2.2.2 Annual Mileage and Origin of Trip.* Of the two studies that have examined drinking-driving with respect to amount of driving, one, the National Roadside Survey, found essentially no differences in annual miles driven between drinking drivers and the driving population as a whole (Wolfe 1975), and the other, the Grand Rapids study, found that its drinking drivers tended to drive fewer miles than drivers as a whole (Borkenstein et al. 1964). The differences observed in the latter study were for individuals who drove very little (i.e., less than 5,000 miles per year), and no sizeable differences were found at the higher mileages (see Figure 4-18).

The Grand Rapids data also indicate that very low mileage drivers were more fre-

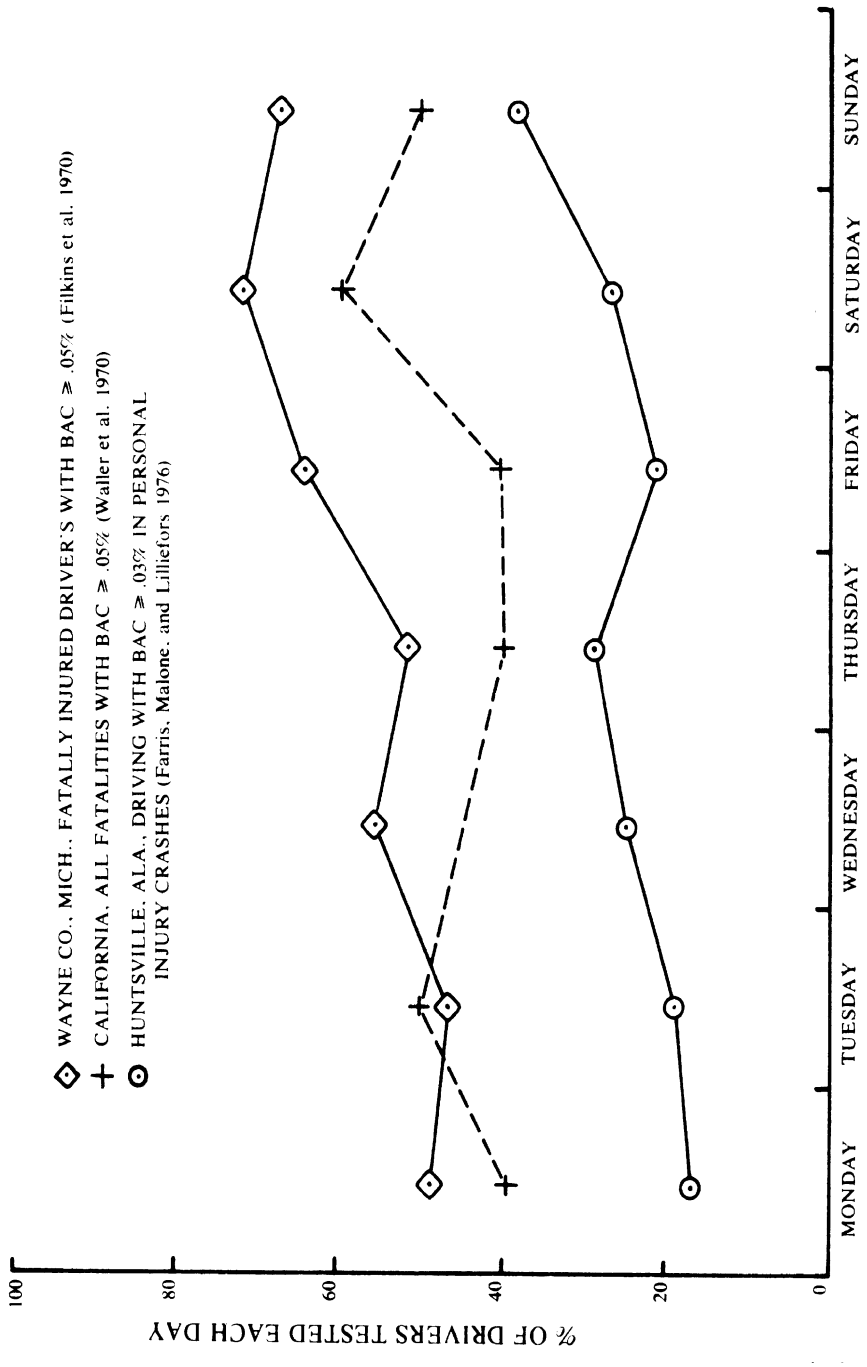
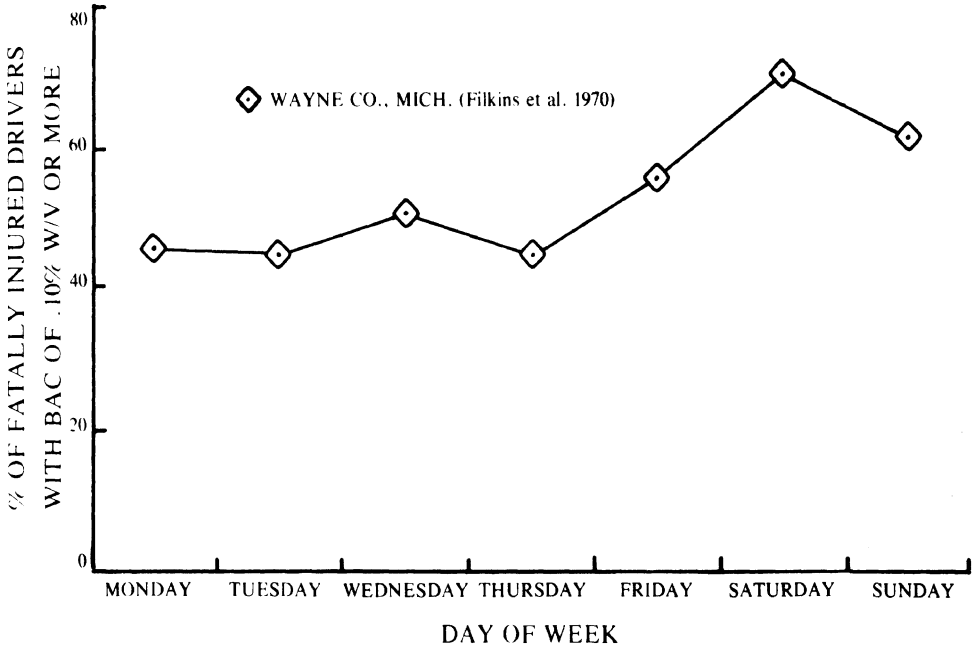



Figure 4-12. Percentage of drivers who had been drinking, by day of week

Figure 4-13. Percentage of fatally injured drivers who had been drinking (BAC of .10% w/v or more), by day of week




quent among drinking drivers who had crashed (BAC ≥ .08% w/v) than among drivers using the road at the times and places of such crashes (Figure 4-19). Further, the relative probability of a crash, given a BAC of at least .05% w/v, was higher for low-mileage drivers than for other drivers (i.e., 3.7 for annual mileage less than 5,000 versus 3.0 for annual mileage greater than 5,000).

Data on the nature of the trip during which the drivers were surveyed were collected in the National Roadside Survey/ASAP Survey of nighttime drivers (Wolfe 1975). The data show that persons coming from their own homes, work, or a sport facility were least likely to be driving while intoxicated (less than 3%). Persons most likely to have reached a BAC of .10% w/v had just come from bars or taverns (nearly 17%). This latter group also made up the largest percentage of all legally intoxicated drivers (30%), followed closely by drivers coming from some other person's home. These trends were in general agreement with those observed by Carlson in an earlier study in Michigan (Carlson 1972).

*4.2.2.3 Previous Crashes.* Three studies of driver records arrived at conflicting findings about the relationship between number of previous crashes and drinking-driving among drivers as a whole. The Wayne County, Michigan study found that 59% of its fatally injured drivers who had experienced one or more crashes in the preceding 6-1/2 years had BACs of at least .10% w/v when killed, but that only 53% of the fatally injured drivers who had no crashes in this period had BACs so high (Filkins et al. 1970). The Vermont study reported 9% of its roadside survey drivers without alcohol had two or more crashes in the past five years, and 13% of these drivers with BACs of .10% w/v

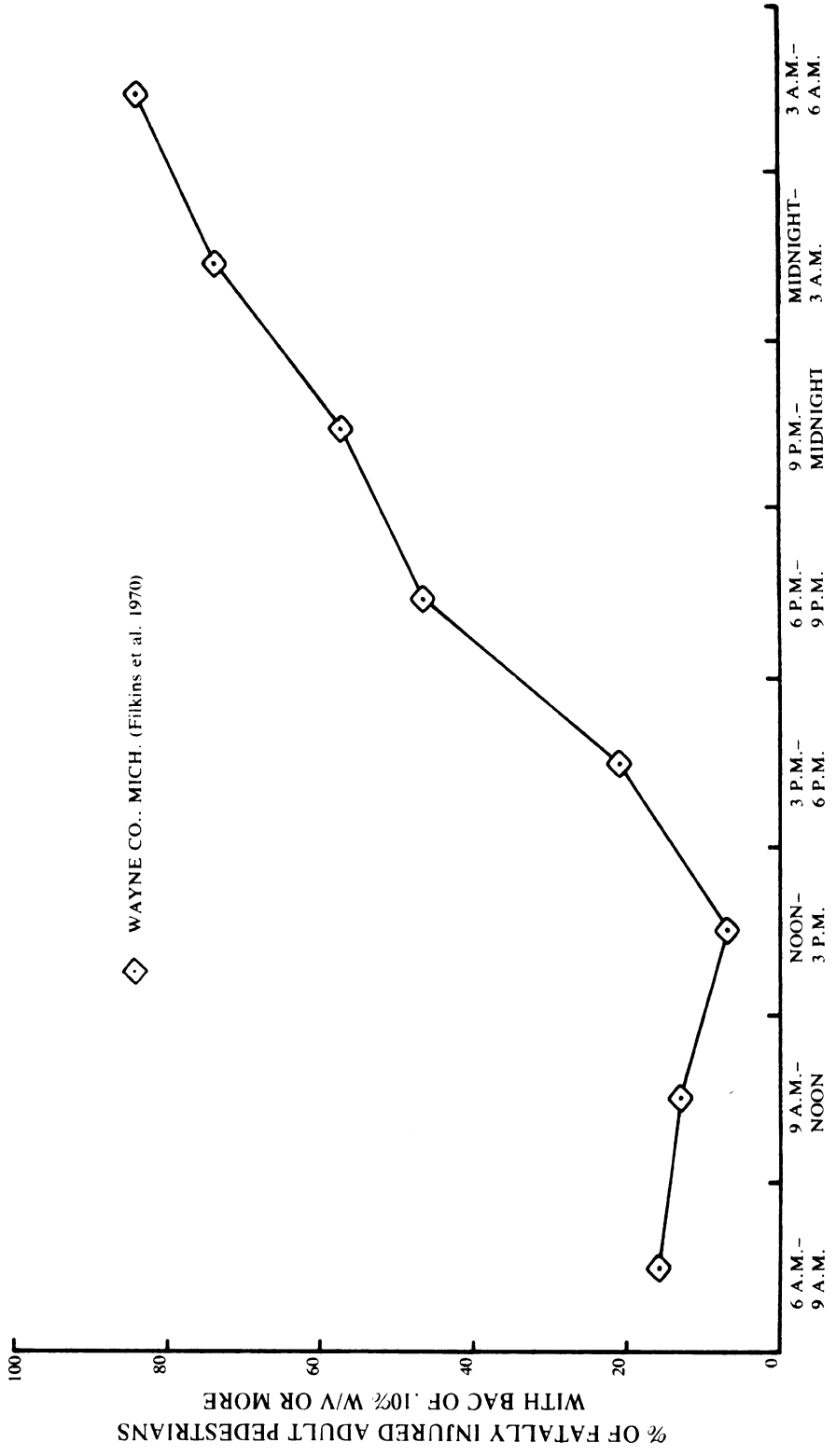
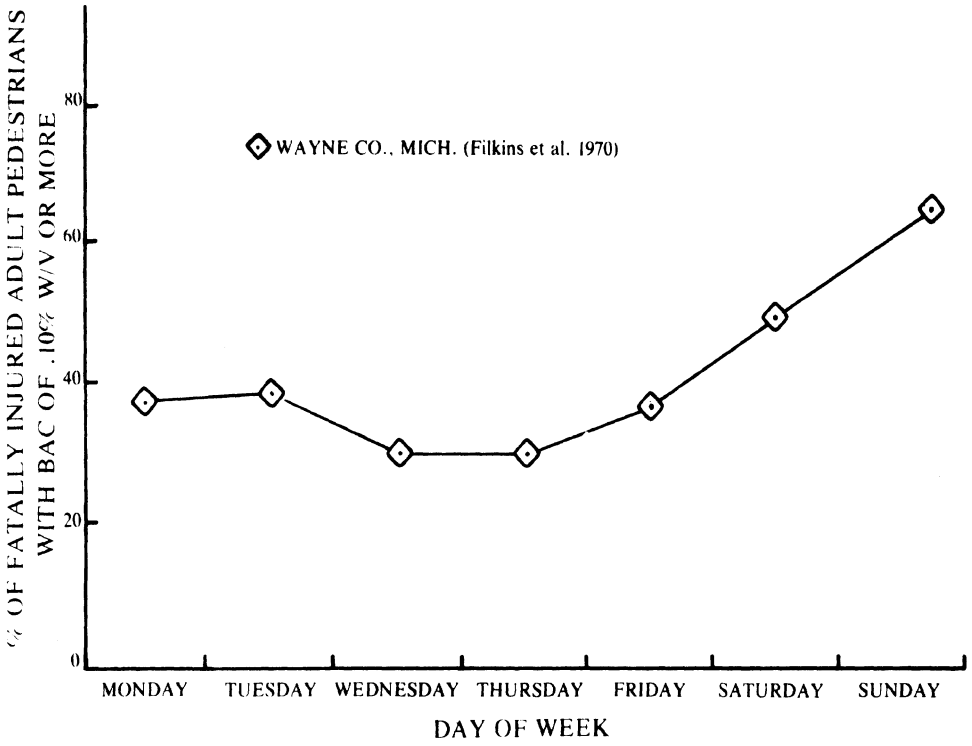



Figure 4-14. Percentage of fatally injured adult pedestrians who had been drinking (BAC of .10% w/v or more), by time of day

Figure 4-15. Percentage of fatally injured adult pedestrians who had been drinking (BAC of .10% w/v or more), by day of week

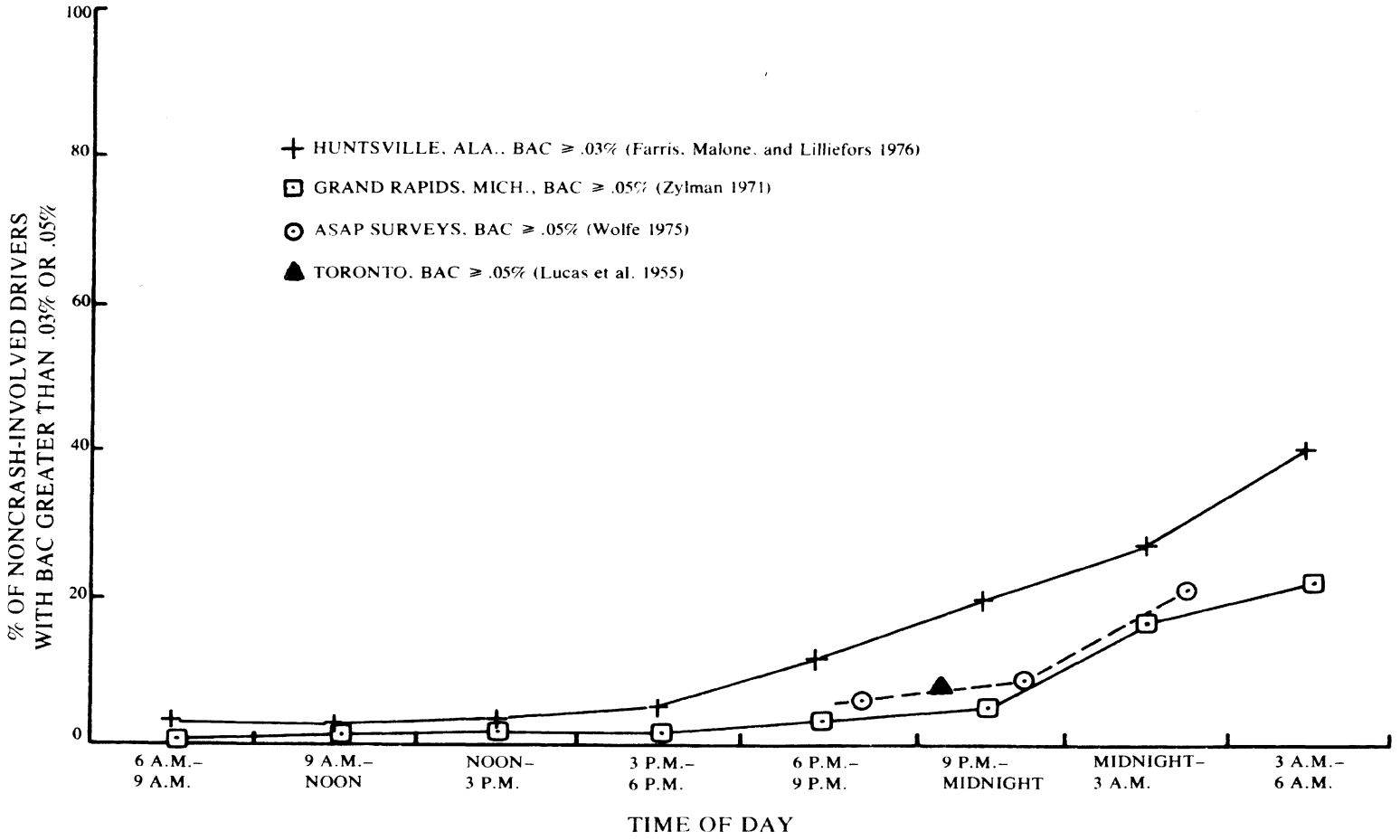



had two or more crashes in the same period (Perrine, Waller, and Harris 1971). A third study of fatally injured drivers in California (Waller et al. 1970) found that the drivers who had been drinking had a slightly higher average number of past accidents per driver (1.37) than drivers who had not been drinking (1.25). No crash risk data were available for any of these studies.

A paper by Voas (1975a) reporting some findings of the National Roadside Survey and the ASAP Surveys stated that "individuals with no accidents in the previous three years were more likely to be using alcohol," but gave no quantitative data. Voas speculated that this result might be due to the correlation of BAC with age insofar as young drivers are more likely to crash, and older drivers, who use alcohol more and are likely to have a higher BAC, have fewer accidents on their records.

*4.2.2.4 Enforcement Actions.* A number of studies have examined the driving of persons involved in alcohol-related crashes to see if such drivers are more likely than other drivers to have had prior contacts with traffic law enforcement agencies. The studies indicate that drinking drivers do tend to be arrested and convicted more often for traffic violations, especially violation of drinking-driving laws. For example, data from the Wayne County study show that 82% of fatally injured drivers with BACs of .10% w/v or higher had at least one prior conviction for a driving offense. Among such drivers with BACs of less than .10% w/v, only 66% had one or more conviction. The study also found a statistically significant relationship between previous convictions for driving under the influence of liquor (DUIL) and BAC at death, with the intoxicated

Figure 4-16. Percentage of noncrash-involved drivers who had been drinking, by time of day



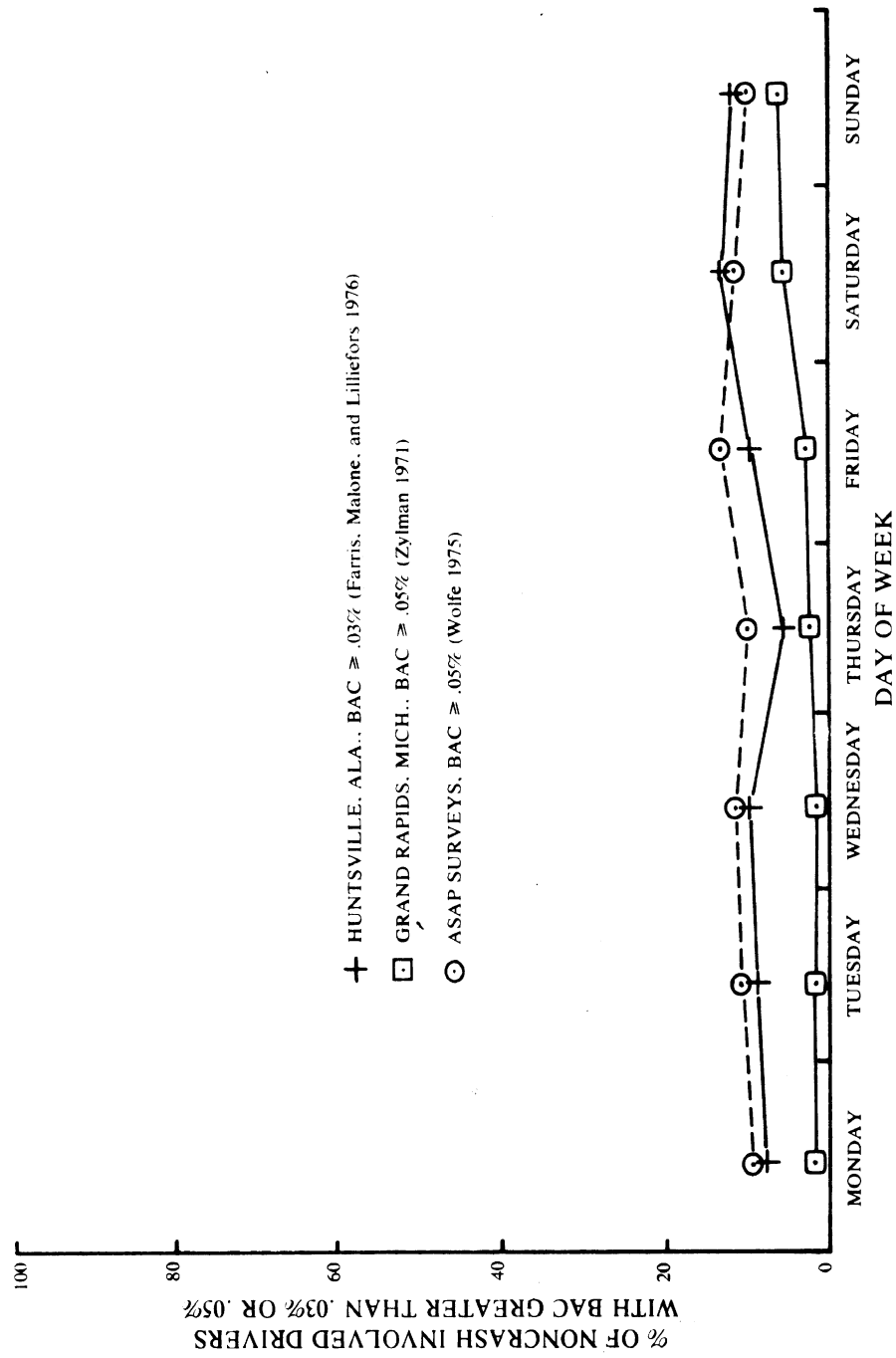



Figure 4-17. Percentage of noncrash-involved drivers who had been drinking, by day of week

Figure 4-18. Percentage of drivers who had driven a given number of miles per year: comparisons of all drivers with drinking drivers

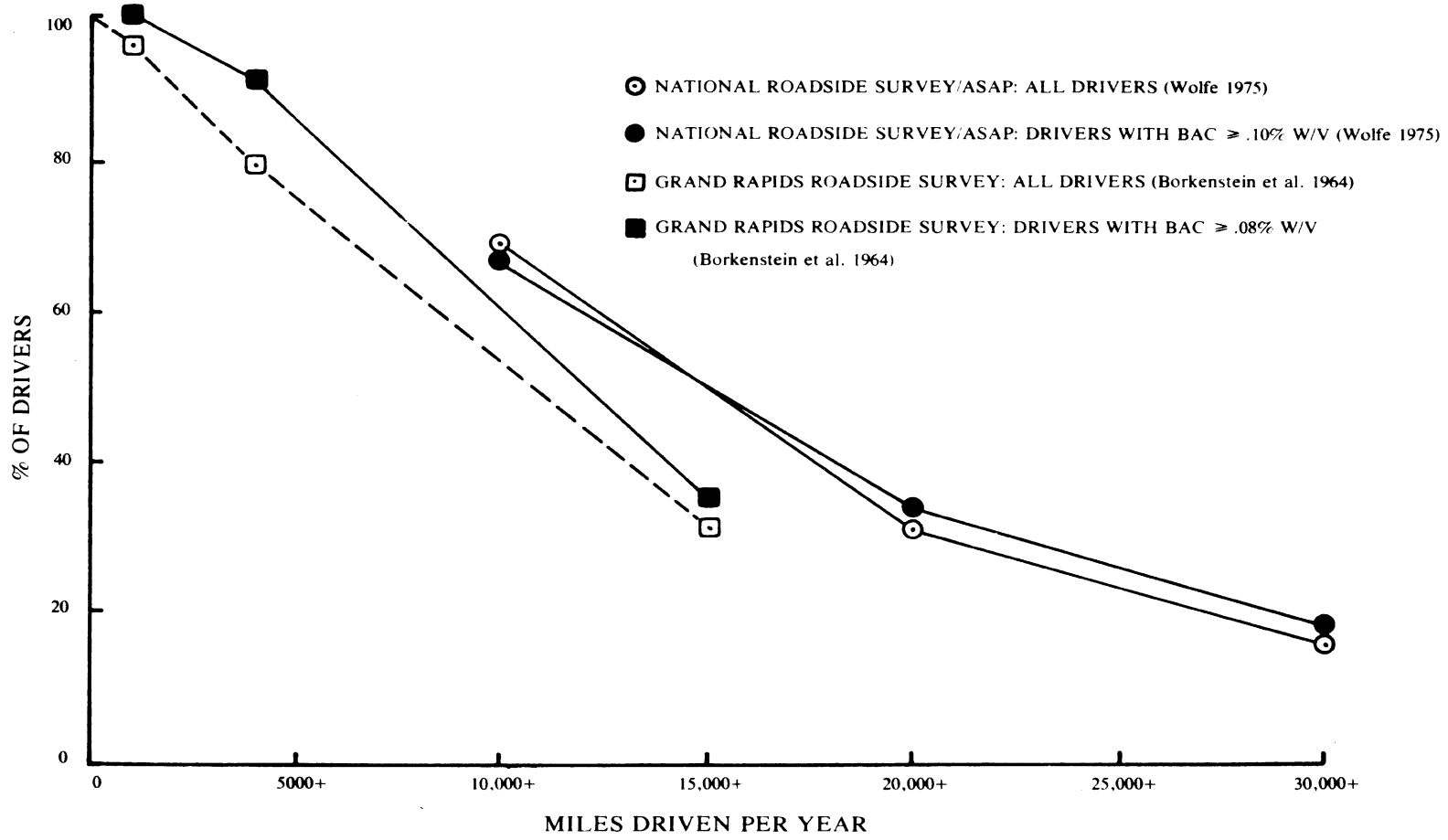
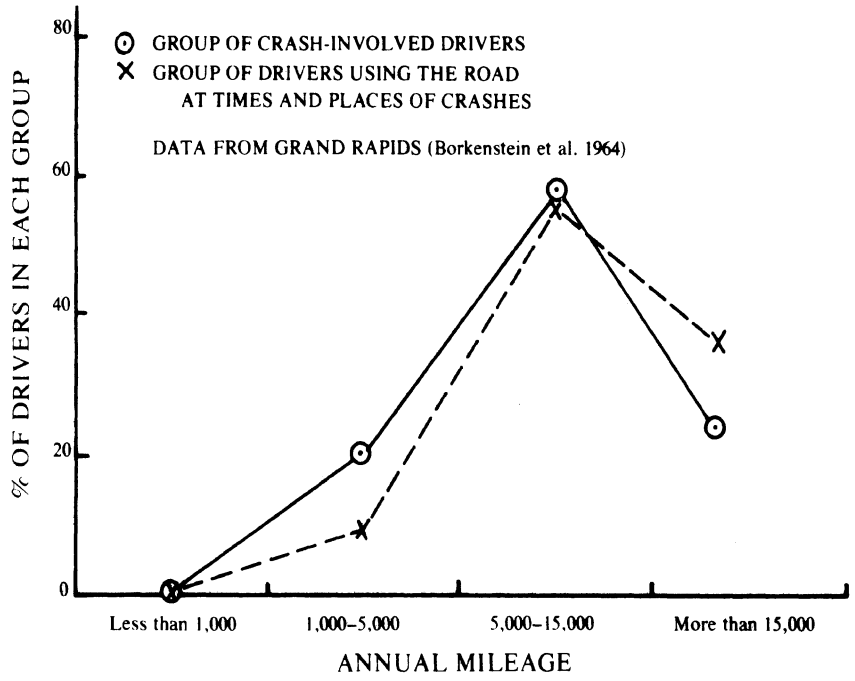


Figure 4-19. Percentage of drivers who had driven a given number of miles per year: comparison of crash-involved drinking drivers (BAC of .08% w/v or more) with noncrash-involved drivers




drivers showing nearly nine times the percentage of previously convicted drivers as the non-intoxicated drivers. Very strong relationships were also found between number of criminal convictions and BAC, and number of nondriving drunkenness convictions and BAC (Filkins et al. 1970).

A recent study of drivers who were found to be responsible for fatal crashes in Boston noted a similar trend with respect to citations for driving under the influence of alcohol and/or for public drunkenness (Sterling-Smith 1976). Thirty-nine percent of the drivers involved in the alcohol-related crashes (BAC $\geq$ .05% w/v) had previous citations, but only 24% of the drivers in the nonalcohol-related crashes had previous citations.

Of course, neither the Wayne County study nor the Boston study provides a sufficient basis (i.e., high alcohol-crash *risk*) for concluding that number of previous citations is somehow a causal factor in alcohol-related crashes. The findings from these and similar studies merely provide clues that must be combined with other evidence for arriving at conclusions about the importance of a trait in identifying high-risk groups.

Persons who have been arrested for driving while intoxicated (DWI) or some equivalent offense have been the subject of considerable study as a group. One of the first of these studies was conducted in Columbus, Ohio in the early 1960s (Shupe and Pfau 1966). The data were developed by reviewing more than 13,000 police records which described the arrestees' demographic characteristics, conditions surrounding the arrest, police officers' observations, the results of physical performance tests administered by the officers (e.g., walking, picking up coins, etc.), drinking habits, and measurements of alcohol concentration in body fluids.

Perhaps the most striking finding of the Columbus study was the common occurrence of very high BACs among the DWIs. The median BAC of the 1,450 drivers who underwent blood tests was .21% w/v, and 97% of the blood specimens yielded BACs of .10% w/v or higher. BAC estimates from the results of 8,500 urine analyses were in general agreement with the direct measurements of BAC (Shupe and Pfau 1966). These findings suggest that enforcement action tends to be directed at drivers who are very intoxicated and applied less often to drivers who are less intoxicated but still impaired.

The Columbus study found its DWIs to be predominantly male (95.4%) and white (76.7%). Non-whites, however, were overrepresented, with an arrest rate almost double that of their incidence in the general population of Columbus at the time of the study. The median age group of the DWIs was 35 to 39 years, and nearly 17% of all DWIs were over 50 years of age. By contrast, only 0.2% were under 18 and less than 1% were under 20 (Shupe and Pfau 1966).

The days of the week and the times of day of DWI arrests in Columbus followed a pattern observed in other studies of drinking drivers who had crashed and in studies of drinking drivers selected at random from the traffic stream. Weekend, nighttime arrests were again the most frequent. Saturday arrests were more than twice as frequent as arrests on all other days, and the arrest rate during the hours of 8:00 p.m. to 4:00 a.m. was nearly three times that for the hours of 4:00 a.m. to 8:00 p.m. (Shupe and Pfau 1966).

Two studies have compared groups of DWIs with other groups of drivers. The first (reported in 1970) analyzed the driving records of a group of 169 Detroit drivers convicted of DUIL or DWI, and the records of 134 drivers killed in Detroit crashes (Filkins et al. 1970). The crash-involved drivers were further segregated into a "high BAC" group (BAC $\geq$ .15% w/v) and a "low BAC" group (BAC $<$ .15% w/v) for purposes of comparison.

The Detroit study found that all three groups were predominantly male. The DWI group contained 98% males. The average age of the high-BAC fatality group was 36 years, compared to 44 years for the DWIs. The fatally injured drivers with high BACs and the DWIs had an almost identical average number of driving violation convictions in the previous 6-1/2 years (about 5.5 per driver). However, fatalities with low BACs had fewer convictions (3.7 per driver) than either of the other groups. Fatally injured drivers with high BACs and DWIs were also closely matched with respect to number of prior convictions for DWI, but fatally injured drivers with low BACs had many fewer DWI convictions than drivers in the other two groups. Both the high-BAC fatalities and the low-BAC fatalities had more prior speeding convictions on the average than DWIs, and the high-BAC fatalities had the highest number of such incidents. Finally, the average DWI had far more prior crashes than drivers from either of the other two groups (Filkins et al. 1970).

The second comparative analysis of DWIs (reported in 1971) was conducted as a part of the Vermont study (Perrine, Waller, and Harris 1971). It found that DWIs are nearly always male (98%), that most DWIs are in the 25 to 59 age group (median age 36 years), that DWIs are more likely to have a low-status occupation than any other type of occupation, and that the Vermont DWI was far more likely to have been arrested on Friday, Saturday, or Sunday than on any other day of the week. Nearly half of all arrests occurred on

Friday and Saturday nights. As in Columbus, BACs were extremely high among the DWIs. Only one out of the 103 tested had a BAC of less than .10% w/v, and more than one-half of the DWIs had BACs of over .20% w/v (Perrine, Waller, and Harris 1971).

After comparing its DWIs with the other drivers, the Vermont study found that the DWIs were far more likely to have had a previous citation for a traffic law violation than either fatally injured drivers or drivers using the roads at times and places of fatal crashes. However, DWIs and drivers using the road did not differ significantly with respect to number of prior crashes reported (Perrine, Waller, and Harris 1971).

The above-cited studies suggest, but do not prove, that drivers with prior convictions (particularly, convictions for DWI) may, as a group, have a higher alcohol-crash risk than drivers as a whole. Any stronger statement about the alcohol-crash risk of drivers with prior convictions would require reliable data from controlled studies, and such data do not exist at present.

### *4.2.3 Drinking Variables*

A number of studies have examined various variables which describe an individual's drinking patterns and have attempted to develop relationships between such variables and the biographical and driving variables discussed in the two preceding sections of this report. Data on drinking patterns have been derived entirely from questionnaires administered in various types of interview situations, e.g., to persons stopped during roadside surveys, to DWIs identified during record searches and later contacted by interviewers, to persons being treated for alcoholism in hospitals, and to survivors of persons killed in crashes. The accuracy of such reports is, therefore, dependent on the ability of an individual to recall information and his willingness to report it accurately if it is recalled.

The information sought is frequently of a highly sensitive nature (e.g., alcohol problems, frequency of driving while intoxicated) which may create a tendency among respondents to conceal or distort their true habits. Thus, to have any chance of obtaining scientifically meaningful data, studies on drinking patterns relative to drinking-driving must be carefully designed and executed. The skill of the interviewer is often crucial in eliciting valid responses. Most studies have not provided detailed descriptions of their research procedures, so that it is not possible to provide an assessment of them here. The reader should keep in mind the inherent limitations of research on drinking patterns when reviewing the material presented below.

*4.2.3.1 Frequency and Quantity of Drinking.* The Grand Rapids study was the first in this country to attempt to collect hard data on drinking habits directly from crash-involved drivers and drivers using the roads at times and places of the crashes. The data indicated that the crash-involved drivers tended to drink less frequently than the drivers who had not been involved in crashes (Table 4-6). However, the BACs of the crash-involved drivers were generally higher than the BACs of the noncrashed-involved drivers regardless of reported drinking frequency (Figure 4-20). An exception to this rule occurred for more frequent drinkers at low BACs. Individuals who said they drank at least on a weekly basis were actually underrepresented among crashed drivers when compared to noncrashed drivers. In fact, at any given BAC interval except the highest, the ratio of crashed drivers to control drivers *decreased* with increasing drinking frequency.

Figure 4-20. Ratio of percentage of crash-involved drivers to percentage of noncrash-involved drivers for given BAC, by self-reported drinking frequency

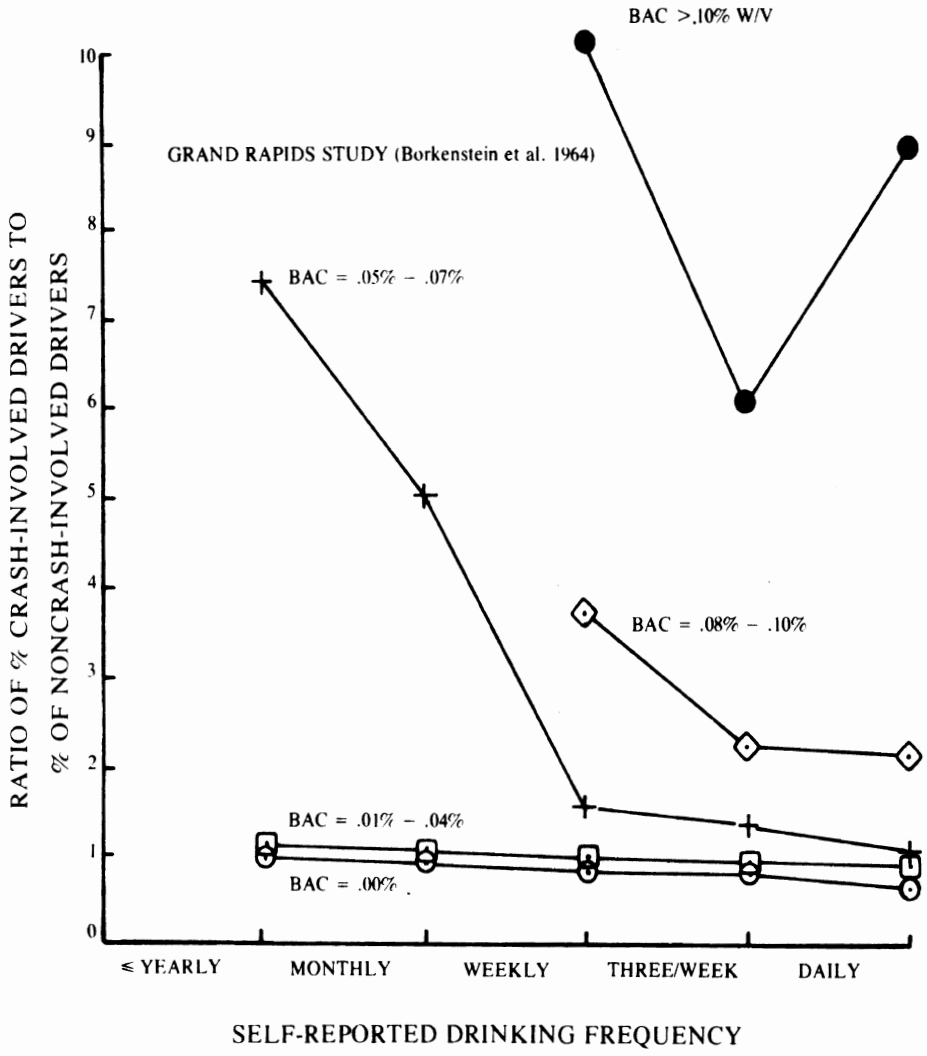


TABLE 4-6

*Average Drinking Frequency Reported by Crash-Involved Drivers and Drivers Using the Road (data from Grand Rapids [Borkenstein et al. 1964])*

| *Group* | *Self-Reported Drinking Frequency, % of Group* | | | | | |
|---|---|---|---|---|---|---|
| | *< 1/year* | *1/year* | *1/month* | *1/week* | *3/week* | *Daily* |
| Non-Crash | 25.7 | 14.8 | 15.1 | 22.9 | 11.2 | 10.4 |
| Crash | 29.0 | 15.7 | 17.7 | 22.6 | 9.0 | 6.0 |

A group's crash probability, given some value of BAC, relative to the group's crash probability given a zero BAC, can also be calculated from the Grand Rapids data as a function of drinking frequency. The results show that at moderate BACs (.05–.07% w/v), the Grand Rapids drivers who drank more frequently faced a much lower relative crash risk than infrequent drinkers (Figure 4-21). In other words, moderate amounts of alcohol seemed to be less risky for these apparently more experienced drinkers. Further, the relative crash probability for the least frequent drinkers turns out to be quite high even at moderate BACs.

An interesting trend can also be observed for the daily drinkers, who had a higher crash risk at the higher BACs (.08–.10% w/v and ≥ .10% w/v) than individuals who said they drank three times a week. In any case, a positive BAC increased the probability of a crash, regardless of drinking frequency.

Hurst has also calculated the relative probability of crash as a function of drinking frequency for the Grand Rapids drivers, but used a different baseline value than was used in Figure 4-21 (Hurst 1974). He obtained a given group's probability of a crash, given some value of BAC, relative to the probability of a crash for *all* drivers, given a zero BAC. His results, reproduced in Figure 4-22, show that the more frequent drinker faced a lower relative crash risk at *any* given BAC than the less frequent drinkers. In fact, the crash risk of the daily drinker at a BAC of about .08% w/v was found to be approximately the same as that of drivers as a whole at zero BAC! Nevertheless, the relative risk of all drivers (including frequent drinkers) increased with increasing BAC. Further, the trends were such as to suggest the existence of very high relative risks for even the frequent drinkers at high BACs (i.e. ≥ .15% w/v).

The so-called "Grand Rapids Dip" (i.e., relative crash probabilities of less than one in the .01–.04% w/v range) has been explained as a drinking frequency effect. It is hypothesized that the drivers with low BACs were predominantly higher frequency drinkers and that these were persons who, for some reason, were safer drivers (Hurst 1974). However, a study by Allsop (1966) in 1966 found that the dip was not statistically significant (i.e., had a fairly high probability of being due to chance alone).

The Vermont study used a measure called a Quantity Frequency Index (QFI) to study the effects of drinking patterns on driving. The Index was based on self-reports of the usual frequency and quantity of alcohol per sitting and the beverage which was reported to have been consumed most frequently and in largest amount (Perrine, Waller, and Harris 1971).

Figure 4-21. Relative probability of crash involvement at given BAC levels for drivers, by self-reported drinking frequency

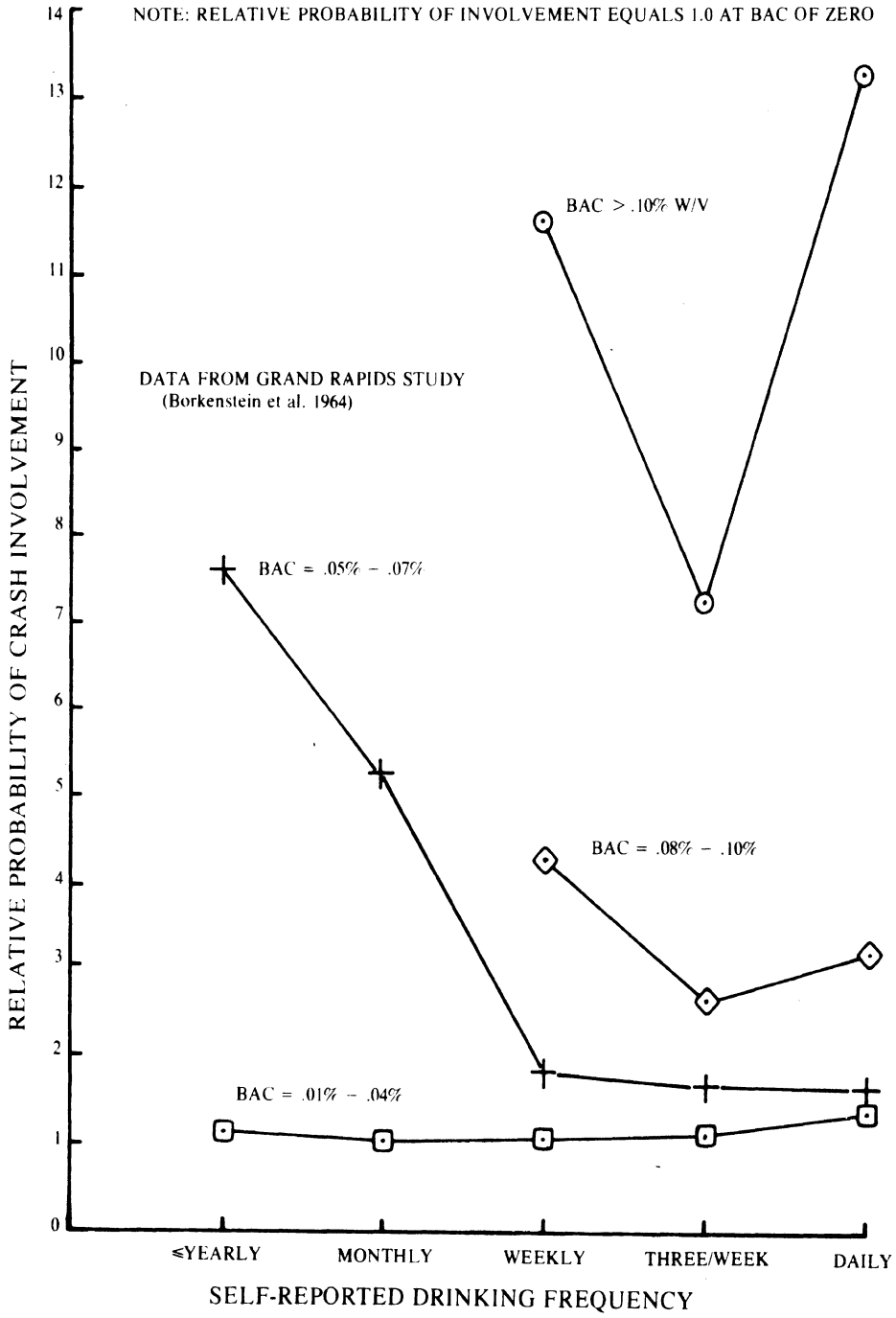
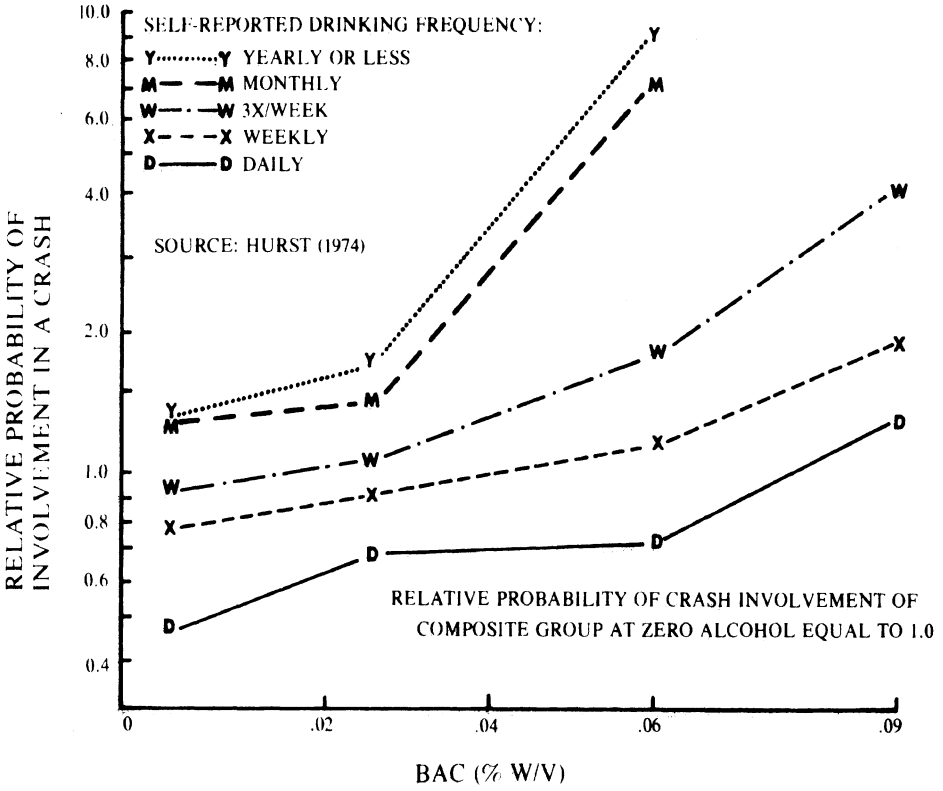


Figure 4-22. Relative probability of crash involvement, by drinking frequency subgroups, as a function of BAC




The interrelationships of QFI with numerous biographical and driving variables (including BACs obtained from drivers) were analyzed in the Vermont study. It was found that the proportion of male drivers increased as QFI increased. A large proportion of teenaged drivers were found to be heavy and frequent drinkers, but QFI tended to decrease with increasing age. Further, married drivers became less frequent as QFI increased. No significant differences were observed with the occupational level of the driver, but the study found some evidence that drivers with high QFIs were more likely to have frequent job changes (Perrine, Waller, and Harris 1971).

A very important finding of the Vermont study was that when the reported frequency of drinking-driving is high, reported drinking is heavy and relatively frequent. It was also found that when the reported frequency of drinking-driving is low, reported drink-

ing is light and relatively infrequent (Perrine, Waller, and Harris 1971). A similar trend was noted in the National Roadside Survey/ASAP Surveys (see Figure 4-23). The data in Figure 4-23 show that the heavier the reported drinking pattern, the greater the proportion of drinking drivers. The consistency of the findings of these two studies provides support for using BAC measurements as an indication of drinking-driving patterns.

The Vermont Study found little relationship between number of crashes or number of license suspensions and QFI. However, it was found that control drivers with higher QFIs tended to have more citations for traffic violations than drivers with lower QFIs. Further analyses of drivers who had been arrested for DWI showed them to have higher QFIs as a group than deceased drivers (i.e., drivers killed in crashes), roadblock drivers (i.e., drivers using the roads at times and places of fatal crashes), or clear-record drivers (i.e., drivers with no previous citations for traffic violations). (See Figure 4-24.)

In the Huntsville study each driver in the crash group and in the control group was asked how many drinks he normally consumes on a single occasion. No significant difference was found between the two groups with respect to percentage of drinkers, but it was found that the crash-involved drivers who drank were slightly heavier drinkers than the control group drivers who drank. The mean number of drinks per sitting for the crash group was 3.04, compared to 2.66 for the control group (Farris, Malone, and Lilliefors 1976).

The Boston study of fatally injured drivers deemed responsible for their crashes found that 39% of such drivers whose crash involved alcohol had consumed alcoholic beverages daily and 38% had consumed alcohol weekly. Only 8% were abstainers. The study also compared the long-term alcohol use patterns of this group with another group of drivers whose crashes had not involved alcohol and found the latter group much less inclined toward heavy alcohol usage than the group whose crashes had involved alcohol (Sterling-Smith 1976). Unfortunately, the validity of these findings is not known, because of the manner in which data on the drinking patterns of the drivers were developed, i.e., through personal interviews with relatives of the deceased drivers.

*4.2.3.2 Type of Beverage.* Research indicates that the preferred beverage of both crash-involved and noncrashed drivers is, by a wide margin, beer. The Grand Rapids study (Borkenstein et al. 1964) found 61% of its drivers preferred beer over either distilled spirits (35%) or wine (4%). The crash-involved group favored beer more than did the control group (65% vs. 59%). Beer drinkers were 81% of control group drivers with BACs of .08% w/v or higher.

The Vermont study (Perrine, Waller, and Harris 1971) found a high correlation between frequent and heavy use of beer and BACs of .10% w/v or higher. Relative to fatally injured drivers with no alcohol, over twice as many deceased drivers with high BACs were said to have drunk beer daily. The same was true of control drivers, although not quite to the same extent. Among these drivers who drank beer, 67% of DWIs and 80% of fatalities with high BACs drank it daily (Perrine 1975).

The more recent National Roadside Survey/ASAP Surveys (Wolfe 1975) also showed a preference for beer among nighttime drivers interviewed in its roadside surveys. Sixty-three percent of all such drivers listed beer as their most used beverage, and 73% of drivers with BACs of at least .10% w/v preferred beer.

Figure 4-23. Percentage of drivers who classify themselves as given drinking types, with given BAC levels

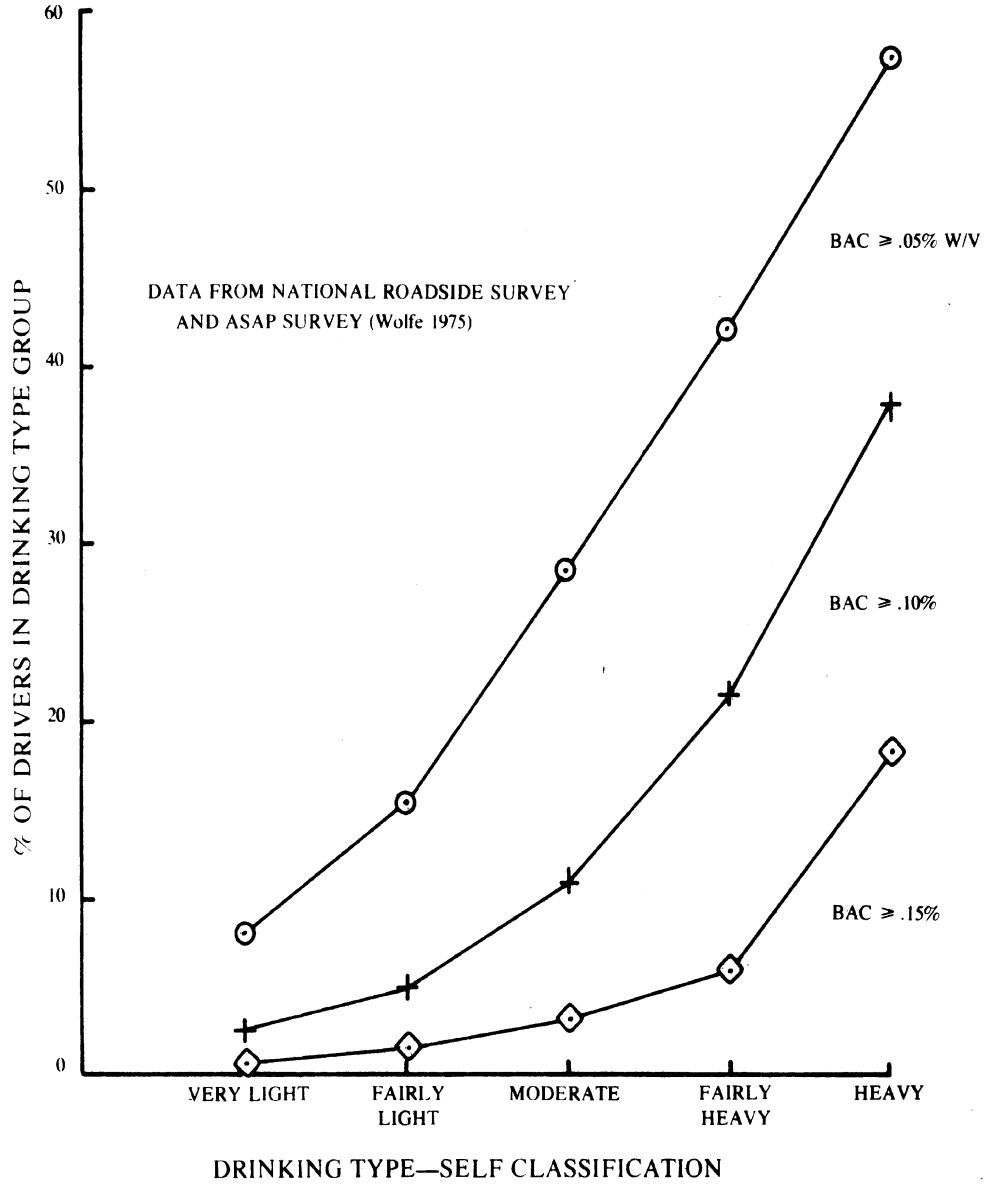
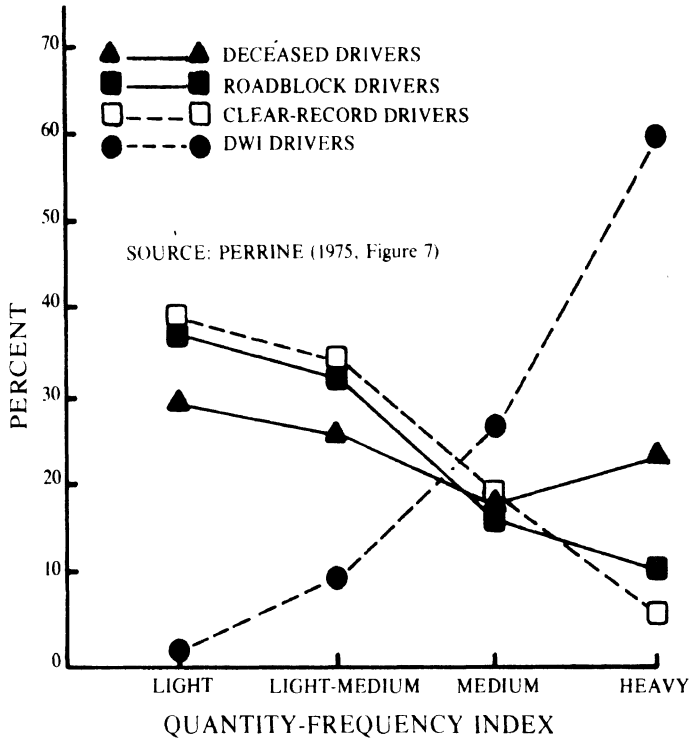


Figure 4-24. Proportion of roadblock, clear-record, DWI, and deceased drivers with light, light-medium, medium, or heavy quantity—frequency index for preferred beverage




None of the studies cited above should be interpreted as showing that beer drinkers have a greater alcohol-crash *risk* than other drinkers.

*4.2.3.3 Place of Drinking.* The Grand Rapids and the Vermont studies found that some two-thirds of their drivers did their drinking at home (Borkenstein et al. 1964; Perrine, Waller, and Harris 1971). In Grand Rapids, a slightly larger percentage of crash-involved drivers than control drivers drank at home (65% compared to 59%). Both studies found that only 10–11% drank at the home of friends and relatives. The remaining 25% or so of the drivers said they usually drank at such places as public establishments, parties, etc.

In Grand Rapids, the higher BACs occurred almost entirely among drivers who drank at home or in a public establishment. Among control group drivers (i.e., noncrash-involved) who drank at public establishments, 4% had BACs of .08% w/v or higher. By contrast, only 2% of all control drivers had BACs above .08% w/v (Borkenstein et al. 1964).

Neither the Vermont study nor the Grand Rapids study shows any strong, direct relationship between place of drinking and alcohol-crash risk.

*4.2.3.4 Alcoholics and Problem Drinkers.* General definitions of alcoholics and so-called "problem drinkers" were given in Section 4.1.2 of this report. In reviewing the multitude of definitions (*circa* 1972) of the term "alcoholic," Joscelyn and Jones (1971) concluded that: "An *alcoholic* is any person who:

- Chronically and habitually uses alcoholic beverages to excess,
- Is physiologically or psychologically dependent on alcohol,
- Loses the power of self-control with respect to use of alcohol,

To the extent that:

- He becomes a menace to the public morals, health, safety, or welfare of the members of society in general. His drinking frequently or continuously interferes with his business life, social life, physical or mental health, relations with the law, or causes a continuing problem in any department of his life,

Or

- Who shows prodromal signs of such development."

The term "problem drinker" is usually used to describe individuals with many of the same characteristics as the alcoholic, but whose drinking problems have not progressed as far as those of the alcoholic. In a study conducted in 1967 and 1969 of the problem drinking male population in the U.S., Cahalan and Room (1974) defined 13 specific measures of drinking-related problems:

(1) *heavy intake*—frequency of drinking 5 or more drinks on an occasion or of getting "high" or "tight,"
(2) *binge drinking*—staying intoxicated for several days at a time,
(3) *psychological dependence*—reliance on alcohol to change moods,
(4) *loss of control*—inability (or impaired ability) to abstain from drinking or inability (or impaired ability) to stop once started,
(5) *symptomatic drinking behavior*—items drawn from classical symptomatology of Alcoholics Anonymous, such as blackouts, skipping meals when drinking, sneaking drinks,
(6) *belligerence after drinking*—feelings of aggressiveness, crossness, getting into fights or arguments,
(7) *problems with spouse*—extent to which marital functioning is disrupted by drinking behavior,
(8) *problems with relatives*—displeasure on the part of relatives with subject's drinking behavior,
(9) *problems with friends or neighbors*—loss of or harm to friendships, advice from friends or neighbors to cut down on drinking,
(10) *job problems*—loss of promotion or job because of drinking, being advised by boss or colleagues to cut down on drinking,
(11) *police problems over drinking*—trouble with law about drinking behavior, includes contact with law when drinking and driving,
(12) *problems with health or injuries related to drinking*—physicians' warning to cut down on drinking, giving up drinking for health reasons, injuries in accidents due to drinking,
(13) *financial problems related to drinking*—drinking seen by subject as harmful to his financial position.

For each of these types of problems, the survey respondent (males aged 21–59 years) indicated whether he currently (within the three years immediately preceding the survey) had the problem and whether he had ever had it within his lifetime. The severity of the problems was also measured. Fifty percent of the survey respondents currently had at least one of the 13 problems at a minimal level of severity. Seventy-two percent of the respondents had had at least one of the problems during his lifetime at a minimal level of severity. Thirty-six percent of the respondents currently had at least one of the problems at a high level of severity, and 55% of the respondents had had at least one of the problems at a high level of severity during his lifetime.

The fact that so many people have had drinking-related problems is indicative of the pervasiveness and potential danger of heavy drinking in the U.S., but does not imply that individuals who have experienced only one or even a few of these problems are necessarily "problem drinkers" in the usual sense of the word. There is, in fact, a general lack of precision in defining the term "problem drinker" in the field of alcohol-highway safety, and this makes it impossible to determine the role of "problem drinkers" (i.e., individuals who have significant drinking problems but are not yet alcoholics) in highway crashes. Obviously, programs to deal with such a broadly-defined group are difficult to design, and no single approach (e.g., treatment and rehabilitation) will be appropriate for all so-called problem drinkers. More will be said about past methods of dealing with alcoholics and problem drinkers in Section 5.3.

Within the field of highway safety, personal-profile instruments have been developed which are used to screen drivers for alcohol-related problems. A recent review has been conducted of a number of these alcohol-use assessment techniques (McBride and Stroad 1975a; McBride and Stroad 1975b). A modification of the thirteen types of problems listed above was used in an analysis of the content of selected diagnostic devices. The reviewers found that the techniques reviewed used almost all of the types of problems listed above in attempting to diagnose problem drinking. An underlying assumption of these techniques is that these problem-content areas have some real, though unknown, relationship to problem driving.

The most widely used of the techniques reviewed is the HSRI Protocol, also known as the Mortimer-Filkins Test (Filkins et al. 1973). The questionnaire, interview, and scoring procedure, and variations of them, which make up this technique have been used extensively in the Alcohol Safety Action Projects (ASAPs) funded during the early 1970s by the National Highway Traffic Safety Administration. The arrested driver is questioned about his health; arrest and driving history; marital, family, and work history; and drinking history (Kerlan et al. 1971). The questions cover many of the 13 measures of drinking-related problems described by Cahalan and Room. The protocol recommends that persons scoring less than 40 on the test be classified as social drinkers, that persons scoring 40–49 be classified as presumptive problem drinkers, and that persons scoring greater than 50 be classified as problem drinkers. In three ASAPs in which full use was made of the HSRI Protocol, it was found that about 55% of the drivers who had been apprehended for driving while impaired (DWI) could be classified as problem drinkers (Filkins et al. 1973).

In validating the HSRI Protocol, the developers used a criterion measure based on the BAC level of the DWI driver at time of arrest, previous DWI arrests and number of

previous other alcohol offenses (e.g., drunk in public [DIP]). (This criterion measure is similar to the "problems with police" category in the classification scheme used by Cahalan and Room [1974] and described above.) The following types of drinkers were defined in validating the HSRI Protocol:

(1) social drinkers—BAC less than 0.15% w/v at time of arrest *and* no previous DWI or DIP arrests,
(2) excessive drinkers—BAC of .15–.19% w/v at time of arrest *or* one prior DWI arrest *or* 1–2 DIP arrests,
(3) problem drinkers—BAC of .20% w/v or more at time of arrest *or* 2 or more prior DWI arrests *or* 3 or more DIP arrests *or* 2 of the items used to indicate excessive drinking.

Use of this criterion measure resulted in the classification as problem drinkers of more than 50% of the subjects in the samples of DWIs studied, compared to 55% when the HSRI Protocol and recommended scoring rules were used. Eighty-three percent of the persons classified as problem drinkers by the criterion variable would be so classified by the HSRI Protocol following recommended scoring rules (Filkins et al. 1973). Conversely, 17% of the persons classified as problem drinkers by the criterion variable would *not* be so-classified by the HSRI Protocol. Thus, even the careful criteria employed in the HSRI Protocol do not permit perfect consistency in classifying drivers as problem drinkers.

No one knows exactly how many alcoholics and problem drinkers there are in the United States. A figure often used is 3½% of the drinking age population are alcoholics and another 3½% are problem drinkers (Efron, Keller, and Gurioli 1974; Keller 1975).

The role of persons with drinking problems in crashes (both alcohol-related and nonalcohol-related) has been the subject of much study by researchers. The range of views on the role of alcoholics in crashes is illustrated by the different conclusions reached by two long-time researchers in the field, Julian A. Waller and Richard Zylman.

In reviewing applicable research prior to 1965, Waller (1968) observed that alcoholic drivers in particular appeared to have nearly twice as many crashes per vehicle-mile traveled as do nonalcoholic drivers. Waller estimated that, in California, drivers with alcoholism could be involved in 41%–62% of "known drinking accidents" and concluded that "the overwhelming weight of evidence is that alcoholism plays a very substantial role, and probably the major role, in the occurrence of traffic accidents involving the use of alcohol" (Waller 1968). In arriving at these figures, Waller classified as alcoholics drivers who were known to the Department of Motor Vehicles (DMV) as alcoholics. Conversely, drivers not known to the DMV as alcoholics were classified as non-alcoholics.

Zylman, on the other hand, has stated that the role of alcoholics in crashes has been exaggerated. He cautioned against branding all alcoholics as "high risk drivers" and cited studies which indicated to him that the driving records of alcoholics were not as bad as had been stated by some. He noted that many studies had suggested that other psychological and social stress factors often interact with alcoholism to create behaviors that lead to crashes and that "the misuse of alcohol is only one manifestation of deviant behavior" (Zylman 1976a).

In some respects, there is really little disagreement between these two views. No responsible researcher has suggested that *all* alcoholics are higher risk drivers, and it is generally accepted that the excessive use of alcohol per se may not be the root cause of crashes involving alcoholic drivers. (See the following section of this report for a discussion of psychological and personality factors relative to alcohol-involved crashes.) Past research indicates that, for whatever reason, individuals who have been identified as alcoholics are, as a group, more frequently involved in crashes and enforcement actions than nonalcoholics as a group and that alcoholics are, therefore, a logical subject for further study.

At the same time, it must be recognized that past studies do *not* provide an adequate basis for stating conclusively that alcohol-impairment of critical driving tasks has actually *caused* any given fraction of crashes involving alcoholics or problem drinkers. This uncertainty about causation is due to a lack of controlled studies of problem drinker-drivers who have crashed and problem drinker-drivers using the roads. It is further exacerbated by a lack of behavioral studies of the impairment of driving performance of alcoholics/problem drinkers relative to other types of drinkers, and by imprecise definitions of the term "problem drinker." Past studies (including those by Waller, Zylman and others cited below) have relied on other data (e.g., driver records, accident reports prepared by police officers, etc.) to provide clues or "indicators" about the involvement of alcoholics and problem drinkers in alcohol-related crashes.

One such indicator that has been studied is one that physiologists associate with excessive drinking over extended periods of time—fatty degeneration of the liver. In a study of persons fatally injured in California crashes, Waller and associates found that the proportion of persons with fatty liver changes among persons who had not been drinking was 14%–15%. Among those with BACs of .15% w/v or greater, the proportion with fatty changes was 21%–39%. The study also found alcohol significantly more often among persons who had previous arrests or fatty liver changes than among those with normal liver and no arrests (Waller et al. 1970).

In the Wayne County, Michigan, study of highway crash fatalities, 39% of persons over 25 years old with BACs *less* than .10% w/v had fatty livers, compared to 50% of those over 25 with BACs of .10% w/v or greater. Four percent had cirrhotic livers and one cirrhotic male, 21 years old, had a BAC of .26% w/v (Filkins et al. 1970).

The Vermont study performed more detailed analyses of fatty degeneration of the livers of persons killed in highway crashes in that the degree of such changes was also noted. The study found that persons under age 15, even with alcohol in their blood, seldom had fatty changes of the liver. Among persons of age 25 or older, the presence of alcohol was associated with greater frequency and greater severity of fatty liver. The study also found that the distribution of fatty livers among highway fatalities with zero BAC was more similar to that of persons dying in the general population than to alcohol-related highway fatalities (Perrine, Waller, and Harris 1971).

It is important to note that fatty changes of the liver do not in themselves provide conclusive proof of a drinking problem in individuals whose livers have undergone such changes. The phenomenon is associated with heavy drinking, but it cannot be said that all persons who drink so heavily are also problem drinkers or alcoholics.

The Grand Rapids study surveyed its control group of drivers to determine if and how

BAC was related to symptoms of problem drinking. It found that persons who reported they "got high" on a weekly basis comprised 29% of drivers with BACs of .08% w/v or greater, but were only 6% of drivers with zero BACs. Also, 21% of drivers with BACs of .08% w/v or greater said they had drinking "problems," compared to 6% of drivers with zero BAC. Similar relationships were found between reports of hangovers and blackouts and BAC (Borkenstein et al. 1964).

The University of Michigan's Highway Safety Research Institute (HSRI) analyzed the medical records, group therapy records, driving records, criminal records, and death certificates of 1,517 hospital patients diagnosed by physicians as alcoholics. The study sought to characterize alcoholic drivers who were disproportionately involved in highway crashes and to develop methods to support early identification and rehabilitation of such drivers (Filkins et al. 1970).

The HSRI study found that the crash rate for the alcoholic drivers was about twice as high as the crash rate for the same age group (26–75 years) for Michigan drivers as a whole. The higher crash rates for these alcoholic drivers were associated both with younger age (less than 46 years) and with a high rate of driving convictions unrelated to crashes. Convictions for DWI were also relatively high for the alcoholics, and the crash rate of alcoholic males was about 50% higher than the crash rate of alcoholic females. The HSRI study also found evidence to support the conclusions that there was a direct correlation between high rate of driving convictions and behavioral deviancy and that behavioral instability was associated with a high crash rate (Filkins et al. 1970).

In comparing the alcoholic driver with other groups of drivers, the HSRI study found that the mean number of crashes for alcoholics was similar to that for fatally injured drivers with high BACs, but higher than the mean number of crashes for drivers as a whole and for fatalities with low BACs. Drivers convicted of DWI had a crash rate about twice that of alcoholic drivers. The alcoholic drivers had the *highest* mean number of DWI convictions among fatally injured drivers, DWIs, and drivers as a whole (Filkins et al. 1970).

Finally, the recent study of fatally injured Boston drivers said to be most responsible for their crashes found that 63% of the drivers in the alcohol-involved crashes had a history of problem drinking (Sterling-Smith 1976). Only 25% of the drivers in the nonalcohol involved crashes had a history of problem drinking. Of the drivers with BACs of .20% w/v or greater, 72% were said to have had known alcohol problems. As was noted previously in this report, the validity of these findings is not known because of the manner in which a history of problem drinking was determined, i.e., through interviews with relatives of the deceased drivers.

In summary, there is considerable evidence to indicate that persons with severe drinking problems (particularly alcoholics) are overrepresented in alcohol-related crashes, but there is insufficient scientific basis for an accurate quantitative estimate of the overrepresentation. Such an estimate cannot be developed without data from carefully-designed controlled studies of the incidence of such problem drinkers in alcohol-related crashes and in the population of drivers using the roads at times and places of such crashes. Behavioral studies of the impairment of performance of critical driving tasks in alcoholics and severe problem drinkers are also needed to support stronger and more quantitative statements about causation. More precise definitions of the term

"problem drinker" and additional research are needed to determine the role of this broad class of drivers in alcohol-related crashes.

### *4.2.4 Variables Describing Personality and Exposure to Stress*

Personality and stress variables associated with crash-involved behavior of drivers have been relatively difficult to define and measure. Most of the research in this subject area focuses on the general driver population, but there are a number of studies which have examined the relationships between personality traits, exposure to socio-psychological stress, and the crash-involved behavior of drinking drivers (McBride and Stroad 1975a; McBride and Stroad 1975b; Selzer and Vinokur 1974; Selzer and Vinokur 1975).

In these studies, researchers have attempted either to select problem drinkers from known problem drivers or to select problem drivers from known problem drinkers. Once this initial selection was completed, the next step was to try to identify those traits of the subgroups which appear to be most related to concurrent and/or future crash involvement. Use of the psychometric diagnostic measures developed in this research has resulted in some success in detecting problem drinkers but has not proved useful in isolating high-risk drivers from samples of problem drinkers (McBride and Stroad 1975a).

The value of these research findings is compromised by several methodological shortcomings characterizing work in this field. Many of the techniques used to measure psychological traits do not have demonstrated reliability, i.e., the capability of producing the same results under similar conditions on different occasions. The Mortimer-Filkins Test (or HSRI Protocol) (Filkins et al. 1973) is an exception. This most widely used of the techniques has been reported to have moderately high reliability. Nor has predictive validity, a demonstrated relationship with future driving behavior, been established for most of these tests. In addition, many of the samples used are too small to allow reliable interpretation of findings (McBride and Stroad 1975a).

Two major variables describing the alcohol usage of drivers have been defined by researchers interested in personality and stress variables. One variable tests the subject's pattern of alcohol usage over an extended time period. The other variable measures BAC at a given point in time—when the driver is arrested for DWI or when a crash occurs. This long term (or historic) versus concurrent (or focal) dichotomy has been extended by some researchers to psychological variables (Finch and Smith 1970).

Table 4-7 describes the major types of variables which appear in the literature on psychosocial characteristics of drinking drivers. The important conclusion to be drawn from the table is that, just as the effects of alcohol consumption on the human body may be either chronic or acute, so may the effects of exposure to stressful events be chronic or acute. The implication is that analysis of relevant data should differentiate between the contribution of the two types of effects to crash involvement of drinking drivers. Since most drinking drivers and most alcoholics do not have crashes, it is apparent that neither acute nor chronic consumption of alcohol can fully explain the overinvolvement of drinking drivers and alcoholics in certain kinds of traffic accidents. Many researchers see psychological and situational stress variables as an important causal link.

TABLE 4-7

*Description of Variables Commonly Used in the Literature on Psychosocial Behavior, Alcohol Consumption, and Highway Safety*

| *Type of Variable* | *Time Frame* | |
|---|---|---|
| | *Historic Conditions* | *Recent or Focal Event* |
| Psychological | Personality, attitudes, characteristic pattern of response to life events | Pre-crash emotional state |
| Situational Stress | Chronic exposure to stressful social situations which may lead to abnormal behavior triggered by certain acute emotional states. | Acute stresses occurring around the time of crash which may trigger certain emotions and patterns of behavioral response. |
| Patterns of Alcohol Consumption | Patterns of alcohol consumption, especially as related to response to chronic stresses and as indication of problem drinking status | BAC at time of arrest for DWI or at time of crash |
| Driving Behavior | Patterns of driving behavior, usually past traffic violations indicating possible problem driver status | Crash involvement, traffic violations |

Several studies have been conducted which found significant psychological differences between accident-involved drivers who were drinking and nondrinking accident-involved drivers. Pelz and Schuman (1974) found that when they looked at a subgroup of a population sample of young men in which the subjects were either strongly hostile or strongly alienated or both, the members of this subgroup were, at each age level between 16 and 24, more likely to drink or to drink heavily than the remainder of the sample. As drinking among this subgroup rose in frequency and amount, so did rates of traffic violation and crashes. No relationship between drinking behavior and driving infractions was found for those who were neither hostile nor alienated. The authors also examined a sense of personal efficacy among this subgroup of hostile and/or alienated young men and found that when sense of personal efficacy was high, there was no additional effect on driving behavior. However, when sense of personal efficacy was low, the effect of drinking behavior on rates of violation and crashes was stronger and more significant statistically. It is important to note that the measure of alcohol consumption used was historic rather than focal.

Another study (Sterling-Smith 1976) examined focal use of alcohol and psychological traits of fatally injured crash-involved drivers. Drivers with BACs $\geq$ .05% w/v scored significantly higher on 7 of 16 items on a Human Factor Stress Scale than drivers with BAC's $<$ .05% w/v. This scale measured stress experienced by drivers immediately prior to fatal crashes. The seven measures on which the two groups differed significantly were domestic tension, social tension, clinical depression, fatigue, excessive speed for conditions, use of alcohol resulting in a BAC $>$ .01% w/v and use of other

drugs. Another finding of this study was that drivers with BACs ≥ .05% w/v scored significantly higher than drivers with BAC < .05% w/v on 6 of 12 items on a Risk Taking Behavior Scale. The six measures on which the two groups differed significantly were having a known problem drinking history, having been known to have attempted suicide, abuse of pharmaceutical drugs, experimental or frequent use of street drugs, normally driving without restraints, and smoking marijuana.

Though age and BAC level at time of crash have been identified by other researchers as variables which are highly related to fatal crash involvement, recent studies (Fisher 1976; Schmidt et al. 1972) have found certain personality characteristics—belligerence, negativism, verbal expansiveness, hyperactivity—to be related to crashes, but, at the same time, to be unrelated to focal alcohol usage among the crash-involved sample. On the other hand, age and long-term patterns of alcohol usage were related to these personality traits in the general population studied.

Selzer and associates (Selzer, Vinokur, and Wilson 1977; Selzer and Barton 1977) compared selected driving, personality, and psychosocial variables of convicted male drunk drivers with those of alcoholics and individuals from the general driving population. The drunk drivers were selected from a group of individuals who were participating in mandatory rehabilitation programs following conviction in Michigan. The studies found that while a large percentage (40–68%) of the drunk drivers were alcoholics, they showed significantly less psychosocial "incapacity" than the alcoholic group. However, the nonalcoholics in the drunk driver group were found to be more malajusted than drivers from the general driving population. Alcoholics, when compared to drivers as a whole, were less responsible, had less self-control, had a more external locus of control, were more depressed and suicidal, had less self-esteem, and were more paranoid and aggressive. The drunk driver group was found to be more aggressive, more depressed, less self-esteeming, less responsible, and less in control of themselves than drivers in general. Selzer and Barton (1977) concluded that the forms of psychosocial impairment that existed among both the alcoholic and non-alcoholic drunk drivers were unlikely to respond to pre-arrest educational programs, but might be responsive to post-arrest rehabilitative programs.

In general, research on personality and stress variables relative to the alcohol-crash problem provides useful clues and insights for describing some characteristics of drinking-drivers. However, the relationships between these variables and alcohol-related crashes are not sufficiently developed for use in predicting crash risk. Great care should be taken in applying the findings of this research to operational programs dealing with the drinking-driving problem.

## 4.3 SUMMARY AND CONCLUSIONS

Much of the research on drinking drivers employs epidemiologic methods and is, therefore, subject to the same limitations outlined previously in Section 2.0 of this report. Additional problems with this method arise as one attempts to "cut" the data finer to arrive at more detailed conclusions. One finds that few studies have sufficiently large sample sizes or sufficiently detailed presentations of their data to support much

analysis beyond the next lower level of detail to that considered in Section 2.0. Even then, there are serious difficulties in many studies because confounding effects between variables often make it impossible to determine the degree to which each separate variable is associated with an observed effect. In addition, studies which rely on self-reported information about drinking and driving habits are obviously limited by the subjects' ability and proclivity to accurately recall and report such information. Similarly, analyses of information collected from the records of public and private organizations are constrained by the accuracy, completeness, and currency of that data. Attempts to combine almost any kind of drinking-driving data from more than one study are complicated (and sometimes made impossible) by inconsistent definitions, procedures, units, etc.

A particularly serious deficiency in past research is the lack of sufficiently detailed controlled studies to assess accurately the alcohol-crash *risk* of most sub-groups of drivers. Without such studies, it is impossible to reliably determine the degree to which drinking drivers possessing a given characteristic are more likely than other drivers to be involved in an alcohol-related crash.

On the positive side, much careful and useful research has been done in spite of these problems, most of which are common to many areas of the social sciences. As with the research described elsewhere in this report, its main value lies not in providing irrefutable proof of hypotheses about drinking-driving, but in supporting informed decision-making. Thus, the information presented above must ultimately be interpreted by the individual reader in light of individual needs and situations. The summary and comments presented here are intended to help support that process rather than preempt it, and are neither definitive nor exhaustive in their content.

The literature indicates that both drinking and driving have increased in the past 30 years, so that it is not surprising that we have a drinking-driving problem. The annual per-capita consumption of absolute alcohol in the U.S. has risen some 33% since 1947. Annual consumption of absolute alcohol is now about 2.7 gallons for each person over age 15 years in the U.S., an equivalent of approximately two drinks of 100-proof distilled spirits per person per day. A disproportionate amount of this alcohol is consumed by some 12% of the population who are classified as heavy drinkers (including 3–4% who are alcoholics), so that most drinkers are probably consuming less than one 100-proof drink per day.

It is hard to relate these figures on gross alcohol consumption to the categories of drinking types that commonly appear in the literature. It is possible, for example, for an "average" drinker to consume his entire quota of drinks on a Saturday night and thus become a "problem drinker" once a week. Similarly, a "heavy" drinker could spread his higher consumption of alcohol more evenly throughout the week and never become a "problem drinker" at all. Thus, the amount of alcohol consumed or average rate of consumption does not alone determine whether a person is a "social drinker" or a "problem drinker." Frequency of attaining high BACs seems a better measure of the degree to which alcohol is a disruptive influence on one's functioning in society.

A host of variables have been examined to learn more about the attributes of persons whose drinking has been associated with an inordinate amount of driving dysfunctions. Among those variables classified as biographical, *sex* has been found to be one of the

best differentiators of drinking drivers. Males are consistently overrepresented in all kinds of drinking driver populations and are particularly frequent among crashed drivers with high BACs (i.e., greater than .08% w/v). The preponderance of males among drinking drivers is thought to be a consequence of social customs which call for males to do most of the driving, particularly at night when most drinking-driving occurs. One study found that at high BACs, females, in fact, suffered 4 to 5 times greater crash risks than males.

With respect to *age*, both the youngest and oldest persons have been found less frequently than others among drinking drivers. The youngest drivers, however, appear to have a much greater alcohol crash risk after drinking (particularly at low BACs) than persons of other age groups. Inexperience with both drinking and driving has been suggested as a reason for the higher relative involvement of young drivers in alcohol-related crashes. In one study, older drivers had higher crash risks at higher BACs than other drivers.

Studies of drivers' *marital status* have shown that married persons comprise the largest percentages of drinking drivers who have crashed and of drinking drivers using the road. However, as a group, divorced and separated persons seem to combine drinking and driving more frequently and may have a higher crash risk than persons of other marital statuses. The effects of marital status on drinking-driving are often confounded, in the literature, with other effects (e.g., age).

There are indications that persons of "lower" *occupational levels* are overrepresented among drinking drivers, but these findings are not conclusive because of the confounding effects of other variables such as age and sex. Increased alcohol involvement among *nonwhites* has been explained in one study as a socio-economic rather than a racial effect. Persons in *low income* groups were especially overrepresented among nighttime drivers in a nationwide survey, particularly at very high BACs (i.e., greater than .15% w/v), where they outnumbered other drivers by a factor of three to one. *Less educated* persons were found more frequently among drinking drivers in some older studies, but more recent studies show less of an educational effect except at high BACs. However, there is no convincing evidence that either occupational level, race, income, or education is strongly related to alcohol/crash risk.

Among the many driving variables that have been studied, *time of day* has shown some of the strongest relationships to drinking-driving patterns. As might be expected, drinking-driving is primarily a nighttime phenomenon. Drinking drivers are found two-to-four times as often in nighttime crashes as in daytime crashes. The same trend occurs among the nighttime driving population as a whole, particularly at the higher BACs. On the other hand, one study found one's relative risk of a "run-of-the-mill" crash after drinking to be substantially less during the nighttime than during the daytime. With respect to *day of the week*, alcohol-related crashes and drinking drivers are also more frequent on weekends than on week-days, although the effect is not nearly as great as it is for time of day.

Conflicting results have been obtained with respect to the relationships between *annual mileage* driven and drinking driving. There are indications that persons who drive relatively infrequently may be overrepresented both among crashed drinking drivers and among drinking drivers using the roads but not involved in crashes, but these

results are not conclusive. The relative risk of a crash after drinking may also be higher for the very-low-mileage driver. The *origin of the trip* which involved the illegal drinking-driving is most frequently bars or taverns and other person's homes.

Research suggests that drinking drivers have had slightly more *previous crashes* and substantially more *enforcement actions* against them than other drivers. Drinking drivers have been found to have on the order of 50% more prior contacts with traffic law enforcement agencies than other drivers.

Particularly, persons arrested for *driving while intoxicated* (DWI) generally have more prior driving convictions than other persons and perhaps more prior crashes. However, because of the lack of applicable controlled studies, it cannot be said conclusively that DWIs have a higher alcohol-crash *risk* than other drivers. The driving records of DWIs have been found to be similar to those of fatally injured drivers with high BACs, but DWIs' prior convictions for driving offenses are more numerous than those of either fatally injured drinking drivers or noncrashed drinking drivers. The BACs of persons arrested for DWI are nearly always at illegally high levels. DWIs are seldom female, very young, or very old. They are usually arrested during weekends and at night and are often engaged in "low status" occupations.

Among those driver-characteristic variables which are classified as "drinking variables," the relationships that have been found with respect to drinking *frequency and quantity* are in many ways the most enlightening. As might be expected, crashed drivers seem generally more likely to have a higher BAC than noncrashed drivers, regardless of drinking frequency. However, the ratio of crashed drivers to noncrashed drivers (and relative crash risk) tends to decrease with increasing drinking frequency, indicating that the more experienced drinkers are somehow better able to cope with the effects of alcohol in driving.

One study which investigated the combined effects of *frequency and quantity* on drinking driving found a higher percentage of males among drivers who reported a high Quantity-Frequency Index (QFI). Also, many teenagers were found to have high QFIs, but QFI decreased with a person's age. Fewer married persons had high QFIs than persons of other marital statuses. Heavy drinkers were more likely than others to engage in drinking at all BACs but had no more prior crashes or license suspensions. DWIs were heavier drinkers than either fatally injured drivers or drivers not involved in crashes. There were indications that crash-involved drivers were slightly heavier drinkers than other drivers and that drivers in alcohol-related crashes were heavier drinkers than drivers in nonalcohol-related crashes.

Studies that have investigated the *type of beverage* preferred by drinking drivers agree that beer is preferred by about two to one over other beverages by drinking drivers. An especially high preference of beer has been expressed by drivers with high BACs and drivers who report that they are heavy drinkers.

The *place of drinking* most frequently reported by drinking drivers was their own home (two out of three). About 25% said they usually drank at public establishments or at parties. The higher BACs have most frequently been found among drivers who said they drank at public establishments.

Much attention has been given in the literature to the drinking-driving habits of *alcoholics* and *problem drinkers*, although many studies do not provide precise

definitions of the latter term. Studies do provide evidence that persons with severe drinking problems are highly overrepresented among fatally injured drivers who have high BACs (i.e., greater than .10% w/v). One study found problem drinking to be highly associated with drivers found to be responsible for the crashes in which they were killed. More than half of all DWIs tested in three Alcohol Safety Action Projects were found to be problem drinkers. Other research indicates that alcoholics in particular have much higher crash rates than the driving population as a whole, perhaps even twice as high. Alcoholics may also engage in drinking-driving more frequently even than DWIs, especially at the higher BACs.

Studies of *personality and stress* variables that may be related to drinking-driving have not been conclusive and offer little reliable information for generalizing. There is some evidence that alienated and hostile young men are more likely than others to drink frequently and heavily and to be involved in crashes and traffic law violations. Such persons who are also low in personal efficacy may run even greater risk of involvement in a traffic incident. Further evidence exists that drivers who are inordinately tense, depressed, fatigued, and given to risk-taking may be especially likely to cause serious alcohol-related crashes. Some personality characteristics that are believed to be highly associated with highway crashes in general (e.g., belligerence, negativism, etc.) have not been found to occur more frequently in alcohol-related crashes.

In summary, research shows that drivers involved in alcohol-related crashes and persons who drink and drive but have not yet crashed tend to be different from other drivers in several important respects. Understanding these differences will help in developing programs to reduce societal and individual losses caused by drinking and then driving. Misinterpreting them, however, can be counterproductive and even dangerous to both society and its individual members. No characteristic discussed above or any combination of such characteristics can identify any given individual as a sure-fire perpetrator of future alcohol-related crashes. In no instance can it be said that all persons possessing certain characteristics are high-risk drivers (e.g., alcoholics, young males). The data can help to determine the gross alcohol-crash risk of entire *groups* of drivers, but are far more difficult to apply to *individual* drivers.

# 5.0 DEALING WITH THE ALCOHOL-CRASH PROBLEM

Research provides strong evidence that excessive drinking plays a major role in a large number of highway crashes in the United States and has furnished many useful clues for identifying the characteristics of groups of drivers who are involved in such crashes. The desire to "do something" to reduce the frequency of these alcohol-related crashes is therefore a natural one and, in fact, occurred long before a reliable scientific basis for action was available. This section of the report examines some past efforts to deal with the alcohol-crash problem with respect to their targets, their design, and their results.

## 5.1 ELEMENTS OF A SYSTEMATIC APPROACH TO THE ALCOHOL-CRASH PROBLEM

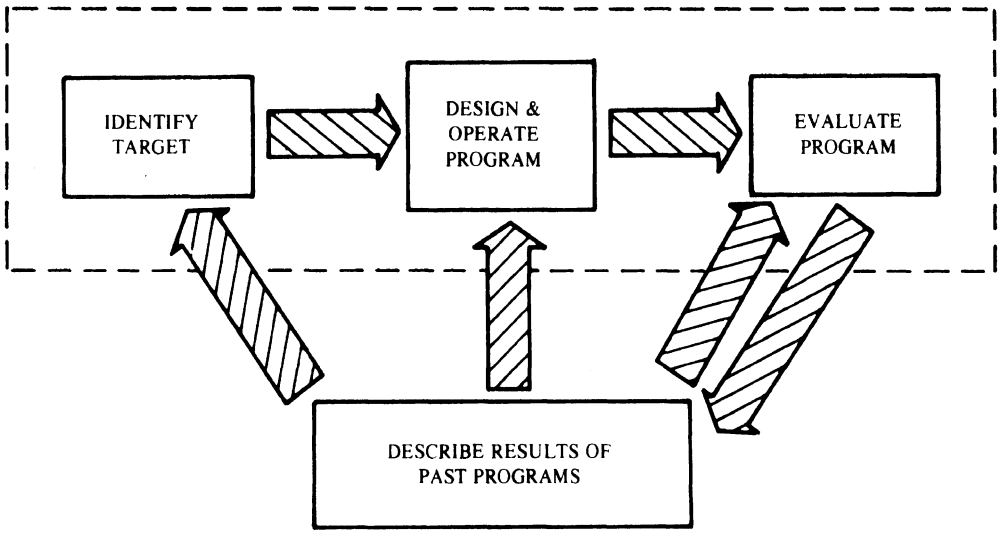
In reviewing efforts made prior to 1968 to reduce alcohol-crash losses, the U.S. Department of Transportation noted that although a wide variety of approaches had been tried, rarely had scientific techniques been applied either to the development of control efforts or to the measurement of their effectiveness (U.S. Department of Transportation 1968). In a more recent article, Voas (1975b) observed that safety programs in general have suffered from a "knee-jerk" approach to the development of countermeasures and have resulted in hastily implemented, unplanned efforts not likely to produce an impact.

A more systematic approach to the problem would incorporate the following elements:

- Target Identification,
- Program Design and Operation, and
- Program Evaluation.

As depicted in the model in Figure 5-1, the results of past programs should provide a basis for identifying a specific target for control action in a particular location and for designing and operating a new program tailored to that target. The results of the new program should then be evaluated against its objectives (stated in terms of desired effects on the target). Findings of this evaluation should be used to improve the ongoing

Figure 5-1. Elements of an alcohol-safety program




program, and should be used in the development and evaluation of other new programs. In the subsections which follow, the three elements are described in more detail.

### *5.1.1 Identification of Targets for Control Action*

The clear identification of that which is to be controlled is perhaps the most fundamental element of a carefully designed control effort. In the most general sense, it is a reduction in crash "losses" that is sought, but much more specific statements are required for operational usage. If by "losses," one means fatalities, it must be stated, for example, whether such losses are to be reduced by preventing some number of alcohol-related crashes from occurring or by decreasing the number of fatalities after the crashes have occurred (e.g., through use of passive restraints or through deployment of emergency medical services). It is also necessary to state at the outset whether the control measures are to be directed primarily at the vehicle (e.g., designing devices to warn other drivers and pedestrians of a drunk driver), at the highway environment (e.g., designing signs more likely to be comprehended by intoxicated drivers), or at the driver (e.g., convincing him not to drive after drinking). Further detailed definition of the target of the control action must follow, e.g., specification of the type of drinkers whose driving behavior is to be modified.

Figure 5-2 shows graphically how broad categories of targets for control actions against a given type of alcohol-related crash loss may be generated. Each of the three-dimensional cells represents a potential target of a program to reduce alcohol-related crash losses. For example, a program could attempt to reduce the frequency of fatal crashes due to *human* impairment by reducing excessive drinking among *social drinkers* in the

*pre-crash* phase. More sharply defined targets could be identified by describing the target components in more detail: for example, the *amount* of impairment to be reduced (stated perhaps in terms of reductions in BACs) among *male* social drinkers by *eliminating their desire to drink excessively* in the pre-crash phase. The target-generating scheme depicted in Figure 5-2 is an expansion of an approach first suggested by Haddon and Brenner in the 1960s (Haddon 1968).

### *5.1.2 Design and Development of Alcohol-Safety Programs*

A second major element of a rational approach to the alcohol-crash problem is the design and development of the program through which control is to be accomplished. Ideally, the methods used in such a program should be matched to the target so that the chances of a satisfactory outcome are maximized. For example, if alcohol-related crashes are to be reduced by controlling the frequency of heavy drinking by problem drinkers, then the means for doing this should be appropriate for problem drinkers, who are different in many respects from social drinkers.

Past alcohol-safety programs may most generally be classified according to whether they were directed at drivers as a whole, at drinkers, or at drinking-drivers. Examples of programs aimed at drinkers include prohibition and various state and local measures to restrict alcohol use among sub-populations of drinkers (e.g., laws establishing the minimum age at which one may purchase liquor). Programs aimed at treating alcohol "addiction" or at educating the general public on the symptoms of alcoholism are further examples of control activities directed at a more broadly defined group of drinkers, who may or may not be drinking drivers.

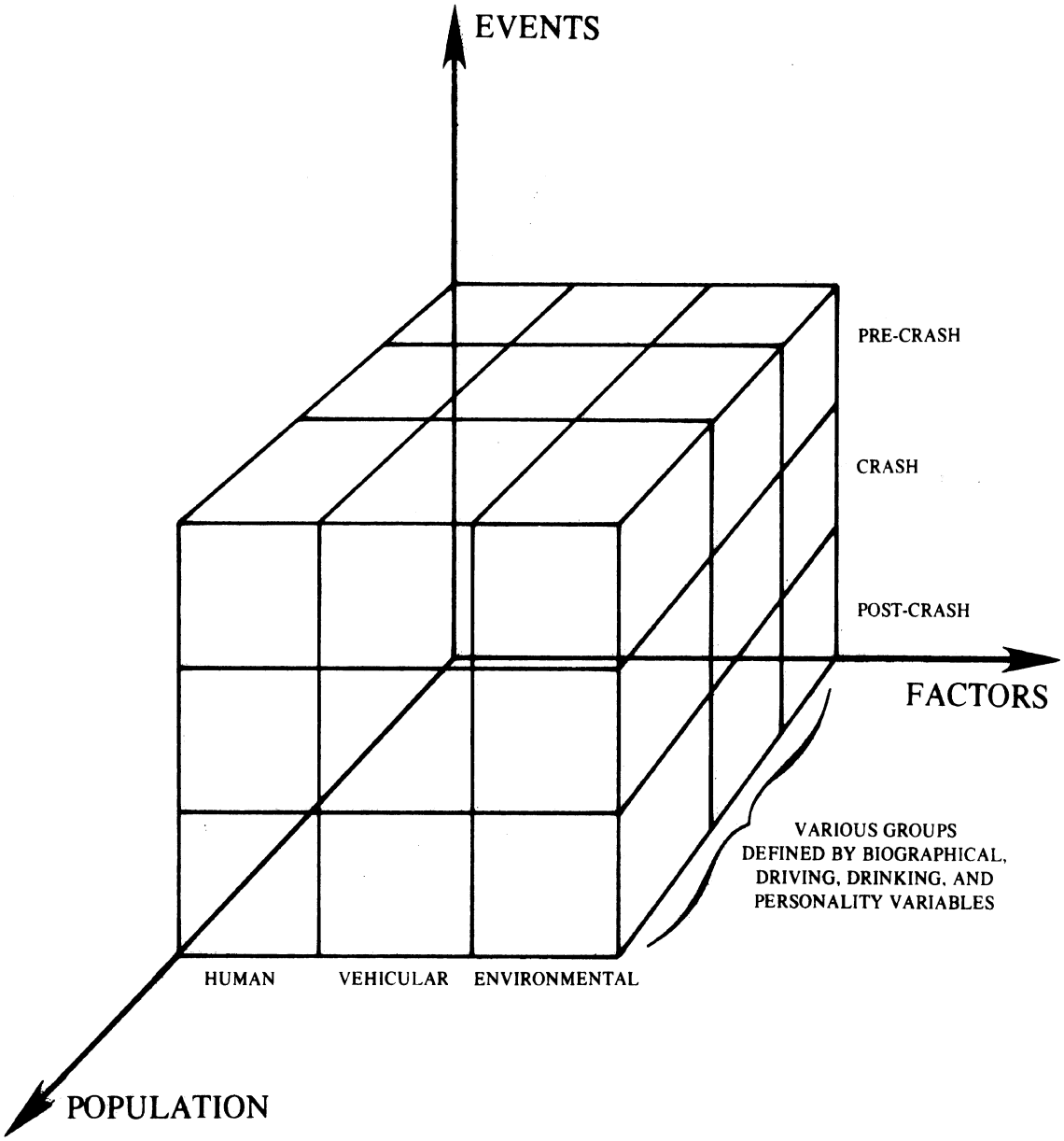
Examples of programs aimed specifically at drinking drivers are campaigns to enforce DWI laws and public education programs on the greater crash risk faced by drinking drivers.

The present report is concerned with this latter class of programs, i.e., those which specifically address drinking drivers. For purposes of discussion and analysis of past programs, the following five categories of such programs are defined:

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

*Legal* approaches to controlling crash losses due to drinking-driving are based on a set of official rules (laws) which specify and prohibit drinking-driving behaviors believed to present unacceptably high risks to society. Failure by the driver to comply with such rules results in punishments (e.g., fines, jail sentences) which are believed to act as a deterrent to the prohibited behavior. This deterrence is accomplished, according to the theory, either through the effect of the punishment in preventing the punished parties from engaging further in drinking-driving (called *special deterrence* in the literature) or by preventing most or all members of a given group from engaging in drinking-driving even if they are not caught and punished (called *general deterrence*) (Zimring and Hawkins 1973).

Figure 5-2. Components of targets of alcohol-safety programs



*Health* approaches are aimed at the underlying drinking problems that often exist among individuals who drive with high BACs. (Filkins et al. 1970; Waller 1968). Various treatments and therapies are applied to such individuals in an effort to induce more moderate drinking habits or to eliminate drinking entirely (e.g., Alcoholics Anonymous). Rehabilitation programs (e.g., DWI schools) for all types of drinking drivers are also included in this category.

*Public Information and Education* (PI&E) approaches attempt to reduce the incidence of drinking-driving by campaigns informing and educating various population groups about the nature of the problem. Such programs address drinking drivers directly by attempting to get them to refrain from the practice in the future or indirectly by attempting to enlist the support of other persons in actions against drinking-driving. A TV commercial designed to motivate persons to drive an intoxicated individual home from a party is an example of the indirect approach.

PI&E approaches are most commonly used in combination with other approaches (e.g., legal), both to inform the public about the control actions that will be undertaken and to create a climate of public support for the alcohol-safety program.

*Technological* approaches apply modern technology to interdicting the sequence of events leading to drinking-driving. A wide range of technologies has been suggested for such applications, from pharmaceuticals designed to speed up the sobering process to devices for measuring a driver's BAC.

Most past and proposed programs for dealing with the drinking driver employ two or more of the above four approaches simultaneously. Few examples of "pure" approaches are documented in the literature on alcohol and highway safety. Programs which methodically employ several approaches have been called *systems approaches* in the literature (Voas 1975b). As with "pure approaches," few examples of full-scale systems approaches have been documented.

### *5.1.3 Evaluation of Alcohol-Safety Programs*

Determining how well the control action has worked is the third major element in a carefully designed program for dealing with the adverse effects of drinking-driving. This step is essential for designing better control programs in the future, both by identifying actions that have worked so that they may be more widely applied, and by identifying actions that have not worked so that they may be either improved or discarded. Recommended techniques for evaluating highway safety programs (including alcohol-safety programs) are described in a recent NHTSA manual (Vilardo et al. 1975). Current practices in the evaluation of alcohol-crash programs are discussed in later subsections of the present report.

It will be seen that the evaluation of alcohol-safety programs has been difficult because such programs usually have not produced an easily discernible effect. The measurement of such small effects and the provision of sufficient evidence to conclude that the effects were due to the program and not to some other factor, requires the use of sophisticated research designs and statistical techniques. For a variety of technical and practical reasons, such designs and techniques have seldom been applied with the rigor and care necessary to provide a clear picture of a program's effect. As a result, it is

sometimes concluded that an effect did not occur, when, in fact, the evaluation procedures were not sufficiently well-designed to detect the effect. Considerable care is necessary to avoid this logical pitfall when studying the findings of evaluations on alcohol-safety programs.

### *5.1.4 Summary*

The elements of a systematic approach to dealing with the alcohol-crash problem are *target identification, program design and development,* and *program evaluation.* Proper target identification involves the detailed specification of the *population, events,* and *factors* to be addressed through the contemplated control actions. Past programs directed at the drinking-driving population may be classified as *legal, health, public information and education, technological, or systems* approaches. Programs must be *evaluated* in order to estimate their impact on the problem in light of the resources expended, and in order to provide information for future applications.

In the following discussion, applications of the above five approaches are described. Specific programs have been chosen to illustrate the salient features of the approach they represent. Each approach is discussed with respect to targets, actions directed at the targets, and evaluation, as applicable.

## 5.2 THE LEGAL APPROACH

### *5.2.1 Concept and Theories of Deterrence*

As noted above, the concept of deterrence is the basis for the legal approach to controlling the drinking driver. The premise of deterrence is simply that a behavior can be prevented by the threat of punishment. It is significant that while deterrence is one of the most fundamental and important hypotheses underlying criminal law and criminal law systems, it has not been the subject of scientific investigation until relatively recent times. Thus, one cannot say with any confidence exactly how deterrence operates to accomplish its objectives. One scholar has observed that "theories of punishment are moral *claims* as to what justifies the practice of punishment—claims as to why, morally, it *should* or *may* be used" (Hart 1957).

The most consistently stated theory of deterrence is that persons contemplating a prohibited activity will refrain from acting if the expected pleasure derived from the activity is less than the expected unpleasantness resulting from some threatened punishment (Andenaes 1952). It has also been suggested that punishment may deter more subtly by helping to educate the public about societally proscribed behavior. The result of such education is the development of inhibitions against the designated behavior (Andenaes 1952; Andenaes 1966). Deterrence may help to provide needed reinforcement for normally law-abiding individuals who may momentarily be tempted to engage in unlawful activity (Zimring and Hawkins 1973).

It has also been observed that the threat of punishment may have an opposite effect to that intended. An individual who has been denied a freedom will sometimes experience reactance in the form of an increased desire to engage in the forbidden behavior

(Brehm 1966), and individuals who have a pathological preference for punishment obviously will be encouraged rather than deterred by the threat of punishment.

Studies indicate that four factors are of primary importance to the deterrence process:

- characteristics of the target population,
- nature of the behavior to be prevented,
- target population's knowledge of the presence of the deterrent threat, and
- credibility of the deterrent threat to the target population.

With respect to *target population*, it has been suggested that both persons who are not inclined to be concerned about the future and impulsive persons may be poor subjects for deterrent programs (Zimring and Hawkins 1973). Individual differences have been found with respect to assessment of risk of apprehension (Joscelyn and Jones 1972) and willingness to take risks (Raiffa 1968), indicating that persons will be differentially affected by deterrents. Differences in attitude and social status may also affect individual response to punishment threats (Zimring and Hawkins 1973). Highly socialized individuals may be expected to respond to a given threat in a different manner from the so-called "anti-authoritarian" personality who rejects authority in any form. Persons of relatively "high" status may be better targets for deterrent measures than persons of "low" status, because the former group may have more to lose by a punishment and may have more loyalty to the society that contributed to their success.

The *nature of the behavior to be prevented* is believed by most researchers to be an important factor affecting public response to an intended deterrent. One writer observed that "simple common sense indicates that a threat of punishment does not play the same role in offenses as different as murder, rape, tax-evasion, shoplifting, or illegal parking" (Andenaes 1966). Another writer speculates that "the effectiveness of deterrence varies in inverse proportion to the moral seriousness of the crime," indicating that, in some cases, other social control forces may exert a greater "deterring" influence than the threat of punishment (Morris 1951). The motivations behind a given offense are also important: for example, alcohol addiction is a powerful motivating force which may be far stronger than any societally acceptable punishment.

Obviously, the *target population's knowledge of the presence of the deterrent threat* is required in any program of deterrence. This requires that both the fact that the behavior is prohibited and the fact that the behavior may be punished, be communicated to the public. There is also a need to advise the public that behavior such as drinking-driving is dangerous to those who engage in it.

The final major factor affecting public response to deterrent programs is the *credibility of the deterrent threat to the target population*. It is generally agreed that no deterrent threat will be effective unless those persons who might engage in the prohibited behavior believe that the threat is applicable to them personally and that the threat can be enforced. This means that a law really will be enforced and that no one will be immune, and it means that it *can* be enforced. Further, the threat offered must be of a type that would cause the potential violator sufficient unpleasantness to outweigh the positive effects of the prohibited behavior. For example, loss of social status might cause more unpleasantness for certain individuals than dollars lost through a fine or even the loss of freedom suffered in serving a short jail sentence.

In discussing general deterrent threats to drinking-driving, Voas states the above principles on credibility in terms of two major factors: the probability of apprehension and processing through the judicial system so that a penalty is imposed, and the severity of that penalty (Voas 1975b). He asserts that probability of apprehension is related to:

- number of arrests in relation to number of licensed drivers,
- number of convictions in relation to number of arrests, and
- level of public information provided.

He emphasizes the significance of public information for general deterrence, which is directed towards people who have not yet been punished for violations and must learn about the deterrent threat indirectly (Voas 1975b).

The formal means for creating the deterrent threats employed in the legal approach to controlling drinking-driving is the system of institutions that generate and enforce laws. Joscelyn and Jones (1972) have described this Traffic Law System (TLS) as a social control system which functions to maintain drinking-driving risk (as well as other highway transportation risks) at some societally-tolerable level. In doing this, the TLS performs four basic functions: law generation, enforcement, adjudication and sanctioning.

The *law generation* function provides a set of laws and regulations governing drinking-driving behavior. Ideally, such laws should be clearly related to risk and should prescribe the necessary action to reduce that risk. Specifically, they should explicitly describe the levels of alcohol impairment that are intolerable in drivers and the means to be used by the TLS in dealing with such impaired drivers.

The *enforcement* function attempts to reduce the frequency of illegal drinking-driving either through the mere presence of policemen on the highway or through actual detection and apprehension of illegally impaired drivers.

The *adjudication* function determines the guilt or innocence of an individual charged with a violation of a drinking-driving law. The *sanctioning* function creates the ultimate deterrent threat of the TLS by imposing punishment on the guilty parties. Such punishments are intended to prevent future drunk-driving by the violator and by drivers as a whole.

It is interesting that, although public perception of a threat of punishment is a basic precept of deterrence and of the legal approach, no single component exists within the TLS, nation-wide, for informing the public about that threat. Traditionally, the system has relied on the news media, word of mouth, and various informal means for communicating to the public the existence of a deterrent threat. One research study has recommended that a new, top-level function be established at the national level to collect information from and to disseminate information to both the general public and members of the TLS (Joscelyn and Jones 1971). NHTSA has performed this function for jurisdictions that have been involved in its Alcohol Safety Action Project.

### *5.2.2 Targets of the Legal Approach*

In most documented applications of the legal approach, targets have not been sharply defined. By definition, such applications have addressed human factors in the pre-crash phase but generally have not specified which human factors were being emphasized in which portions of the pre-crash sequence of events. In a review, presented in the 1968

Report on Alcohol and Highway Safety (U.S. Department of Transportation 1968), of approaches which had been used to control alcohol-crash problems, it was concluded that the lack of specific definitions of population groups had led to "the use of 'shotgun' approaches directed toward the entire population that drinks . . . " The same report observed that the law had not yet distinguished one type of drinker from another and had not developed measures to deal with drinking drivers differentially. The report went on to note that by 1968 the scientific findings on the characteristics of drinking drivers were beginning to be emphasized in the legal literature and quoted the following statement made at an international conference in 1962: "since . . . no one type of drinker is exclusively responsible for alcohol-involved motor accidents, it is likely that no one type of approach would work equally well with all of those involved" (U.S. Department of Transportation 1968).

The U.S. Department of Transportation's Alcohol Safety Action Project (ASAP) appears to be the first large-scale program in the United States to recognize the basic differences among drinking drivers and to develop control measures specifically designed for different population groups (Voas 1975b). It accepted the findings of research on deterrence that neither the threat of punishment nor the actual suffering of punishment is likely to have much effect on drinking drivers who have lost control of their drinking. It reasoned that strictly legal approaches should be directed only at social drinkers whose motivations are more amenable to control by legal threats (Voas 1975b).

At almost the same time ASAP was being initiated, TLS officials in Chicago had concluded, on the basis of a local survey, that the social drinker was actually responsible for most alcohol-related crashes. A program designed to deter social drinkers by the threat of "stern" enforcement was implemented but was discontinued after seven months of operation.

Foreign programs employing the legal approach have generally made no deliberate attempt to deal differentially with various categories of drinking drivers, even in recent years. For example, legal approaches in Europe, Australia, and Canada have been targeted at all types of alcohol-impaired drivers, who were defined most typically (though not always) in terms of BAC (Birrell 1975; Carr, Goldberg, and Farbar 1975; Ross 1973; Ross 1975).

### *5.2.3 Applications of the Legal Approach*

As stated above, the formal mechanism for applying the legal approach is the Traffic Law System (TLS) which generates and enforces applicable laws and then applies legal sanctions against those individuals it has found guilty of violating the laws. The nature of TLS activities relevant to controlling alcohol-crash losses is discussed below. Activities of agencies that have been involved in various aspects of *public information* related specifically to deterrence are also discussed.

*5.2.3.1 Law Generation.* In the United States, laws about drinking-driving are generated by state governments but may be supplemented or duplicated by local governments (Joscelyn and Jones 1971). In general, the laws attempt to proscribe risk behavior, usually in terms of what constitutes intoxication by alcohol, and to define what punishment (nearly always license suspension or revocation, fines, or imprisonment) may be

or must be imposed against guilty parties. Laws also define the rules for enforcing, adjudicating, and imposing sanctions.

At first, intoxication was described only in qualitative terms, but in 1939, Indiana enacted legislation making chemical tests admissible as evidence for prosecuting persons accused of driving while intoxicated (DWI). The law specified .15% w/v as the BAC at which a driver is presumed to be "under the influence" of alcohol, but this was reduced to .10% w/v in 1971. In 1962, the *Uniform Vehicle Code* recommended .10% w/v as the BAC at which a driver is presumed to be intoxicated (Reese et al. 1974). Today, all states define impairment in terms of BAC measured by a chemical test. In 48 states, the Virgin Islands, and American Samoa, a driver with a BAC of .10% w/v or higher is considered to be impaired. In Idaho and Utah the maximum permissable level is .08% w/v (U.S. Department of Transportation 1974d). Some states have established more than one class of drinking-driving offenses. Usually, one class defines impairment at .10% w/v or .15% w/v BAC, and the other classes use lower values of BAC. Penalties for violation of the offense defined by the higher BAC are more severe than the lower-BAC penalties.

A distinction is made in the laws as to whether the attainment of a specified BAC limit is "presumptive" or "per se" evidence that the accused was actually impaired at the prohibited BAC. The specification of a BAC limit as presumptive allows the accused to submit evidence that he was, in fact, not impaired at the proscribed limit; or a prosecutor may produce evidence to show that a driver was, in fact, impaired at a BAC of less than that stated in the law. In states that have per se laws, driving with a BAC exceeding a given value is in itself illegal. At present, 10 states have per se laws, and nine of these states specify .10% w/v as the legal limit. One state (Oregon) requires a BAC of at least .15% w/v as conclusive evidence of impairment (U.S. Department of Transportation 1975a, ch. 1).

As noted, punishments specified in laws on drinking-driving commonly include fines, license suspensions, and license forfeitures. Typically, the laws provide for fines of up to $500, imprisonment for up to a year, and license suspensions of up to a year (Joscelyn and Jones 1971). The suspensions are usually mandatory (Reese et al. 1974). Several states also require mandatory jail sentences for a first-offense conviction for DWI, and more than half of the states have mandatory jail sentences for a second offense. In four states, the law allows vehicles to be impounded after conviction for DWI, and seven states provide for license plate suspensions for DWI.

Numerous statutory provisions deal with the operation of the TLS in implementing the legal approach. For example, the manner in which chemical tests may be administered is prescribed by law. In 10 states, only breath tests are authorized; the other states authorize various combinations of breath, blood, urine, and saliva tests (U.S. Department of Transportation 1975a, ch. 1).

The principle of implied consent was introduced in New York in 1953 to induce people to submit to chemical tests. It states that when a person drives he implicitly consents to submit to a chemical test if asked to do so after being arrested for DWI. The principle was incorporated into the *Uniform Vehicle Code* in 1962 and has now been adopted by all states. Twelve states authorize a law enforcement office to administer a preliminary breath test (PBT) prior to an actual arrest, provided the officer has reason

to suspect that the driver is impaired by alcohol (U.S. Department of Transportation 1975a, ch. 1).

Several states have attempted to expedite the processing of accused drinking drivers by passing legislation authorizing arrests to be made without a warrant, even if the police officer is not present when the offense is committed. Some states require mandatory blood tests of drivers and adult pedestrians killed in crashes (U.S. Department of Transportation, 1975a, ch. 1).

Foreign countries have tended to set lower BAC limits for impairment and to specify more severe punishments for DWI than the U.S. For example, Canada's Breathalyzer legislation enacted in 1969 defined .08% w/v as the legal limit for BAC and authorized fines of up to $1,000 and imprisonment for periods of up to six months (Carr, Goldberg, and Farbar 1975).

The British Road Safety Act of 1967 also limited BAC to .08% w/v and prescribed a mandatory punishment of a one-year license suspension and a fine of £100, or imprisonment for up to four months, or both (Ross 1973). The British Road Safety Act of 1967 also authorized a preliminary breath test when an officer had "reasonable cause" to suspect that a driver had alcohol in his body or had committed a traffic violation, or in the event of a crash. Refusal to take the test is penalized by a fine of £50. After such refusal, an arrest can still be made, after which the accused driver is given a second opportunity to take a test at a police station. Refusal to take the second test or a blood or urine test, is punishable as though the sample had been given and the test failed (Ross 1973; Department of the Environment 1976).

All Australian states have enacted per se laws with a BAC limit of no more than .08% w/v (Birrell 1975). The state of Victoria has had a limit of .05% w/v since 1969. Norway, Sweden, and Denmark all have BAC limits of .05% w/v and relatively strong punishments for violators. Likewise, the Netherlands has a BAC limit of .05% w/v, and its courts may impose a fine, imprisonment (up to three months), or license suspension (up to five years) for driving under the influence of alcohol (Van Ooijen 1977). Finland does not specify impairment in terms of BAC but provides stiff penalties, including a permanent revokation of license after a second offense (Ross 1975).

*5.2.3.2 Enforcement.* Enforcement practices in the United States, *circa* 1970, were reviewed by Joscelyn and Jones in a NHTSA-sponsored study (Joscelyn and Jones 1971). Major steps described included:

- Detection,
- Apprehension,
- Initial observation,
- Decision making on further processing,
- Booking,
- Administering a BAC test,
- Processing refusals to submit to a BAC test, and
- Releasing the accused violator to await trial.

The most common mode of detection was said to be officer observation of such manifestations of DWI behavior as "chronically high or low rates of speed, erratic

weaving, 'jack rabbit' starts, 'screeching' stops, and dramatic over-corrections of driving errors." Apprehension of the suspected DWI (usually by pull-over) then followed. DWI arrests related to crashes were found to be uncommon because of the difficulty in determining whether an intoxicated participant was a driver or merely a passenger. DWI arrests as a result of citizen complaint were said to be less likely because of the necessity to have a motivated witness sign a complaint and have a warrant issued.

It was common practice for the officer to make initial observations to help him decide if he should arrest the suspected DWI. "Field tests" involving the driver's picking up a coin, walking a straight line, etc., were commonly employed for this purpose. A recent study (Burns and Moskowitz 1977) found that, when properly given, field tests can be highly accurate in correctly classifying individuals as at or above .10% w/v BAC. In some cases preliminary breath tests were used, but only with the driver's permission.

What followed was the most critical decision in the enforcement process. The officer had to decide whether to:

- arrest the driver for DWI,
- arrest the driver for some lesser offense, or
- release the driver.

Important factors influencing this decision were said to include:

- the lengthy amount of time required to "process" the suspect (often several hours),
- perceptions that the suspect would not be convicted or that the penalty would be too "soft,"
- a tendency for the officer to identify with a suspect who is not believed to be really dangerous, and
- responsibility to remove a potential threat from the road.

The net result was that often the suspect was either not charged or was charged for some lesser offense. In one jurisdiction with a population of 500,000 the arrest rate for DWI was found to be less than 100 per year (Joscelyn and Jones 1971).

Following arrest for DWI, the suspect had to be transferred to police headquarters for booking and then taken to a facility to have a BAC test administered. Typically, considerable paper work was involved, including the signing of a release for damage incurred in administering the test or the processing of a refusal to submit to the test, etc. After posting bond and sobering up, the suspect was then released to await trial (Joscelyn and Jones 1971).

Several detailed studies of the DWI enforcement process have appeared since 1970. The most comprehensive of these was conducted in late 1974 by Planning and Human Systems, Inc. (PHS) in order to obtain in-depth background information on enforcement activities in 22 jurisdictions participating in the ASAP effort (Planning and Human Systems, Inc. 1976). The study is significant because it attempts to describe actual practices rather than stated policies and is therefore directly comparable to the 1970 study.

With respect to *detection and apprehension* of alcohol-impaired drivers, the PHS study found practices to be essentially the same as those described earlier by Joscelyn

and Jones. A few sites augmented their visual observations of erratic driving behavior with mechanical devices, including audio-recording, video-recording, radar, and helicopters. One site was said to use stationary surveillance of drinking establishments to detect drinking drivers. The PHS study found that eleven of the 22 sites were using preliminary breath testing devices to assist in *decision-making* about whether to arrest the suspect for DWI (Planning and Human Systems, Inc. 1976).

Two other recent studies have investigated factors influencing a police officer's decision to arrest a suspect for DWI. The first study, reported by Arthur Young and Co. in 1974 (Young & Co. 1974b), involved a survey of attitudes of police officers and supervisors at 16 ASAP sites. It found that an officer's personal beliefs about the nature and extent of the alcohol-crash problem affects his arrest decision, as does his tendency to identify with the suspect; but certain operational factors, including lengthy and time-consuming processing procedures have the most effect. Departmental factors found to be important included those affecting an officer's morale. The study found that the attitude and practices of other agencies (e.g., Courts, prosecutor's offices) and of the community could strongly influence an officer's decision to arrest.

The second study of the arrest decision was reported by Oates, also in 1974 (Oates 1974). It was concerned with the more general population of jurisdictions which were not a part of ASAP. Eleven sites were deliberately chosen to represent a broad range of jurisdictions. Police patrolmen, police supervisors, judicial personnel, and other officials were interviewed in order to ascertain their attitudes. The general findings were in agreement with the previous study of ASAP sites. Factors found to contribute to the decision to arrest included youth and relative inexperience of officer, his knowledge of alcohol and its effect on driving performance, his lack of a tendency to identify with a suspect, his perception that sanctions are not overly severe, his own accident involvement, high police morale and clear departmental policy on drunk-driving enforcement, and simple procedures for processing a suspect. The study found that persons from minority groups, young drivers, and female drivers tended to be arrested less frequently than others when suspected of DWI (Oates 1974).

The PHS study of ASAP enforcement procedures found post-arrest practices to be similar to those reported in 1970. A major difference at some sites was an apparent decrease in post-arrest processing time largely effected by making BAC testing more convenient, accomplished by increasing the use of breath testing devices located at the law enforcement agency (Planning and Human Systems, Inc. 1976).

Studies of DWI enforcement prior to ASAP indicate relatively low levels of activity except for sporadic "crackdowns." Data from 73 jurisdictions compiled by Fennessey et al. (1968) indicate that a typical full-time enforcement officer made only 1.83 arrests per year for "alcohol impairment." The arrest rates varied widely among these jurisdictions, from a low of .02 per year to a high of 11.58 per year. Low levels of enforcement have also been observed in other jurisdictions (Joscelyn and Jones 1971; Newman, Dihrberg, and Rivo 1971; U.S. Department of Transportation 1975a, ch. 2). Borkenstein estimated that on the order of 2000 DWI violations occur for every arrest (Borkenstein 1975), a DWI violation being defined as a trip made while at a BAC of .10% w/v or more.

The effect of ASAP has been to increase DWI arrests overall by a factor of two to

three for participating sites (U.S. Department of Transportation 1975a, ch. 2). Enormous increases occurred in several jurisdictions. For example, Fairfax County, Virginia, which had only 75 arrests in 1971, increased its arrests to 3,777 in 1973. Oklahoma City had *no* arrests for DWI in 1971 and 4,887 in 1973. Arrest rates increased from a range of 0–1.5% per licensed driver before ASAP to a range of .5–3.5% during ASAP (U.S. Department of Transportation 1975a, ch. 2), but a study of one ASAP site estimated that the probability of being arrested with a BAC of at least .10% w/v was still only about .005 (Beitel, Sharp, and Glauz 1975).

Data on foreign enforcement practices and levels of activity are scarce and would, in any case, be difficult to interpret in view of the different drinking-driving problems they address. The relative level of enforcement in Great Britain and Sweden is indicated by the following quote from a 1973 study, conducted by Ross, of the British Road Safety Act of 1967:

> The number of tests per month (in Great Britain) went from the neighborhood of 3,000 in 1967 to around 7,000 or 8,000 by early 1971. In all of 1970, approximately 70,000 breath tests were given in Britain. This contrasts with 48,000 given in Sweden, with a population less than one-sixth as large, or the 93,000 given in Los Angeles County, with a population of 7 million (Ross 1973, p. 41).

Arrests in Great Britain, after the introduction of the 1967 Act, doubled and then tripled before returning to the original level, even though there were no significant changes in resources allocated to enforcement (Ross 1973).

*5.2.3.3 Adjudication and Sanctioning.* Adjudication and sanctioning are functions of the legal approach which are performed by the so-called "lower" courts in the United States. The process involved is basically the same as for other serious traffic violations and requires at least one court appearance. In some jurisdictions, the accused violator is first arraigned (i.e., formally charged, advised of his rights and possible punishment, etc.) and then enters his plea to the charge. If the plea is "guilty," the court imposes a penalty and disposes of the case. A plea of "not guilty" requires a trial (either with or without a jury, depending on the jurisdiction) following rules and procedures prescribed for criminal trials. A verdict of guilty may be appealed leading either to a review by an appellate judge or to a new trial (Joscelyn and Jones 1971). More detailed descriptions of the adjudication and sanctioning process applicable to drinking-driving and crashes are provided in several recent studies sponsored by NHTSA (Joscelyn and Jones 1971; Institute for Research in Public Safety 1972a; Jones et al. 1976).

An important intermediate function must occur before the formal adjudication and sanctioning process can begin. The prosecution must decide if the suspect should be charged with DWI, charged with some other offense, or released. So called "plea bargaining" may be engaged in at this point in order to obtain the suspect's agreement to take some action against his drinking-driving problem in exchange for reducing or dropping the charge (Joscelyn and Jones 1971).

The legal approach and its underlying principle of deterrence require that the adjudication and sanctioning process result in the conviction of arrested drunk drivers and the

imposition of prescribed punishments. Three major decision points affecting the accomplishment of this requirement are apparent from the preceding discussion:

- the decision to charge a suspected drunk driver with DWI when strong evidence exists that such a violation did occur,
- the decision to render a guilty decision against an individual who is guilty by legal standards, and
- the decision to select and apply a prescribed punishment against the guilty party.

Documented analyses of factors influencing these decisions have been less formal than those referenced in the preceding section on enforcement. Factors said to inhibit a prosecutor from charging a suspect include a belief that conviction and punishment will not result because of a "lenient" court, a belief that punishment will be too harsh, a lack of understanding of the alcohol-crash problem, and a lack of sufficient resources to prepare and present cases (Joscelyn and Jones 1971; Voas 1975b; Institute for Research in Public Safety 1972a; Wagner 1976).

Similar factors have been found to have an adverse effect on the adjudication and sanctioning functions, and the effect of overly-severe punishments is claimed by some experts to be especially serious (Joscelyn and Jones 1971). Voas listed six specific examples of "nullification" of the adjudication/sanctioning process by severe penalties, which caused the courts to be more likely to accept plea bargaining, less likely to convict, and less likely to impose even a mandatory sanction (Voas 1975b). The Chicago crackdown on drunken driving, cited by Voas, is an especially illustrative example. The Chicago judges agreed to impose a 7-day jail sentence on all persons convicted of DWI, but after six months only 557 of 6,600 drivers arrested for DWI had actually received such a sentence.

The operation of the adjudication and sanctioning process in a purely legal mode has not been subject to much quantitative analysis. Joscelyn and Jones (1971) reported case studies in two jurisdictions that later became ASAP sites and found that nearly all of those arrested for DWI were prosecuted for DWI. Of those prosecuted, more than half were found guilty. Fines imposed were at the lower end of the range permitted by statute, and jail sentences averaged only about 1½ weeks per conviction. License suspensions averaged about 6 months in one jurisdiction and 10 months in the other. Data from a mail survey of 344 New York State enforcement agencies, conducted by Newman, Dihrberg, and Rivo (1971), indicate that 17.6% of persons arrested for DWI in 1968 were convicted for DWI after trial, that another 17.7% pleaded guilty to DWI or some lesser offense, and that 26.3% of the cases were still pending at the end of 1968. The New York data also indicate that some 27% of those arrested were never prosecuted for DWI, nor were they prosecuted for any lesser offense. The data collected in a nationwide mail survey conducted in 1970 by Joscelyn et al. indicated that in most of the responding jurisdictions, a fine was typically imposed for a DWI conviction and that jail sentences were relatively infrequent (Joscelyn, Maickel, and Goldenbaum 1971). License suspensions were used in 58% of the jurisdictions. License revocations were imposed in 43% of the jurisdictions.

Data reported by ASAP sites showed that about 54% of persons arrested for DWI were actually convicted of DWI. However, in some sites, many individuals were pur-

posely "diverted" from the legal system in the pre-trial phase to participate in treatment and rehabilitation programs, and this undoubtedly resulted in a lower conviction rate than could have been obtained under a purely legal approach. Some sites which did not engage in pre-trial diversion reported much higher conviction rates; for example, Denver, Vermont, and Oklahoma City had conviction rates of 66%, 81%, and 69%, respectively (U.S. Department of Transportation 1975a, ch. 4).

There is evidence that the legal approach in many foreign countries has resulted in surer and more severe punishments for individuals arrested for DWI than it has in the U.S. In 1968, 70% of all persons convicted for DWI in the Netherlands received prison sentences (Farmer 1973). In Sweden, 40% of prison sentences are for DWI (Farmer 1973). In the three years following the implementation of the British Road Safety Act of 1967, conviction rates averaged more than 90%, compared to 80% before the Act (Herrick 1973).

*5.2.3.4 Public Information.* The British Road Safety Act of 1967 (Sheppard 1968) is a prime example of the use of a public information campaign to support a legal approach. The Act went into effect on October 9, 1967. A large-scale publicity program on the new legislation was launched on September 25, 1967 and ended December 31, 1967. The objectives of this campaign were to inform the public of:

- the BAC limit which would be considered evidence per se of intoxication,
- the procedures which would be followed by law enforcement officers in apprehending, arresting, and testing the motorist suspected of impaired driving,
- the penalties associated with conviction under the new law, and
- the dangers to individuals and to communities of driving while impaired by alcohol.

The function fulfilled by this type of information campaign has been interpreted as increasing the probability of apprehension perceived by the public (Ross 1973; Wilde 1975). It is theorized that the legislation of interest is more likely effectively to deter proscribed behavior when the perception of apprehension is positively reinforced by increased enforcement of the law.

The perception of apprehension was apparently increased by the Act (see section 5.4.6), and a significant decrease in "casualties" per 100 million vehicle units was noted (Ross 1973). However, three years after the Act was implemented, the rates began to approach their former levels. Ross (1973) attributes this decay in program effectiveness to a realization by the public that the actual probability of apprehension was much lower than was at first perceived, resulting in an erosion of the deterrent effect.

A more recent analysis of the Act (Department of the Environment 1976) found indications that the effects of the Act may have been more lasting among drivers in the 40–60 age group and that they wore off most rapidly among those in the under-30 age group. The analysis noted that the efforts of the PI&E campaign had continued to diminish and that, as a result, younger persons who were just reaching driving age had not been exposed to it.

Breathalyzer legislation was enacted in Canada and became effective in December 1969. Enforcement of this law in Canada was followed by an increase of 50% in the

number of drivers tested for BAC. The introduction of the new law was accompanied by a widespread information campaign; and during the first year in which the new legislation was effective, there was also emphasis placed by federal safety agencies on motor vehicle safety standards. No significant decrease in fatal crashes was attributed to the legislation.

The enactment of Breathalyzer legislation in Canada has been compared with the enactment of similar legislation in Great Britain. The British Road Safety Act of 1967 was followed by a more dramatic and lasting decrease in drunk driving than the Canadian legislation, even though enforcement in Great Britain was not significantly increased. Important differences between the two cases are:

- Canadian police officers must have evidence of impairment before requesting a breath test; in Great Britain, the only prerequisite is evidence of drinking, moving violation, or accident involvement;
- roadside screening tests cannot be required in Canada; they can be required in Great Britain;
- the Canadian public had greater familiarity with breath testing than residents of Great Britain; thus, the Canadian legislation had less "shock value" (Carr, Goldberg, and Farbar 1975).

In a study of the effects of a public information campaign conducted by the Vermont ASAP (Worden, Waller, and Riley 1975), the evaluation design included comparisons among the effects of an educational campaign used alone, an educational campaign conducted in conjunction with increased enforcement of drinking-driving laws, and a control condition in which there was no educational campaign and no increase in enforcement. The findings of this study were that the educational campaign was most effective when combined with increased enforcement and that the educational campaign when used alone had a more positive effect than no educational campaign.

These findings support the interpretations (Planning and Human Systems 1976; Wilde 1975) cited above that perceived probability of apprehension and actual probability of apprehension are directly related. Public information campaigns thus appear essential in accomplishing a general deterrent effect through a legal approach. NHTSA has recognized the importance of public awareness of the threat of apprehension and has initiated a new program of research in this area.

### *5.2.4 Evaluation of the Legal Approach*

The literature provides few examples of alcohol-safety programs which have incorporated an evaluation component into their overall design. Most evaluations have occurred after programs were completed and have been performed by researchers who did not participate in the program. Buikhuisen and his associates at Groningen University in the Netherlands, among the first to engage in these *post hoc* evaluations of the legal approach, found that neither severe punishments nor withdrawing drivers' licenses had any apparent effect on reducing future violations (Buikhuisen 1969; Buikhuisen 1972b). The Dutch researchers found that more than 36% of a group of DWIs were reconvicted for DWI within 10 years, despite the relatively strong sanctions that were applied (Buikhuisen 1969).

Ross has performed analyses of crash rates in the Scandinavian countries during the period of time when their increasingly severe drinking-driving legislation was being developed. Various points in the development of these laws were the subject of pre- and post-examination. No changes of significance were revealed for different types of crashes or for different types of sanctions for any of the four countries (Ross 1975).

More recently, some of the Scandinavian data was subjected to economic analysis, and it was concluded that Scandinavians had been responsive to increased law enforcement activity (Votey 1976). The study found that "legal sanctions" strongly reinforced an individual's tendency not to drive after drinking and that the Scandinavian data suggested that both law enforcement and control of alcoholic beverage sales influence the level of crashes.

In one of the better known *post hoc* evaluations, Ross analyzed the effect of the British Road Safety Act of 1967 (Ross 1973). He used the technique of the interrupted time series analysis, a method by which trends in accident rates can be examined over large stretches of time both before and after enactment of the legislation. Ross determined that the 1967 law was effective for a period of three years in decreasing the rate of accident casualties. Evidence was also found that the public engaged in less drinking and driving. A pre- and post-survey of adults found that more people said they walked to drinking sites and fewer admitted to drinking and driving. In addition, among traffic fatalities, there was a smaller percentage who had illegally high BACs.

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

There are indications that the program of drinking-driver control accompanying the 1974 Dutch legislation limiting BAC to .05% w/v may have had an effect similar to the British Road Safety Act. A preliminary analysis by Noordzij (1977) found a sharp decline in the percentage of drunk drivers (i.e., BAC $\geq$ .05% w/v) using the road immediately following the introduction of the legislation, followed by a rise in drunk driving one year later.

In contrast to the British Road Safety Act, the Breathalyzer legislation in Canada appeared to have little effect, even in the short term (Carr, Goldberg and Farbar 1975). The average BAC of breath-tested drivers did not change significantly after the law became effective. During 1970, there was a decrease of 6.3% in the total number of fatal crashes, using the year 1969 as a comparison. However, in the U.S., fatal crashes declined 2.1%, though comparable legislation was not enacted.

In the U.S., the so called "Chicago crackdown" in 1971 was evaluated *a posteriori* by Robertson et al. (Robertson, Rich, and Ross 1973), using the interrupted time series technique. They found that there was no statistically significant change in Chicago's accident rate resulting from the program. This finding held true for fatalities, DWI arrests, and DWI convictions (except for those drivers who were not tested for BAC). (There was not an implied consent law in Illinois during the program.) The change in Chicago's accident rates was seen by these researchers as part of a long-term trend.

When Chicago's long-term trend was compared with nearby Milwaukee's, no significant differences were found. Milwaukee has a police-court system and climate which are similar to Chicago's.

NHTSA's ASAP program was designed from the outset to be evaluated. It sought to assess the impact of both the overall program and its individual "countermeasures" on a variety of ultimate and intermediate program objectives. However, because ASAP employed a systems approach, simultaneously applying elements of the legal, health, public information and education, and technological approaches, it is impossible to say exactly which element, if any, was responsible for what part of the results. The best available indication of a positive effect of the legal component could appear to be a negative correlation between DWI arrest rate and crash rate. No such effect has been found by the NHTSA evaluators of ASAP. Their evaluation of 1974 operations stated:

> No simple relationship of enforcement and crashes has been established in the ASAP project. In several instances, fourfold and fivefold increases in arrest have not been able to have an impact on the crash level" (U.S. Department of Transportation 1975a, ch. 2, p. 23).

The NHTSA evaluators speculated that a possible explanation for this disappointing result was that the target population had not perceived the increased enforcement threat or that this threat was still not high enough.

In an analysis of earlier ASAP enforcement data, Zylman grouped the data in a manner which suggested that nighttime fatal crashes actually *increased* with increasing enforcement intensity (Zylman 1975). The statistical significance of this relationship was not discussed in Zylman's analysis, and he concurred with the official (i.e., NHTSA) evaluation report's statement that "there is no evidence of a relationship between alcohol-related arrest activity and the change in level in nighttime crashes" (U.S. Department of Transportation 1974c).

NHTSA is currently evaluating the effects of increased DWI enforcement in one local jurisdiction (Hause et al. 1977). The study is employing control groups in an attempt to measure the impact of enforcement activity on several drinking-driving variables (including drinking-related crashes). The results of the study should be helpful in understanding how one component of the legal approach (i.e., enforcement) affects the frequency of alcohol-related crashes. More research is needed to describe the effects of other TLS components (e.g., sanctions) on the alcohol-crash problem.

Thus, evaluations indicate that most past applications of the legal approach have not been effective in promoting either general or special deterrence of drinking drivers. The one program with a clear positive impact on the alcohol-crash problem, the British Road Safety Act of 1967, relied on a strong public information component to create a public perception of great risk of apprehension. In this case, perceived risk probably exceeded actual risk by a substantial amount. Actual risks of apprehension do not appear to have been sufficient in past programs to have posed much of a deterrent threat. Research suggests that a driver in the U.S. would have to commit some 200 to 2000 DWI violations to be caught. After apprehension, he would still stand only a 50–50 chance of suffering no more than a relatively mild punishment. Such a threat is apparently acceptable even to most social drinkers, who are able to control their drinking.

## 5.3 THE HEALTH APPROACH

In recent years it has become more and more popular in the United States to regard problem drinking (including alcoholism) as a health problem rather than a crime. In 1967, the President's Commission on Law Enforcement and Administration of Justice estimated that from 40 to 49 percent of all non-traffic arrests in the U.S. were for alcohol-related offenses (President's Commission on Law Enforcement and Administration of Justice 1967). The commission recommended that "drunkenness should not in itself be a criminal offense" and that drunkenness be taken out of the Criminal Justice System by establishing detoxification units as part of comprehensive treatment programs and by coordinating and extending after care resources. The recommendations were no doubt influenced by two landmark court decisions, Easter v. District of Columbia (1966) and Driver v. Hinnant (1966), holding that alcoholics could not be convicted for drunkenness.

The impact of these two decisions was moderated shortly thereafter (in 1968) when the Supreme Court held in Powell v. Texas (1968) that chronic alcoholics *could* be punished by the criminal justice system if convicted for criminal conduct which is not a characteristic and involuntary part of the disease of alcoholism. Nevertheless, advocates of the health approach continued to press for treatment of alcoholism rather than punishment, as evidenced by the Uniform Alcoholism and Intoxication Act promulgated in 1971 by the National Conference of Commissioners on Uniform State Laws (1973). The policy of the act was that "alcoholics and intoxicated persons may not be subject to criminal prosecution solely because of their consumption of alcoholic beverages but rather should be afforded a continuum of treatment in order that they may lead normal lives as productive members of society." The provisions of the act were first adopted in the state of Washington in 1972, and other states have since adopted parts of it. The federal Comprehensive Alcohol Abuse and Alcoholism Prevention, Treatment, and Rehabilitation Act Amendments of 1974 authorized $13 million in federal support to those states that enacted the Uniform Alcoholism and Treatment Act (Chafetz 1975).

Paralleling the movement to treat rather than punish drunkenness, some highway safety specialists were recommending a health approach for dealing with the drinking driver. At a conference in 1969, Filkins of the University of Michigan described the major functional elements of such an approach as case-finding, diagnosis, prescription, treatment, follow-up, and evaluation (Filkins 1969). He recommended that the legal system and the health system better coordinate their efforts in performing these functions. Filkins also recommended that the legal system act "as the primary case-finders for the immediate future, and (it) should continue to play a prominent role in these functions" of a "combined health-legal approach." Joscelyn and Jones (1971) further developed the concept of a combined approach in their 1970 study which envisaged a Drinking-Driver Control System consisting of agencies of the Traffic Law System and an even more informal Alcoholism Control System which attempted to treat and rehabilitate drunken drivers. Studies of the past operation of this conceptual Drinking-Driver Control System in various jurisdictions revealed a general lack of coordination among the various agencies involved and a lack of motivation to apply available resources and methods (Joscelyn and Jones 1971; Joscelyn and Jones 1972). Over half of

jurisdictions responding to a nationwide mail survey said they attempted in some fashion to refer problem drinking drivers to treatment (Joscelyn, Maickel, and Goldenbaum 1971). NHTSA's ASAP program followed and has placed heavy emphasis on dealing with the problem drinking driver through a coordinated, systematic, health/legal approach (U.S. Department of Transportation 1974a).

Actual implementation of the health/legal approach has not been without its problems. Some scholars have even questioned whether it is proper for the legal system to participate in non-legal modes of rehabilitation. For example, Lewis (1953) presents the argument that such involvement does not support the cause of justice, which is properly concerned only with whether a punishment is deserved and not with whether it will deter or cure. Rubin (1968) argued that treatment is not necessarily humane and may be an invasion of human rights. Practitioners have experienced great difficulty in applying the approach because of conflicts in the objectives and roles of the legal and health institutions involved (Aiken and Weiner 1974).

The literature offers little evidence of large-scale applications of other case-finding techniques for bringing drinking drivers into treatment and rehabilitation programs. Filkins has provided an extensive list of possible non-legal system techniques for identification of problem drinkers by hospitals, alcoholism treatment facilities, health care professionals, social service agencies, employers and unions, insurance underwriters, etc. (Filkins 1969), but there is no record of any program which has employed these techniques to any large extent. Thus, for all practical purposes, health approaches to controlling drinking drivers have really been combined health/legal approaches.

### *5.3.1. Targets of the Health Approach*

By its very nature, the health approach is directed at controlling the precrash behavior of drivers. The population group dealt with is predetermined by its most common mode of entry into treatment and rehabilitation programs and is, therefore, composed of persons arrested for and, for the most part, convicted of driving while intoxicated or some similar offense. As such, nearly all members of the group will have been legally drunk (BAC $\geq$ .10% w/v) at the time of their arrest, and some 50 to 75 percent of them have been classified as problem drinkers in several studies (see Section 4.0). The remaining 25 to 50 percent will be either heavy social drinkers or (a few) moderate or light social drinkers who rarely consume such large amounts of alcohol.

Further a priori breakdown of target populations in order to provide treatments more suitable to specific needs does not seem to have occurred as a part of any deliberate plan in most jurisdictions. The 1970 survey of court procedures for handling problem drinkers found some jurisdictions using fairly sophisticated procedures to ascertain whether a DWI needed treatment. As a result of these procedures, an equally wide range of treatments was being "prescribed" (Joscelyn, Maickel, and Goldenbaum 1971). This suggests at least some implicit attempt to deal differentially with subgroups of the DWI population. Similarly, several of the Alcohol Safety Action Projects (ASAPs) which used the protocol developed by HSRI for identifying problem drinkers regularly classified individuals beyond the usual problem-drinker/social-drinker dichotomy in order to permit more specific referrals (U.S. Department of Transportation 1975a, ch. 4). Even the prototype DWI course developed by Arizona State University

and applied in Phoenix, Arizona, over 10 years ago was used selectively by magistrates, but it is not clear exactly what criteria were followed in assigning persons to the course (Stewart and Malfetti 1970).

One application of the health approach addressed a very special group consisting of airmen stationed at Lackland Air Force Base in Texas (Barmack and Payne 1961a). When found to have been involved in a crash, the airmen were required to undergo review by their squadron commanders and by a psychiatrist for possible further action, which included psychotherapy and discharge. In Holland, some DWIs were sentenced to a special prison where information on traffic safety and an opportunity for treatment were offered (Buikhuisen and Steenhuis 1971).

In summary, most applications of the health approach to the general public in the United States have explicitly addressed two major target populations: heavy drinkers (including alcoholics, problem drinkers, and heavy social drinkers) and light to moderate social drinkers. Implicit target groups identified retrospectively have been defined to correspond with the most appropriate treatments available.

### *5.3.2 Applications of the Health Approach*

As noted above, many of the functions of the health approach to drinking-driver control in this country have often been performed and influenced by the Traffic Law System (TLS), resulting in what Filkins (1969) has appropriately described as a "combined health/legal approach." Formal analyses of various operational configurations of the "systems" involved in this approach were performed in the early 1970s by other researchers (Joscelyn and Jones 1971; Joscelyn, Maickel, and Goldenbaum 1971) and have continued periodically under the ASAP program (U.S. Department of Transportation 1975a; Struckman-Johnson 1976; Ellingstad 1976). These analyses suggest that in its most general form, the mode of operation of this Drinking-Driver Control System can be depicted as in Figure 5-3. The diagram shows that in addition to its usual functions of law generation, enforcement, adjudication, and sanctioning, the TLS takes on the public health functions of casefinding, diagnosis, and referral. The final health functions of treatment and rehabilitation are performed by another, less well-oganized societal system termed, in one study (Joscelyn and Jones 1971), the Alcoholism Control System. The nature of the functions, processes, and interfaces of various forms of this conceptual Drinking-Driver Control System are described in the following sections.

*5.3.2.1 Health-Legal Functions of the Traffic Law System.* The initial health function of the TLS is that of *case-finding*, identifying individuals among the general population who pose an unacceptably high risk of causing an alcohol-related crash. As in the case of the pure legal approach, TLS legislative and enforcement components have been the primary performers of the case-finding function by proscribing risky behavior in terms of laws and regulations and then arresting violators of the laws. In general, the content of these laws and the manner in which they have been enforced have not been such as to differentiate drivers according to whether they are subsequently to be dealt with through a legal approach or a health approach. For all practical purposes, problem drinker-drivers and social drinker-drivers are treated alike with respect to case-finding (see Sections 5.2.3.1 and 5.2.3.2).

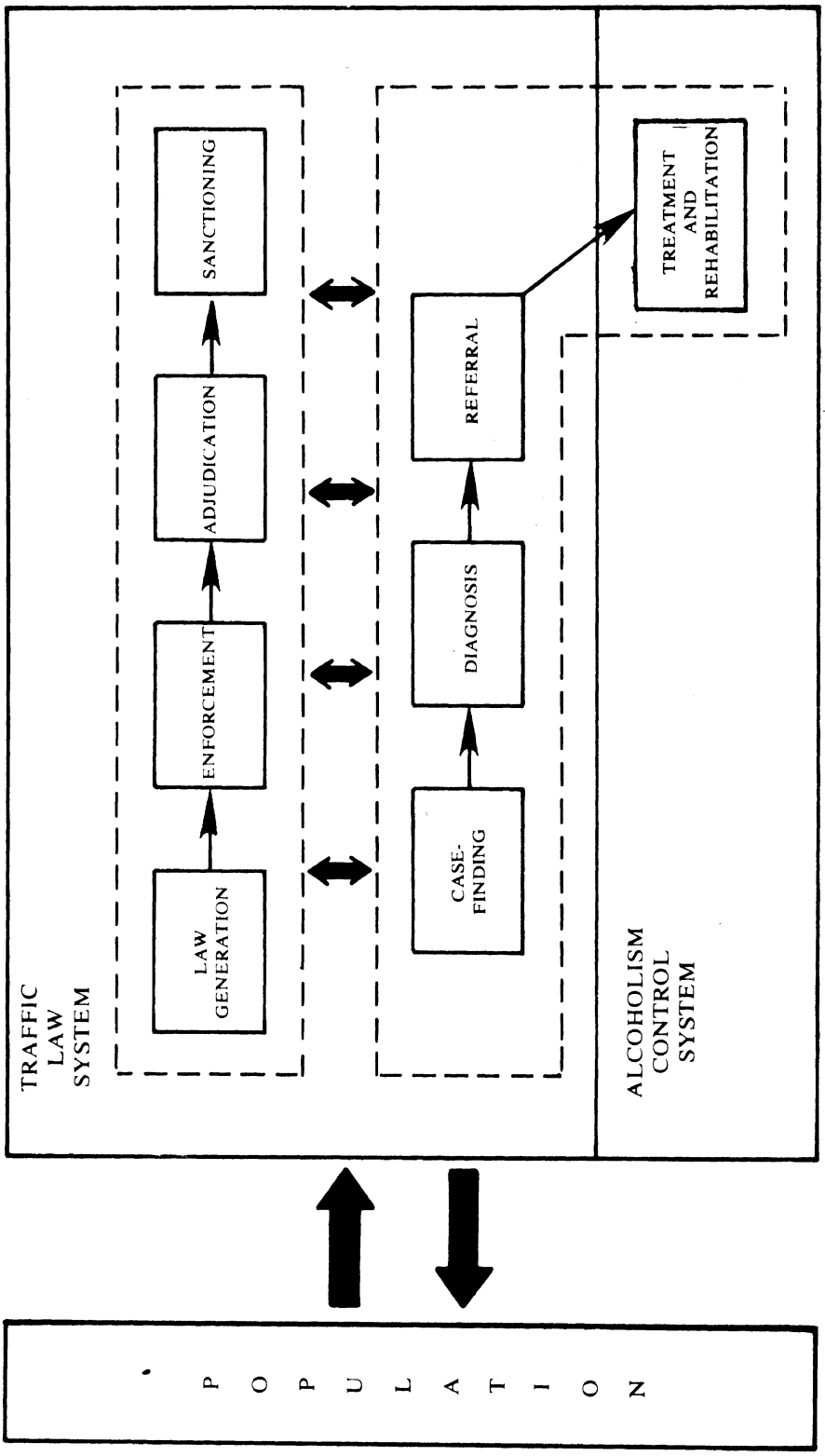



Figure 5-3 The drinking driver control system

The *diagnosis* and *referral* functions are concerned with determining the nature of the problem that brought the individual into the Drinking-Driving Control System, and with specifying how the problem is to be treated (Joscelyn and Jones 1971; Joscelyn, Maickel, and Goldenbaum, 1971; U.S. Department of Transportation 1975a). The functions are performed by the adjudication and sanctioning components of the Traffic Law System within the constraints provided by the body of law. The formal mechanism used by the TLS is the probation system through which an individual is offered treatment in exchange for a less severe and/or a suspended sanction. Little (1970) has used the term "coercive volunteerism" to describe this judicial use of the probation power.

Referral to medical treatment by direct sentencing is not authorized in any state, but several states authorize civil commitment for chronic alcoholics (Reese et al. 1974). The approach has seldom been used in dealing with problem drinking-drivers (Joscelyn and Jones 1971; Joscelyn, Maickel, and Goldenbaum 1971). By contrast, referral to non-medical rehabilitation (i.e., DWI schools) has been authorized by statutes in several states (Reese et al. 1974).

An extremely wide variety of procedures and methods have been used in performing diagnosis and referral, especially since the start of ASAP. Some jurisdictions perform the two functions even before the adjudicative hearing has occurred. In these jurisdictions, the prosecutor plays a key role in the process, determining both the nature and the provider of the treatment. The prosecutor obtains the driver's agreement to undergo treatment and/or rehabilitation in exchange for a promise not to prosecute for the original DWI charge or, in some cases, *any* charge. When all charges are dropped, "pretrial diversion" is said to have occurred, and the prosecutor performs the traditional probationary function of the court.

In other jurisdictions, it is more common for diagnosis and referral to occur after the adjudicative hearing. Here, the normal procedure is for the judge to perform the two functions, usually before (but sometimes after) sentencing. In a relatively small percentage of jurisdictions, diagnosis and referral may occur during the treatment process itself, for example, while an individual is attending DWI school.

Table 5-1 illustrates the diversity of the diagnosis process among the sites which participated in ASAP. It is apparent that several of the sites used hybrid approaches or employed different approaches depending on the circumstances. The presentence approach (either alone or in combination with other approaches) was by far the most common, occurring in 29 out of 35 ASAPs.

A critical support function to diagnosis and referral is the provision of information for decision making. The formal means by which such information is provided is misleadingly called a *presentence investigation* (PSI) because it was originally used in felony cases just prior to sentencing (Reese et al. 1974). Reese et al. (1974) observed the close linkage between PSIs and the Federal Probation Law of 1925 which led to statutory recognition of PSIs in the Federal Rules of Criminal Procedure in 1946.

The kinds of information included in a PSI for use in drinking-driving violations vary widely, from driver records to a broad range of social, psychological, medical, and economic background information (U.S. Department of Transportation 1975a, ch. 4). The comprehensiveness of some PSI reports (not necessarily for DWI) has, in fact, led the American Bar Association to warn of unwarranted invasions of privacy that might

TABLE 5-1

*Stages at Which Background Investigation-Diagnosis Occurred at ASAP Sites*

| *Project* | *Pretrial* | *Presentence* | *Postsentence* | *In treatment* |
|---|---|---|---|---|
| Albuquerque | X | | | |
| Charlotte | X | X | | |
| Denver | | X | | |
| Wisconsin | | X | | |
| Nassau County, N.Y. | | | | X |
| Portland-Eugene | | X | | |
| Seattle | | X | | |
| Vermont | | | | X |
| Washtenaw County, Mich. | | X | | |
| Baltimore | X | X | X | |
| Boston | | X | | |
| Cincinnati | | X | | |
| Columbus, Ga. | X | X | | X |
| Fairfax County, Va. | X | | | |
| Hennepin County, Minn. | | | X | |
| Indianapolis | | X | | |
| Kansas City | X | X | X | |
| Lincoln | | X | | |
| Tampa | | X | | |
| New Hampshire | X | X | | |
| New Orleans | | X | | |
| Oklahoma City | | X | | |
| Phoenix | X | X | | |
| Portland, Me. | X | X | X | |
| Pulaski County, Ark. | X | X | X | |
| Richland County, S.C. | X | X | | |
| San Antonio | | X | | |
| South Dakota | | X | | |
| Wichita | X | X | | |
| Delaware | | X | | |
| Idaho | | X | | |
| Los Angeles County | | X | X | |
| Puerto Rico | | | X | |
| Salt Lake City | | X | | |
| Sioux City | | X | | |

Source: U.S. Department of Transportation 1975a, ch. 3, p. 7.

result from delving too deeply into a person's background (American Bar Association 1958).

The survey of court procedures conducted in 1970 by Joscelyn et al. (1971) provides a rough idea of the level of detail of PSI information prior to ASAP. The survey found that approximately one-half of the 1778 jurisdictions polled said they used testimony from the DWI and arrest records to ascertain whether a convicted DWI needed treatment for a drinking problem. Some 30% stated they used information collected in court-conducted interviews with the driver and/or contacts with friends, relatives, and employer. Twenty percent said they reviewed the violator's drinking patterns. Fewer than 10% consulted social case histories, conducted medical examinations, performed psychological diagnoses, or were assisted by social workers. Nearly one-third of the respondents said they used no formal procedures. Site visits to eleven jurisdictions believed to favor the health approach to the drinking-driving problem revealed "formal" PSIs to be the rule, but such PSIs typically involved only an interview with a probation officer. At four sites the judge performed the PSI in a five- to ten-minute interview. Eight sites occasionally used some sort of psychiatric interview or psychological test as a tool.

Sources of information for diagnosis and referral at ASAP sites were listed in NHTSA's evaluation of 1974 operations as:

- a check of the offender's driving and criminal records for arrests and convictions involving alcohol, including BAC at the time of arrest,
- a check for previous contacts with local health or social service agencies,
- a personal interview of the offender by the presentence investigator,
- an interview with the offender's family, friends, and employer,
- a written diagnostic test of problem drinking, and
- an in-depth medical or psychological evaluation by physicians, psychologists, psychiatrists, or psychiatric social workers (U.S. Department of Transportation 1975a, ch. 5).

The number of sites using each source of information or the specific data items included in the various sources was not stated. However, the evaluation report did present data which suggested that in 1973 all PSIs included record checks, that more than one-half involved personal interviews, and that about one-third included in-depth examination. The major uses of the PSI information in ASAP were to determine whether an individual was a "problem drinker" or a "social drinker" (U.S. Department of Transportation 1975a, ch. 4) and to aid in referral.

Early in the ASAP program, NHTSA sponsored the development of a detailed protocol for identifying problem drinking among drivers who have been arrested for DWI. The Highway Safety Research Institute of the University of Michigan was the contractor and devised a two part questionnaire and accompanying procedure (Kerlan et al. 1971) that was widely used in the ASAPs. The first part of the questionnaire is self-administered while the second part is conducted by an interviewer. Both together require about an hour to administer. Studies of the HSRI protocol (often called the Mortimer-Filkins test after its two principal authors) have shown it to be one of the most accurate discriminators of problem drinking drivers yet devised (Jacobson 1976).

Less explicit guidance exists for making referrals of individuals diagnosed as problem drinkers, although some of the factors influencing the selection of providers of care are mentioned in the HSRI protocol (Kerlan et al. 1971). It seems likely that the subjective judgments of the involved Traffic Law System personnel have most often been the basis for making referrals. Whatever the basis, in 1972 and 1973, nearly 80,000 individuals entered treatment and rehabilitation in the ASAP projects (U.S. Department of Transportation 1975a, ch. 5). This amounted to about a third of all persons arrested for DWI and more than 80% of persons undergoing PSIs in those two years.

*5.3.2.2 The Alcoholism Control System.* A full discussion of the operation of the conceptual "Alcoholism Control System" which performs the *treatment and rehabilitation* functions is beyond the scope of the present report, but a short summary description is essential to understanding the health approach.

Various classifications of treatment and rehabilitation agencies have appeared in the literature. Joscelyn and Jones (1971) analyzed the treatment function in terms of the different stages of treatments that were typically provided to problem drinkers and then described the facilities involved in each stage. Four stages of treatment were defined as follows:

- *Emergency treatment:* The provision of intensive medical care for patients suffering from acute consequences of excessive alcohol intake and the alcohol withdrawal syndrome (delirium tremens, hallucinations, etc.). Treatment usually requires hospitalization for two or three days, the use of tranquilizers, and control of fluid and electrolyte balance.
- *Detoxification Care:* The provision of less intensive medical care to sober up the intoxicated patient over a one- to four-day period until the disappearance of such symptoms as hangover and the shakes. Treatment involves nursing care, tranquilizers, and an improved diet. Psychological, pyschiatric, or therapeutic treatment may begin in this stage, which should result in referrals for subsequent treatment.
- *In-Patient Treatment:* A wide range of treatment and rehabilitation techniques in a variety of settings. Emphasis is on long-term treatment such as psychiatric help and vocational training. Its main elements are:

  1. *Intensive medical care:* hospital treatment.
  2. *Convalescent care:* provision of a nursing environment.
  3. *Intensive psychotherapy:* for serious surface symptoms of underlying psychoses.
  4. *Individual psychotherapy:* short-term situation counseling or longer behavior-modifying therapy administered by a psychiatrist, psychologist, psychiatric social worker, or counselor.
  5. *Group psychotherapy:* long-term therapy in which small groups of patients share experiences and problems.
  6. *Milieu therapy:* involvement of the patient in the daily life of the institution as a member of a "therapeutic community."
  7. *Drug therapy:* long-term use of drugs to control the symptoms of withdrawal and anxiety or to reduce the desire for alcohol. Drugs such as

Antabuse are sometimes used for the latter purpose, causing severe (but temporary) physical distress for persons who drink after taking the drug.

8. *Alcoholics Anonymous:* use of mutual self-help, among peers, in maintaining sobriety; "treatment" provided in small group settings; no medical or psychiatric treatment provided; is not considered a substitute for professional counseling or treatment; many members rely on a spiritual approach (U.S. Department of Health, Education and Welfare 1971).
9. *Didactic presentations:* lectures, films, and other educational programs on alcohol.
10. *Rehabilitative services:* education, manual arts, exercise, industrial and occupational training, vocational rehabilitation, and job placement.

- *Out-Patient Treatment and Aftercare:* Serves patients who have not received treatment as in-patients, and also serves former in-patients who need more help in returning to the general community. Therapy is provided in the form of counseling, casework, and individual or group psychotherapy. Supportive residential care is provided in half-way houses, where patients may gradually adjust to independent life.

The study identified eight major types of agencies offering the above treatments: general hospitals, mental hospitals, detoxification centers, alcoholism treatment centers, mental health centers, alcoholism clinics, private treatment facilities, and half-way houses. The involvement of the various treatment agencies in the four stages of treatment were summarized in the manner shown in Table 5-2.

TABLE 5-2

*Facilities Providing Various Types of Treatment for Problem Drinkers*

| *Treatment Facility* | *ACS Function* | | | |
|---|---|---|---|---|
| | *Emergency Treatment* | *Detoxification* | *In-Patient Treatment* | *Out-Patient & After Care* |
| General Hospital | X | X | X | |
| Detoxification Center | X | X | | |
| Alcoholism Treatment Center | | | X | |
| Mental Hospital | X | | X | X |
| Mental Health Center | X | | X | X |
| Alcoholism Clinic | | | X | X |
| Private Treatment Facility | X | X | X | X |
| Halfway House | | | | X |

Source: Joscelyn, Maickel, and Goldenbaum 1971

A later review of treatment modalities for problem drinking-drivers (Joscelyn, Maickel, and Goldenbaum 1971) provided more detailed descriptions of treatments in use *circa* 1970, recategorizing the treatment techniques into psychotherapy, indirect pharmacotherapy, direct pharmacotherapy, and combination therapy. A more recent review by the Department of Health, Education, and Welfare discusses later developments in treating problem drinkers in general, including various group therapies (e.g., transactional analysis) and motivational theories (U.S. Department of Health, Education and Welfare 1974). The DHEW report recommends a "social-system" approach, a community-oriented program that should "take into account the differences among the patients, as well as the interactions of the several components in the society, and systematically seek to fit the appropriate treatment to each individual."

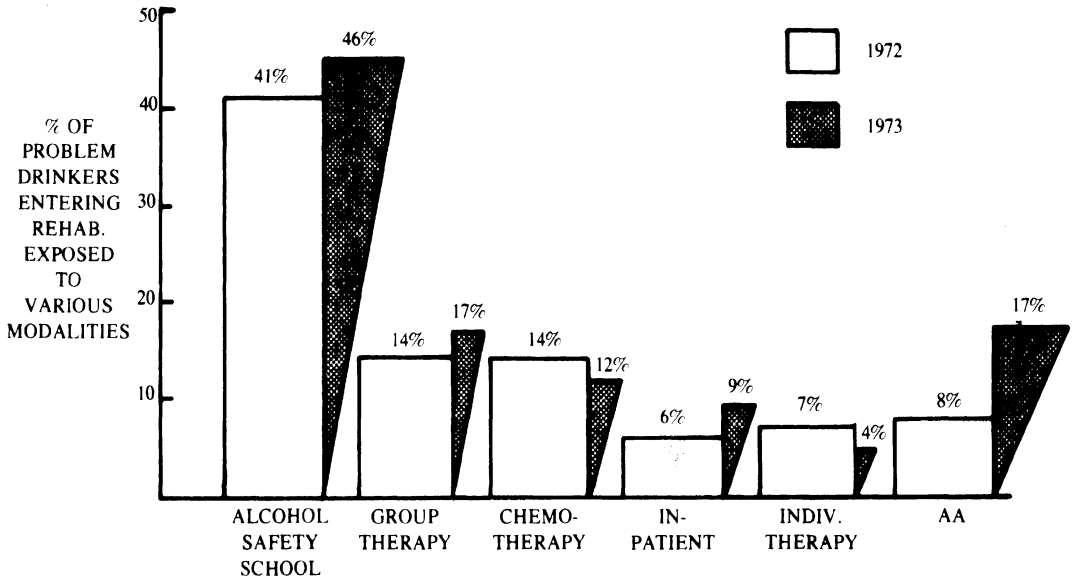
Examples of treatment and rehabilitation programs aimed specifically at problem drinking-drivers are rare in the literature. Most such programs follow an educational approach based on the archetypal Phoenix DWI course. Since its first formal session took place in 1966, the course has served as a prototype for over 400 programs in the U.S. and Canada (Malfetti 1975). Between 1966 and 1973, over 15,000 DWIs completed the course.

The course consisted of four sessions at weekly intervals, each session lasting about 2½ hours. The basic methods of instruction included informally structured discussion, films, reading materials, and oral and written exercises requiring self-analysis. Each session was conducted by an instructor and attended by probation officers and counselors with special training in alcoholism. A magistrate attended the first session only and described the relationship between the court system and the course. The counselors were present in order to assist with referrals to community agencies. Probation officers and counselors participated in discussions.

Session 1 focused on the drinking driver and establishing the fact that a problem exists. A homework assignment for participants was the recording of all activities in the 12 hours preceding arrest for DWI. Session 2 focused on the influence of alcohol on driving skills. The goal of Session 3 was to define problem drinking. Each participant assessed his own drinking habits. In Session 4 actions to modify behavior were emphasized. The outcome of this session was a description by each student of his plans to modify his behavior. Oral descriptions and discussion preceded an exercise requiring a written description (Stewart and Malfetti 1970).

Over 70% of the nearly 49,000 persons who entered rehabilitation programs at 26 ASAP sites in 1973 attended DWI schools (U.S. Department of Transportation 1975a, ch. 5). Twenty-seven percent of the drivers were classified as problem drinkers (primarily by Mortimer-Filkens tests or variants of the test) and 45% as social drinkers. The problem drinkers were referred to DWI schools less frequently and to other modes of treatment more frequently than other categories of drinkers. Forty-six percent of problem drinkers entered DWI schools and 59% entered one or more other treatment modes. The most popular nonschool treatment modes for problem drinkers were short term group therapy and Alcoholics Anonymous (17% each). (See Figure 5-4). Long-term treatments (Including Alcoholics Anonymous) were provided by the available community treatment agencies (i.e., the Alcoholism Control System component of the Drinking-Driving Control System). The National Institute on Alcohol Abuse and Alcoholism

Figure 5-4. Use of basic treatment modalities for ASAP problem drinkers in 1973




Source: U.S. Department of Transportation 1975a, ch. 5, p. 7

(NIAAA) of the U.S. Department of Health, Education, and Welfare, collaborated with ASAP by providing support to Alcoholism Centers (ACs) designed to extend and improve longer-term treatment of problem drinkers at ten ASAP sites (Eagleston, Rittenhouse, and Towle 1974). The ACs were oriented toward outpatient care, and most of them had all modalities available, i.e., individual counseling and therapy; group counseling and therapy; family counseling and therapy; family services; vocational rehabilitation; social, occupational, and recreational therapy; and medical maintenance. It was estimated that approximately 37% of all persons convicted of DWI at the ten sites during the period May, 1973, through March, 1974, were treated at the ACs (Eagleston, Rittenhouse, and Towle 1974).

### *5.3.3 Evaluation of the Health Approach*

Few programs are known to have attempted any kind of formal evaluation of the health approach to drinking-driver control. The first known program to be evaluated occurred at Lackland Air Force Base (Barmack and Payne 1961b). Drinking-driving was characterized as sick, disturbed behavior that could lead to psychiatric evaluation and possible referral for psychotherapy which might result in a recommendation for medical discharge. Following the implementation of this program, lost-time injury accidents declined by more than 50%. After comparing accident history at Lackland with that at another Air Force base in the area and with local, state, and national experience, the researchers concluded that the decline was more likely due to the "countermeasure" rather than to a general downward trend in accidents.

The only documented evaluation of a health approach program aimed at a more general population of drinking drivers occurred under the ASAP program and its 35 ASAP projects. This program attempted to estimate the effects of its individual health/legal activities on a wide range of variables thought to be meaningful measures of the program's results. Evaluations were conducted at both the project level (i.e., the individual ASAP sites) and the program level (i.e., the sum of all sites).

The diagnosis and referral functions of ASAP were evaluated with respect to their primary objective of classifying drinkers so that they would receive the most appropriate treatment (U.S. Department of Transportation 1975a, ch. 5; Struckman-Johnson 1976). The term "appropriate" was apparently used to describe the available treatment that would cause the greatest reduction in an individual's DWI violations and alcohol-related crashes in some future time period. Two criteria were used to determine whether diagnosis and referral were being properly performed. The first criterion, termed *reliability*, was concerned with the consistency of a diagnosis or a referral, that is, whether a given individual would always be classified and referred the same way. The second criterion, called *validity*, dealt with the correctness of a diagnosis, that is, whether a given individual was properly placed on the social-drinker/problem-drinker spectrum and, given that placement, referred to the most "appropriate" treatment.

Only six ASAP sites submitted data for analyzing the reliability of their *diagnostic* approaches, and three of those sites were classified by evaluators as having reliable systems (Struckman-Johnson 1976). (See Table 5-3.) Seven out of 14 sites were said to have valid diagnostic systems. The evaluators felt that no unequivocal statement could be made about the reliability or validity of diagnosis for ASAPs as a group. Three out of four reporting sites were said to have reliable *referral* systems, and two out of eight had valid referral systems. Again, no statement could be made about the reliability or validity of the referral process for ASAP as a whole. Further discussion of the validity of the ASAP diagnosis and referral process may be found in Struckman-Johnson and Mushill (1976).

TABLE 5-3

*Reliability and Validity of Diagnosis and Referral Functions at Reporting ASAP Sites*

| | *Reliability* | | *Validity* | |
|---|---|---|---|---|
| *Function* | *Number Reliable* | *Number Inconclusive or Unreliable* | *Number Valid* | *Number Inconclusive or Invalid* |
| Diagnosis | 3 | 3 | 7 | 7 |
| Referral | 3 | 1 | 6 | 2 |

Source: Struckman-Johnson 1976

The "bottom line" of the evaluation of ASAP health/legal applications is the determination of the impact of treatment and rehabilitation activities on the subsequent drinking-driving behavior of individuals exposed to the various modalities offered. The DWI schools were the most commonly used modality and have also received the most attention by ASAP evaluators. Seventeen project level evaluations of the school were summarized by Ellingstad in 1976 (Ellingstad 1976). The schools were evaluated with respect to their effectiveness in influencing accident involvement; re-arrest for DWI; and life changes, knowledge changes, and attitude changes relative to drinking and driving. Of the evaluations which utilized "adequate comparison groups and a statistical comparison," none showed any positive effects on accident involvement and only one showed a positive effect on re-arrest rate (see Table 5-4, However, six indicated positive effects in increasing knowledge about alcohol-safety, and four had a positive effect in changing attitudes. No relationship between knowledge or attitude changes and crashes was reported. No site was found to have induced "life changes" through its DWI school.

TABLE 5-4

*Reported Results of ASAP DWI School Effectiveness Analysis Which Utilized Adequate Comparison Groups and Statistical Comparisons*

| *Measure of Effectiveness* | *No. of Sites Reporting Positive Effect* | *No. of Sites Reporting No Evidence of Effect* |
|---|---|---|
| Accident Involvement | 0 | 2 |
| Re-arrest Rate | 1 | 5 |
| Life Changes | 0 | 1 |
| Knowledge Change | 6 | 0 |
| Attitude Change | 4 | 0 |

Source: Ellingstad 1976

A more recent analysis by Nichols (1977) formed substantially the same conclusions with respect to the effect of ASAP's DWI schools on knowledge, attitudes, re-arrest rate, and crash rate. Nichols also concluded that ASAP's treatment and rehabilitation program *as a whole* had been effective in reducing re-arrest rates of social drinkers referred to the program, but that it had not significantly reduced the re-arrest rates of problem drinkers. The latter finding suggests that the DWI school component of ASAP's treatment and rehabilitation program may have been responsible for the observed effect, since social drinkers were not, as a rule, referred to non-school treatment and rehabilitation modes.

A rigorous quantitative analysis of the highway safety impact of one ASAP DWI school (Nassau County, N.Y.) was conducted recently by Preusser, Ulmer, and Adams (1976). The analysis was unusual in that the drivers who attended the school were compared with another group of drivers who did not attend the school. Both groups were selected at random from individuals convicted of DWI or DWAI (Driving While

Ability Impaired-Alcohol). The study found no difference in subsequent DWI or DWAI conviction rates between the two groups and concluded that:

> . . . . . this program did not meet its objective of reducing the number of repeat convictions for alcohol-related driving events. Further, there is some evidence that those invited to attend the program actually experienced more reported motor vehicle accidents than the control group (p. 104).

In summarizing the results of ASAP DWI schools in dealing with the alcohol-crash problem, NHTSA concluded that the schools were causing increases in knowledge and positive attitude changes but that "there was not much convincing evidence to indicate that such schools were causing a decrease in arrest or crash involvement for clients exposed to them" (U.S. Department of Transportation 1975a, ch. 5). Research studies of the effects of the Phoenix DWI schools lead to similar conclusions (Crabb et al. 1971; Malfetti and Simon 1974).

Effectiveness-analyses of various other treatment-oriented modalities employed under ASAP were also assessed by Ellingstad in the 1976 study (Ellingstad 1976). The evaluations of the ASAP-supported short-term group therapy activities were found to offer "insufficient evidence to either support or challenge the efficacy of ASAP administered group therapy programs." With respect to out-patient treatment (non-ASAP sponsored) as a whole, one site out of three with adequate comparison groups reported a statistically significant decrease in repeat arrests for DWI, and the one site that analyzed the effect of out-patient treatment on accident involvement did not employ a control group or eliminate alternative explanations to support its claim of a positive effect. One of the studies showing re-arrest frequency to be unaffected by out-patient treatment used an experimental design employing a control group with random assignment.

In analyzing the effects of treatment through Alcoholics Anonymous, one site reported re-arrest frequency to be significantly lower after seven months of follow-up but found no significant decrease after 18 months. The same site (Los Angeles) also performed a rigorous analysis of its chemotherapy (i.e., Antabuse) treatment modality and found a statistically significant decrease in DWI re-arrest rate among the group treated (Ellingstad 1976).

NHTSA's conclusion on the effectiveness of ASAP rehabilitation across treatment modalities was that while some positive effect might exist, no firm evidence could be offered that rehabilitation was effective in reducing re-arrest and crash involvement (U.S. Department of Transportation 1975a, ch. 5). It also found that no conclusions could be made about the *relative* effectiveness of the various treatment modalities.

Eagleston et al. (Eagleston, Rittenhouse, and Towle 1974) of Stanford Research Institute (SRI) evaluated the ten ASAP Alcoholism Center (AC) projects sponsored by NIAAA. A number of variables were used to measure the effectiveness of the treatment program provided by the Centers. They included several indices and indicators used for making descriptive assessments of client changes; alcohol consumption; impairment in personal, social, and work-related activities; self-esteem; earnings; and re-arrest for DWI. The evaluations were based on comparisons of the following five groups of individuals:

- DWIs sentenced to probation only (including those receiving a sentence of jail or fine, and those receiving unconditional probation),
- DWIs assigned to DWI school only (although they may also have received a jail sentence or fine),
- DWIs assigned to non-AC treatment (i.e., to treatment at a non-AC facility or agency),
- DWIs assigned to AC treatment, and
- Non-ASAP referred persons contacting and/or entering ACs.

Unfortunately (and as noted in the SRI report) data collection problems plagued the evaluation effort, resulting in non-representative data from the ten sites. For example, the reported practices in assigning DWIs to various treatments are based on data from only two or three sites, and, in effect, the control group (the combination of groups 1 and 2 above) was non-existent except for the Tampa, Florida site. In addition much of the data gathered was apparently self-reported by the clients, and is, therefore, subject to the usual limitations of such data. Thus, the general applicability of the evaluation of the various out-patient treatment modalities sponsored by NIAAA is severely limited.

The evaluation nevertheless suggests that the ACs had a beneficial effect in reducing alcohol consumption and impairment. More than 92% of its clients reported drinking less than one ounce of alcohol per day six months after intake into the program. However, treatment seemed to have no positive effect in increasing self-esteem or earnings over time. The most effective treatment in reducing drinking seemed to be family counseling, followed by individual therapy, group therapy, group counseling, and medical maintenance in that order. Fragmented data and other constraints prevented any reliable analysis of the effectiveness of the ACs in reducing re-arrests for DWI (Eagleston, Rittenhouse, and Towle 1974).

Other evaluations of treatment and rehabilitation efforts have been mostly negative. Didenko et al. (Didenko, McEachern, and Berger 1972) compared the driving records of 1306 California DWIs who had received six different treatment modalities with the records of 442 DWIs who had received no treatment. No significant differences in either subsequent crashes or DWI convictions were found to exist between the two groups. Blumenthal and Ross's study (1975) of 495 convicted DWIs in Colorado found no significant differences in the number of subsequent drinking-driving violations or crashes among groups of drivers receiving different punishments and treatments.

## 5.4 PUBLIC INFORMATION AND EDUCATION APPROACHES

Public information and education (PI&E) approaches (called "campaigns" in the literature) have been used as separate and distinct "countermeasures" and in combination with other approaches. In the following subsections, several examples of PI&E programs are described in terms of their targets, their methods, and their findings. The discussion is preceded by a brief description of some of the theories upon which PI&E approaches are based.

### 5.4.1 Theoretical Bases of PI&E Campaigns

There are many theories in the alcohol-related PI&E literature, but they are difficult to assess because so few PI&E campaigns and their underlying theories have been rigorously evaluated. A Canadian review of PI&E literature, (Kates, Peat, Marwick & Co. 1970a) described three theories of behavioral modification in use in this field. The first theory states that information reception can lead to attitudinal change which, in turn, can lead to behavioral change. The second theory sees reception of new information as leading to behavioral change which, in turn, leads to attitudinal change. The third theory predicts that reception of new information about crashes is a vicarious experience for the recipient, which leads to a temporary attitudinal change. The temporary attitudinal change permits the recipient to engage in experimental behavior which tests directly the truth of the information received. If the information received is validated by this informal experiment, long-term attitudinal change may result which, in turn, will lead to long-term behavioral change.

Wilde et al. (1971), in a review of current theories and practices in road safety campaigns, stated that

> psychological research in other areas has shown that many behaviors are controlled by certain reinforcement schedules. Behaviors are difficult to influence if they are of long standing, are frequently displayed, and lead to many and immediate advantages for the individual, and when they are strongly interwoven with other habitual behaviors (p. 38).

Hyman and Sheatsley (1947) listed psychological characteristics which affect the impact of public information campaigns as follows:

- some people remain among the uninformed on all issues, forming a hard core which is relatively impossible to reach;
- degree of interest in an issue differentially motivates the willingness of people to be exposed to information;
- prior attitudes affect the degree to which people permit exposure; and
- prior attitudes result in differential changes in attitudes after exposure.

The National Highway Traffic Safety Administration adopted the following standards (discussed by Wilde et al. [1971]) for use by the ASAPs which it sponsors: campaign messages must be *instructive*, should reach the audience in the situation in which decisions about drinking and driving are made (*immediacy*), should be seen by the recipient as *personally relevant*, and should employ a model of the *desired behavior* (U.S. Department of Transportation 1975a, ch. 6).

Clearly, the selection of appeals to motivate the target audience is critical to the design of effective PI&E campaigns. It has been theorized (Wilde et al. 1971) that such appeals should:

- focus on the human need to avoid anxiety and to fulfill basic physiological and psychological needs;
- use fear or anxiety appeals only when accompanied by specific directions for alleviating or fulfilling needs; and

- focus on behavior that is observable to all members of the target audience so that it is possible that social pressures can be used to reinforce desired behavior.

No known studies have attempted to verify any of the above theories when applied in the field of alcohol safety.

### *5.4.2 Targets of PI&E Campaigns*

Because there is no proven relationship between exposure to information, attitudinal change, and behavioral change, Wilde et al. (1971) advise that PI&E road safety campaigns should focus directly on the behavior which is desired. The selection of a target audience for PI&E campaigns should be based on the identification of those who engage more frequently than the general driving population in the target behavior of interest, e.g., drinking-driving behavior. Target groups may be further defined in terms of their demographic characteristics, types of trips which they make, types of vehicles driven, attitudes about driving etc. (Wilde 1977).

The target group should also be defined in terms of its drinking patterns. For example, though there is evidence that the alcoholic is over-involved in traffic accidents, PI&E campaigns directed toward the alcoholic will be ineffective. Exposure to information alone has not been shown to be effective in reaching those who may be addicted to alcohol (Wilde et al. 1971). Groups may also be identified by their lack of knowledge of alcohol effects, inexperience with consumption of alcohol or inexperience in driving.

Most past alcohol-safety PI&E campaigns have been directed toward the social drinker who may find himself in a situation in which he must decide how much to drink if he has to drive or, having consumed a given amount of alcohol, has to decide whether or not to drive. Few of these campaigns have defined their target groups in much detail. However, two programs are known to have conducted in-depth target analyses of non-crash-involved drivers, and their efforts in this regard are described below.

The first of these target definition efforts was conducted in the Vermont ASAP which used mass communications methodology recommended in the 1971 report of the Organisation for Economic Cooperation and Development (Wilde et al. 1971). Specifically, the Vermont ASAP used the results of a roadside survey to identify the high risk group, to determine characteristics of risky behavior indulged in by this group, to identify the type of media to which the group was normally exposed, to identify the appeals most likely to influence the group's behavior, and to evaluate the impact of the resulting campaign.

The target population defined by the Vermont ASAP consisted of males 16–30 years of age (45% teenage males) who are beer drinkers, single, divorced or separated; have less than high school educations; work as laborers, operatives, farm workers, in service occupations, or are unemployed; have had one or two traffic citations in the previous three years; go to drive-in movies with other young males; listen to the radio in their cars; look at TV news; read newspapers; and go to auto races. The caveats about driver profiles stated in section 4.0 should be kept in mind when interpreting studies on target groups for PI&E campaigns. Specifically, the fact that a given driver possesses the attributes of a given target group does not necessarily mean that the driver has a high risk of an alcohol-related crash.

The data collected in the Vermont survey were also used to identify the knowledge needs of the target population, the appeals which would be most effective, and the media which would most effectively transfer the needed information to the target population.

Target audiences defined by the 35 ASAPs in the U.S. (U.S. Department of Transportation 1975a, ch. 6) have included bar patrons, package store patrons, legislatures, police, physicians, youths, drinking-drivers convicted of DWI, and the general drinking-driving population.

The second target definition study was sponsored by NHTSA and conducted by Grey Advertising (1975). Using a nationwide probability sample, Grey surveyed 1512 adults who were 18–55 years of age and 148 college students during June and July, 1974. This survey was preceded by an "incidence study" consisting of a telephone survey of a probability sample of 507 adults, 21–60 years of age. The purpose of this initial survey was to establish the frequency with which adult Americans are exposed to social and business situations in which alcoholic beverages are served.

Findings of the Grey surveys showed that 54% of adult Americans, 18–55 years of age, participate one or more times a month in social or business situations in which alcoholic beverages are served. The researchers estimate that these situations account for 87% of all situations conducive to driving after drinking.

Awareness of the potential drinking-driving situation was also measured in the Grey study. Fifty-seven percent of those who participated in alcohol-related situations (ARS) did not feel that they had found themselves in a potential drinking-driving situation. The majority of this group did not know how to tell when others are drunk and didn't know appropriate steps to take when faced with a drinking-driving situation. When action was taken, it involved close friends or relatives, whether at home or in public drinking places; and it involved driving the friend or relative home rather than physically restraining the intoxicated person.

The Grey Advertising study also attempted to identify targets in terms of their exposure to potential drinking-driving situations and their willingness to engage in effective actions to prevent drinking-driving in those situations. Four groups of individuals were defined with respect to these and other attributes:

- *social conformers* (43% of ARS group, 46% of ARS occasions): males and females, 20–45 years of age; well educated, higher than average income, white collar occupation; likely to offer to drive intoxicated friend home or to ask him to stay over or to call a taxi if it is considered socially acceptable to do so, serve food with drinks, are moderately heavy drinkers, can identify the potential DWI situation and take action.
- *aggressive restrainers* (27% of ARS group, 32% of ARS occasions): males, less than 35 years of age, less well-educated than social conformers, less income; reside in the Northeastern U.S.A.; have positive attitudes towards alcohol; know less of alcohol effects, can identify potential DWI situation and take action; one-third find themselves in ARSs two or more times a week; one-half drink most often at home; are heaviest drinkers, prefer beer; friendships and affiliations are very important; are willing to use physical restraint with intoxicated friends who decide to drive.

- *cautious preplanners* (18% of ARS group, 13% of ARS occasions): female, one-third Southern; three-quarters are 35 years or more in age; anticipate and avoid DWI situations, less likely to take action after drinking, have misinformation on alcohol, know a number of problem drinkers; four-fifths drink once a week or less; two-thirds drink 3 or fewer drinks per occasion.
- *legal enforcers*(12% of ARS group, 9% of ARS occasions): 56% female; 40% are 35 years of age or more; 75% have annual incomes greater than $10,000; 67% have less than a college education; are likely to call police or report bars selling liquor to minors to authorities; have the greatest understanding of the role of problem drinkers in traffic fatalities; 90% are likely to take some action in potential DWI situations, including the use of restraint; are likely to call police if intoxicated person is a problem drinker; are the lightest drinkers of the four groups.

Grey Advertising (1975) recommended that alcohol-crash PI&E campaigns should focus on social conformers and aggressive restrainers, since these groups account for both most of the people exposed to alcohol-related situations and for most of the situations. The other groups were found to be too small, but it was stated that care should be taken to avoid alienating them. The objectives recommended include:

- correction of misinformation about alcohol consumption;
- identification of potential DWI situations; and
- persuading people to take appropriate action in potential DWI situations.

The Lackland Air Force Base program against drinking and driving (Barmack and Payne 1961b) also used research on characteristics of the target audience in order to develop and plan their countermeasure activities. The 35 ASAPs used both roadside and household surveys to learn more about the drinking-driving patterns and knowledge needs of their target audiences. The findings of the study conducted by Grey Advertising (described above) were intended for use in the remaining ASAPs in refining definitions of target audiences and in selecting the content of PI&E campaigns (Grey Advertising, Inc. 1975).

### *5.4.3 Applications of the PI&E Approach*

Content of drinking-driving laws has been the focus for most campaigns associated with the introduction of new drinking-driving legislation. The British campaign of 1967 and the 1969 Canadian campaign were both designed to heighten awareness of the public to their rights and obligations under new legislation. The presumptive or per se BAC limit, the procedures for apprehension, arrest and charging of drinking-drivers, and the penalties associated with conviction are the major variables about which factual information was disseminated in these campaigns.

Many other information campaigns conducted in the U.S.A., Canada, England and Australia have been run when, though drinking-driving laws were not new, it was determined that the public was poorly informed about the dangers of drinking and driving, had attitudes about the dangers of drinking that were not conducive to the maintenance of safe highways, or were engaging in behavior that contributed to the dangers of drinking and driving.

In at least two campaigns, an attempt was made to change the social value attached to drinking-driving behavior. Development of the Lackland Air Force Base countermeasure against drinking and driving (Barmack and Payne 1961b) involved the examination of the relevant customs and values concerning consumption of alcohol by airmen stationed at the base. Researchers found that reckless driving after drinking had group tolerance and was seen as courageous and daring. Assigning a different and conflicting value to this behavior was the essential element of the Lackland countermeasure. Reckless driving after drinking was recharacterized as sick, disturbed behavior. This recharacterization was supported by the establishment of a policy requiring that airmen involved in accidents resulting in loss of duty time of 24 hours or more would be required to undergo psychiatric evaluation and possible referral for psychotherapy, which might lead to a recommendation for medical discharge. Enforcement of this policy was preceded by an educational program to inform airmen of the details of the new policy. Though it was not possible to isolate the impact of the educational program from the impact of other elements of the program, the rate of accidents was reduced.

An Australian campaign (1974) against drinking and driving, which began in July 1974, used an approach similar to that used at Lackland Air Force Base. The campaign used the offensive word "SLOB" to describe drinking drivers. The campaign strategy was based on the social sanctioning process. The existing social climate was one in which there were frequent pressures to drink before driving. The impaired or intoxicated driver was sometimes treated sympathetically or with amusement. It was assumed that the drivers' desire to avoid a negative label and the resulting shame if it could not be avoided would reduce the number of drinking-drivers. The campaign focused on the susceptibility of the drinking-driver to social definitions of what is considered tasteful or appropriate behavior. (Additional information on this campaign was not available at the time of the publication of the present report.)

Both the 1967 British and the 1969 Canadian campaigns also included attitudinal measures which tapped the opinions of the public about the adequacy of the new legislation to prevent or to reduce alcohol-related accidents (Ross 1973; Kates, Peat, Marwick and Co. 1970a).

In the U.S.A., the ASAPs sponsored by the National Highway Traffic Safety Administration have conducted public information campaigns since 1971 (U.S. Department of Transportation 1975a, ch. 6). Objectives for these campaigns were defined in terms of waves or phases. The objective of the first wave was to develop an awareness among the public of the dangers and consequences of drinking and driving. In the second wave, attempts were made to personalize the problem by identifying drunk drivers as friends, relatives, and acquaintances in order to counteract the tendency to see the drinking-driver as a deviant. The stimulation of social and peer group concern and the description of specific actions which might be taken to cope with drinking drivers were objectives of the third wave. The fourth wave focused on specific calls for action. As stated above in Section 5.4.2, on the basis of the 1974 study by Grey Advertising (1975), recommendations for future objectives for ASAP's PI&E campaigns were:

- correction of misinformation about alcohol consumption;
- identification of potential DWI situations; and
- persuading people to take appropriate action in potential DWI situations.

It is not clear that very many actual PI&E campaigns were explicitly based on any given psychological theory. However, the approach of ASAP appears to be consistent with the theory that information reception can lead to attitudinal change which can, in turn, lead to behavioral change. The theory that reception of new information leads to behavioral change followed by attitudinal change seems to underlie the Lackland experiment, the Australian "SLOB" campaign, and the British and Canadian campaigns.

With respect to audience motivational theories, the Vermont ASAP (Zylman 1973a) found that a mild-fear-of-arrest appeal when combined with the presentation of useful information in a positive fashion (e.g., how to get home safely without getting caught for DWI) was effective for increasing knowledge. The Lackland AFB experiment and the Australian "SLOB" campaign used the need for social acceptance as a central motivating approach. The information campaign which is used to increase the deterrent effect of legislation also employs the fear-of-arrest approach. However, in such campaigns specifications on how to avoid arrest are not always stated in positive terms. The various ASAPs have used fear, humor, slice of life, and other approaches in their PI&E campaigns. There is little or no sound evidence of the effectiveness of these various approaches for most of the campaigns reviewed.

A recent study of materials used in public information campaigns for alcohol-safety found that such materials have become more sophisticated since 1970 (Douglass and Wadleigh 1976). Themes and messages appeared to be aimed more toward specific behaviors and audiences than they had been in early campaigns, and intermediate target groups were being addressed in the more recent campaigns. Fear-arousal themes were found to have been used less frequently than before.

*5.4.4 Evaluations of PI&E Campaigns*

Several measures of effectiveness have been used for PI&E campaigns (Wilde 1975):

1. reduction in the presence of alcohol in drivers involved in fatal and other crashes (regardless of fault);
2. overall reduction in average BACs in the road-using public at risk—if this also results in fewer crashes;
3. reduction in those higher BACs considered to be critical in contributory effect on crashes—if this also results in fewer crashes;
4. increase in the public's knowledge of dangers related to driving with high BAC and decrease in negative attitudes toward dangers—if this also results in fewer crashes; and
5. increase in public knowledge of drinking-driving laws, reflected in their ability to recall elements of the information campaign—if this also results in fewer crashes.

Measures 4 and 5 are dependent upon the verbal responses of those interviewed, and these responses may not accurately reflect behavioral responses. The conditional phrase associated with measures 2–5 reflects the intermediacy of these measures. The ultimate measure of campaign effectiveness is the change in accident rates upon which measure 1 is based. However, measure 1 is also subject to limitations. Crashes are rare events,

especially serious crashes. Crashes are subject to marked statistical fluctuations over time and from site to site. Methods and likelihood of reporting crashes vary widely. And environmental (physical and social) factors beyond the control and, sometimes, the knowledge of researchers may have as great an impact on crash rates as drinking and driving.

Haskins (1968a; 1968b; 1969; 1970), in his reviews of research on the effectiveness of mass communications safety campaigns, characterizes the model campaign as one which employs:

- naturalistic communications conditions;
- a clearly stated cause-effect relationship (this requires use of treatment and control groups and pre- and post-testing);
- procedures and instruments of measurement which are valid and unobtrusive; and
- accurate implementation of soundly designed program and evaluation plans.

When the measure of campaign effectiveness is reduction in accident rates, few PI&E campaigns provide evidence of effectiveness. In the British and Canadian legislation/information campaigns, there was evidence of ultimate effectiveness. However, because no control groups were used, it is not possible to state with any degree of confidence exactly what role was played by the information campaign. In the Canadian case, there was also an increase in enforcement activity, so that interpreting the causal factors of the short-lived reduction in crash rates is even more problematic in this instance.

An excellent evaluation design for determining campaign effectiveness was developed by the Vermont ASAP (Worden, Waller, and Riley 1975). In geographically dispersed areas, the impact of an education campaign was compared with the impact of an education campaign used in combination with an enforcement countermeasure. A third condition, in which neither education campaign nor enforcement countermeasure was employed, served as the control for this study. Evaluation and program development and implementation were interdependent activities. Baseline data collected in a roadside survey were used to identify knowledge needs, appropriate appeal tactics, and media. Interim and postmeasures of effectiveness were also made.

Other examples of alcohol-related safety campaigns in which some attempt was made to proceed in a methodologically sound manner are the Edmonton, Alberta, Canada study (Farmer 1975; Farmer and Stroh 1973) and a study conducted in the Canadian province of Ontario (Pierce et al. 1975). In both instances geographically dispersed areas were designated control or treatment cities, and pre- and post-testing of campaign effects were conducted.

In reviewing the findings of road safety campaigns in 1971, Wilde et al. (1971) concluded that media campaigns cannot bring about behavioral changes and result in few significant attitudinal changes, but that such campaigns can be successful in transferring information. Other reviewers (Swinehart 1972; Swinehart and Grimm 1972) concur in this conclusion, stating that the mass media are not effective in changing attitudes or inducing action, but are good in conveying information. Any alteration of individual drinking-driving habits which results from such campaigns are seen by the reviewer as an unexpected side effect. Examination of the findings of the specific campigns cited in the subsections above reveals the conclusion of Wilde et al. (1971) to be valid. Only in

cases where media campaigns are combined with other types of countermeasures is there significant behavioral change. Thus, the 1967 British case (Sheppard 1968; Ross 1973), the case of the Lackland AFB (Barmack and Payne 1961b), and, to a lesser extent, the 1969 Canadian case (Kates, Peat, Marwick and Co. 1970a) are the three major examples of campaigns whose impact went beyond knowledge gains.

The inadequacy of evaluation design and of other features of campaign development have made it difficult to determine the exact nature and extent of the impact of most alcohol/highway safety media campaigns. Pre- and post-testing is done for almost all campaigns, but very few of them use control groups. Even the British and Canadian cases did not use control groups. Members of the control group used, informally, in the case of the Lackland AFB were not randomly selected, nor were control group members matched with members of the treatment group on any basis other than the fact that they were airmen assigned to a base in Texas as were members of the treatment group.

The Edmonton (Farmer 1975; Farmer and Stroh 1973) and Ontario (Morton et al. 1975; Pierce et al. 1975) media campaigns used control groups which, in each case, were cities selected to match treatment cities in terms of size and of relative isolation from the media of the treatment cities. Both campaigns were successful in transferring factual information about the contents of drinking-driving laws. The Sidney, Australia, media campaign (Freedman, Henderson, and Wood 1975) did not use a control group, but did claim statistically significant positive changes in the public's knowledge of the role alcohol consumption plays in crashes, of the legal BAC limit, of penalties associated with DWI convictions, and of the amount of alcohol which can be consumed by the average person before he reaches the legal BAC limit.

In the case of the British Road Safety Act of 1967 (Ross 1973), results of public opinion surveys conducted in September 1967 and January 1968, indicated that while only 27% of a random sample of adults knew of the fixed BAC limit before the campaign, 39% knew of it after the campaign. The post-campaign survey indicated that 99% of drivers knew that alcohol consumption would be detected by a breath test; 95% knew that refusal could lead to arrests; and 27% correctly described disqualification as a minimum penalty, while 42% described it as a maximum penalty.

A much greater proportion of Canadian drivers, 87%, than in the British case, knew that police could give tests for BAC. This percentage increased to 96% after the 1969 media campaign. Many fewer drivers, 35%, knew that even if a driver's BAC were less than .08% w/v (the Canadian legal limit), the driver could be charged with impaired driving. This percentage decreased to 31% after the campaign. The proportion of drivers who knew that the breath test was compulsory grew from 49%, pre-media campaign, to 87%, post-media campaign (Kates, Peat, Marwick and Co. 1970a).

In many of the campaigns knowledge gains were greater for women than for men (Kates, Peat, Marwick and Co. 1970a; Freedman, Henderson, and Wood 1975; Ross 1973).

In the U.S., the NHTSA sponsored ASAPs (U.S. Department of Transportation 1975a, ch. 6) focused on the following areas in their PI&E campaigns:

- awareness of the drunk-driving problem and the relationship between levels of blood alcohol and the risk of a crash;

- public's interpretations of alcohol myths;
- respondent's reported perception of personal responsibility for drinking-driving behavior; and
- reduction of alcohol-related crashes and resultant death or injury.

"In each area of concentration, substantially more sites with public information activities achieved positive results than sites without an effort" (U.S. Department of Transportation 1974a, ch. 6., p. 1). It should be noted that all of the ASAPs conducted other types of countermeasures concurrently with the PI&E campaigns and few used more than pre- and post-testing in their evaluation of campaign effectiveness.

On most of the twenty-four questions asked on pre- and post-household surveys, both ASAP sites *with* PI&E campaigns and ASAP sites *without* such campaigns produced gains in knowledge. However, for each of nine of the questions, 50% or more of ASAP sites *with* PI&E campaigns produced knowledge gains, and this proportion was, at the same time, greater than the proportion of ASAP sites *without* PI&E campaign that produced such gains. The nine questions focused on the following subjects:

- factors causing the greatest number of automobile accidents;
- the contribution to accident causation of the social drinker v. the problem drinker;
- the contribution to accident causation of the drinking-driver;
- recognition of the term "blood alcohol level" or "blood alcohol concentration;"
- the effect of having eaten on the impact of alcohol on the body;
- recognition of potential DWI situations;
- subjective probability of apprehension by police when driving under the influence of alcohol; and
- reported frequence of drinking and driving, a behavioral measure.

To conclude, the inadequacy of existing practices in the development and evaluation of PI&E campaigns makes it difficult to determine the impacts of the campaigns on their chosen target audiences. There exists some evidence that PI&E campaigns are effective in bringing about gains in knowledge of drinking-driving laws and in knowledge of the effects of alcohol on the body and on driving skills. There is little evidence to show that PI&E campaigns change either attitudes or behavior. In the few cases in which behavioral change, i.e., reduction in accident rates, especially of alcohol-related accidents, occurred, PI&E campaigns were conducted in conjunction with other countermeasures. In most cases, the impact of the PI&E campaign could not be isolated from the impact of other countermeasures. In the Vermont ASAP, however, it was found that a PI&E campaign, when combined with an enforcement countermeasure, was more successful in effecting knowledge gains than a PI&E campaign used alone, which, in turn, was more successful than the control condition of no PI&E campaign and no enforcement countermeasure.

Thus, research does *not* show that PI&E in general is ineffective, but merely indicates that it has not been successful in reducing crashes *when used alone*. There is evidence that PI&E has been effective in supporting other alcohol-safety approaches, particularly the legal approach.

## 5.5 TECHNOLOGICAL APPROACHES

In the past, specific applications of technology to control of the drinking driver have been limited almost entirely to devices which support the legal and health approaches described in Sections 5.2 and 5.3 of this report. No purely (or even largely) technological approach has yet been tried, although several have been proposed and studied. This section of the report discusses a type of technology that has had, in its various applications, the greatest impact on the alcohol-crash problem: breath-alcohol analysis. A brief description of some other possible, but untried, applications of technology is also provided here.

### *5.5.1 Breath-Alcohol Analysis*

Several excellent reviews of the history and state of the art of breath-alcohol analysis have appeared recently (Driessen and Bryk 1973; Harger 1974; Mason and Dubowski 1974; Mason and Dubowski 1976; Moulden and Voas 1975). Mason and Dubowski (1976) traced the science of breath-alcohol analysis back to at least as early as 1847 (in Europe) and found an American paper on the subject published in 1874. Relatively precise measurements became possible in the early 1900s.

The purpose of breath-alcohol testing for traffic safety purposes has been to calculate *blood* alcohol concentrations (BAC) from breath samples. This requires air from deep within the lungs where blood circulates through the pulmonary capillaries. Deep lung air (called "alveolar" air by physiologists) is needed because it is the only type for which *breath* alcohol concentration can be directly related to *blood* alcohol concentration through a relatively straightforward application of a rule, known in physics as Henry's Law (AMA Committee on Medicolegal Problems 1970). This law states that the amount of the concentration of a gas in its *liquid* phase divided by the concentration of the gas in its *gaseous* phase is equal to a constant at a given temperature. In the case of alcohol and blood this constant turns out to be approximately 2100 at 34°C, which means that the amount of alcohol per milliliter of *blood* is equal to 2100 times the amount of alcohol per milliliter of *breath*.

A major problem in developing operationally practical breath testing instruments for alcohol safety applications has been one of meeting the conditions imposed by Henry's Law. The earliest device used extensively in the United States (after passage of the 1939 law in Indiana admitting chemical tests of BAC as evidence) was the Drunkometer which analyzed expired air containing both alveolar air and air not in equilibrium with the capillary plasma. The analysis was based on the assumption that the fraction of alveolar air in the total sample of mixed air could be estimated by determining the amount of carbon dioxide in the sample. Later studies proved this assumption led to unacceptably inaccurate and variable estimates of BAC, and in 1969 the manual for Federal Highway Safety Programs Standard Number 8 (Alcohol in Relation to Highway Safety) required the use of "substantially alveolar" deep lung air in breath-alcohol analysis (Mason and Dubowski 1976). The reader is referred to Mason and Dubowski (1976) for a detailed discussion of current problems in breath-alcohol analysis.

Moulden and Voas (1975) have classified current breath-testing devices according to their application in support of efforts to control the drinking-driver. Six basic classes of instrumentation were defined:

- Screening Breath Testers (SBT),
- Evidential Breath Testers (EBT),
- Roadside Collection Devices (RCD),
- Passive Breath Testers (PBT),
- Educational Testers, and
- Alcohol Safety Interlock Systems (ASIS)*

The *screening breath testers* (SBTs) are designed for use in jurisdictions that permit a police officer to check a driver's BAC prior to arrest, thus providing additional and more reliable information than traditional "field tests" for determining if an arrest should be made. Chemical SBTs collect expired air in a rubber balloon or some similar device and pass the air over an alcohol-sensitive chemical. Electromechanical SBTs are small, reusable analyzers about the size of a transister radio and employ several different techniques for sensing and measuring the amount of alcohol in a sample.

The U.S. Department of Transportation has field tested several types of electromechanical SBTs in four states that have enacted appropriate legislation. It found that in one jurisdiction nearly half of the drivers tested indicated BACs of greater than .10% w/v and stated that most of these individuals would have been released without tests because they were not obviously intoxicated. Arrest rates of the SBT-equipped patrols increased 62% in one year, compared to an increase of only 23% for the patrols with no SBTs. Further, the average BAC of *arrested* drivers decreased from .18% w/v to .14% w/v when the SBTs were used (Moulden and Voas 1975).

*Evidential breath testers* (EBTs) are more accurate and reliable than SBTs since, as the name suggests, their results must be admissable in court as evidence. Three basic types are in use. Gas chromatography EBTs determine the presence of alcohol in a sample by measuring the time required for the alcohol molecules to pass through a "chromatographic" column. Photometric EBTs measure color changes caused by alcohol passing through an indicator solution. Infrared EBTs pass an infrared beam through a breath sample and measure the change in energy transmittance caused by the alcohol.

It is interesting that, although EBTs have been used operationally for nearly 30 years, no formal evaluation of their effectiveness in supporting legal and health/legal objectives has been made. They are now such an integral part of both approaches that it seems doubtful that any meaningful evaluation could be performed.

*Roadside collection devices* (RCDs) are used to collect breath samples for later analysis by EBTs, thus simplifying the processing of DWIs by police officers. The samples are collected either directly as a volume of breath in a special container or by absorption of the alcohol in a silica gel.

Mason and Dubowski (1976) have tabulated the results of 28 studies of the correlation between the BACs obtained indirectly from breath-alcohol tests and BACs obtained directly from nearly simultaneous blood-alcohol tests (see Table 5-5). Nine different instruments, dating back to an improved version of the Drunkometer in 1956, were compared. The data indicate that the breath-testers typically underestimate BACs deter-

*The ASIS concept is no longer being considered by NHTSA. It has been replaced by the Drunk Driver Warning System (DDWS).

mined from blood analysis by up to 10% or so. Thus, a BAC reading of say .10% w/v from a breath tester would generally correspond to a reading of .10% w/v to .11% w/v from a blood tester.

TABLE 5-5

*Blood/Breath Correlations Found in 28 Studies with Nine Breath-Testing Instruments (1956–1974)*

| | | *Correlation of Reported Values, %* | | | | *Mean of* |
|---|---|---|---|---|---|---|
| *Year* | *Instrument* | *Within ±5%* | *Within ±10%* | *Within ±15%* | *Beyond ±15%* | *Blood/Breath Deviation, %* |
| 1956 | Drunkometer, rebreathed air | 54 | 87 | 98 | 2 | +1.3 |
| 1957 | Breathalyzer® | 38 | 62 | 91 | 9 | −6.7 |
| 1957 | Alcometer® | 53 | 78 | 95 | 5 | −1.3 |
| 1959 | Breathalyzer® | 30 | 51 | 68 | 32 | −10.0 |
| 1959 | Breathalyzer® | 40 | 68 | 84 | 16 | −6.1 |
| 1960 | Breathalyzer® | 26 | 52 | 72 | 28 | −8.5 |
| 1963 | Breathalyzer® | . . . | . . . | . . . | . . . | −12(mg/100 ml) |
| 1964 | Breathalyzer® | 5 | 17 | 38 | 62 | −17.5[a] |
| 1964 | Kitagawa-Wright Hermes system | 31 | 49 | 68 | 32 | −1.9[a] |
| 1964 | Drunkometer, rebreathed air, arterial blood | 64 | 86 | 93 | 7 | −4.0[a] |
| 1969 | Breathalyzer® vs blood | 33 | 59 | 87 | 13 | −9.7 |
| 1969 | Breathalyzer® vs plasma | 28 | 59 | 76 | 24 | −9.9 |
| 1969 | Breathalyzer® | 42 | 61 | 84 | 16 | −0.3 |
| 1969 | G. C. Alco-Analyzer | 60 | 70 | 75 | 25 | −4.9 |
| 1969 | Alco-Tector | 51 | 78 | 88 | 12 | +1.7 |
| 1969 | G. C. Intoximeter® | 58 | 61 | 73 | 27 | −4.3 |
| 1969 | Breathalyzer® | 25 | 61 | 80 | 20 | −7.1 |
| 1969 | Breathalyzer®, rebreathed air | 57 | 74 | 92 | 8 | −2.2 |
| 1970 | Alcolinger Automatic | 45 | 66 | 85 | 15 | +3.6 |
| 1971 | Intoxilyzer | . . . | . . . | . . . | . . . | −3.2 |
| 1971 | Breathalyzer® | 25 | 57 | 74 | 26 | −5.2 |
| 1972 | Breathalyzer® | 31 | 58 | 82 | 18 | −0.7 |
| 1972 | G. C. Alco Analyzer | 15 | 31 | 66 | 34 | −13.7[b] |
| 1972 | G. C. Intoximeter® | 45 | 65 | 82 | 23 | −4.4[b] |
| 1973 | G. C. Intoximeter® direct analysis | 15 | 63 | 77 | 23 | −10.2 |
| 1973 | G. C. Intoximeter® indium capsules | 61 | 79 | 97 | 3 | +1.8[b] |
| 1974 | Intoxilyzer | 28 | 65 | 86 | 14 | −10.0[b] |
| 1974 | G. C. Intoximeter® | 34 | 82 | 90 | 9 | −6.6[b] |

[a]Comparisons in which the blood alcohol was less than 0.05% w/v are omitted.
[b]Data calculated from estimates made from scatter diagrams.
Source: Mason and Dubowski 1976, p. 16

The remaining three classes of breath testers have not yet been used operationally. *Passive breath testing* devices (now called *noncooperative breath testers*) might help overcome the objection that pre-arrest breath testing is self-incriminating or constitutes illegal search or seizure. They would make a qualitative determination of breath-alcohol by "sniffing" the air around the driver and would not require the driver's cooperation. *Educational testers* (now called *self testers*) would be used by drivers to test their own breaths to determine if their BACs had reached levels indicating impairment. They could be low-cost, individual, disposable devices that could be distributed by liquor stores, schools, etc., or reusable self-breath testers that could be installed in bars, restaurants, etc.

*The Drunk Driver Warning System* (DDWS) has superseded the Alcohol Safety Interlock System (ASIS) at NHTSA. ASIS would prevent a driver from starting his car if his BAC were too high. The DDWS concept now being studied would allow the impaired driver to start his car, but would cause his lights to flash at speeds of less than 10 mph and his horn to sound intermittently at speeds above 10 mph. One way of activating the DDWS would be the driver's failure to perform a critical tracking task (CTT) which would require him to keep a needle in the center of a display by turning the steering wheel. A possible use of the DDWS would be to install it on the cars of convicted DWIs as a condition of probation.

Again, neither the non-cooperative breath tester, the self tester, nor the drunk driver warning system has yet been demonstrated to be feasible for use in drinking-driving control programs (Moulden and Voas 1975). Ranges of cost-benefit ratios for several such devices were estimated by Moore et al. (1976) and presented as a function of such parameters as deterrent effect, usage rate, etc.

### *5.5.2 Other Technology-Oriented Concepts*

Devices other than the CTT tester have been suggested for assessing alcohol impairment (Voas 1970). Devices that measure the driver's BAC directly were considered first, but are receiving little attention today because of the ease with which they can be defeated. A second class of devices would measure a driver's ability to perform tasks related to driving or thought to be critical in avoiding crashes. This class includes devices that would measure reaction time, coordination, steadiness, proficiency at divided attention tasks, and short-term memory. Such devices have been built and tested, but have not been placed in general use (Moulden and Voas 1975).

Any of the above devices for assessing impairment could be used in conjunction with other devices which might prevent an impaired driver from starting his car (e.g., ASIS) or warn other drivers of the presence of impaired drivers (e.g., DDWS, see above discussion). Such devices might incorporate a feature that would require a driver to insert his driver's license or other identification into a reading device as a condition for passing the impairment test (Voas 1970).

It has also been suggested that driving performance be continuously monitored for clues that would betray alcohol impairment (Voas 1970; Moore et al. 1976). When the continuous monitoring device indicated unacceptably high impairment, a warning signal would be given (e.g., a flashing light) or a speed governor would be activated. A similar system has been designed to prevent truck drivers from falling asleep. It measures

steering wheel reversals and sounds an alarm when the driver's steering performance falls below some critical level.

It is conceivable that a mechanical or electronic device could be built to restrict a convicted DWI to driving only during certain specified hours. The device could use a light sensor or timing mechanism either to activate an interlock or to give a warning signal if the vehicle were being driven during restricted (e.g., nighttime) hours. Alternatively, an operating time recorder could be used to indicate if the vehicle had been driven during restricted hours (Moore et al. 1976).

An application of pharmacological technology has been studied as a means for reducing the impairing effects of alcohol. Several drugs for blocking the effects of alcohol on the central nervous system have been tested in the search for such a "sobering pill" (Noble 1974). One drug, L-dopa, had a statistically significant effect on improving the subjects' performance on a divided attention task, but induced unpleasant side effects (i.e., nausea and vomiting). Research is continuing, but no practical drug for canceling the effects of alcohol has yet been discovered.

Analysis of the various technological concepts outlined in this subsection (5.5.2) indicates substantial problems in using any of them in any operational programs to reduce alcohol-related crashes. In some cases (e.g., the sobering pill), feasibility has not been demonstrated. Devices to prevent a drunk driver from starting his car face substantial public acceptability problems and are no longer being considered by NHTSA. The drinking driver may decide not to use the self tester and the cost of self testers may be too high for practical use. Continuous monitoring devices could cause rather than prevent crashes if their warning signals were to startle or upset drivers. All of these devices would run the risk of being defeated by ingenious drivers and could present substantial legal problems. None appears to be a panacea in itself, but would have to be used in combination with or in support of other approaches (Voas 1970).

## 5.6 THE SYSTEMS APPROACH

The term *systems approach* appears to have been introduced in the early 1950s to describe techniques being developed for managing large and complex aerospace projects (Jones and Joscelyn 1976). Its most essential distinguishing feature is its concentration on the whole problem rather than on its component parts. One of its most successful practitioners, Simon Ramo, described it as follows:

> It is an approach that insists upon looking at a problem in its entirety, taking into account all the facets, all the intertwined parameters. It is a process for understanding how they interact with one another and how these factors can be brought into proper relationship for the optimum solution of the problem. The systems approach relates the technology to the need, the social to the technological aspects; indeed, it starts by insisting on a clear understanding of exactly what the problem is and of the goals that should dominate the solution and lead to the criteria for evaluating alternative avenues. As the end result, the approach seeks to work out a detailed description of a specified combination of men and machines—with such concomitant assignment of function, designated use of material, and pattern of information flow that the whole

> system represents a compatible, optimum, interconnected ensemble for achieving the performance desired (Ramo 1971, p. 11).

The systems approach has also been described as "a way of thinking about management," providing the means for arriving at the best solution to a problem through a methodical process of identification and control of its interrelated parts (Morse 1966). Rather than breaking down a problem into small pieces and solving each one independently, the systems approach attempts to address the total problem by tracing the effect of a choice or decision upon each element of a problem, and, ultimately, upon the whole problem.

Some writers have proposed that the systems approach be applied to those societal problems which are more concerned with the activities and interrelationships of human beings than with the primarily technological problem. One of the first writers to suggest what amounted to a systems approach to societal problems was Sir Julian Huxley, the biologist, who perceived the evolution of a societal "brain" having a greatly increased capability for obtaining information and for planning, correlating, and flexibly controlling the execution of social programs (Jones and Joscelyn 1976). Simon Ramo (1971) proposed the application of the more specific tools of the aerospace systems approach as a "cure for chaos," resulting eventually in the dawning of a "golden age" when "the full application of logic, objectivity, and all the facets of science and technology (are used to) get solutions to society's problems . . . . . "

The first documented application of the systems approach to the alcohol-crash problem was the Joscelyn and Jones analysis of the so-called Drinking Driver Control System (Joscelyn and Jones 1971). The study used the functional analysis technique (a basic tool of the aerospace systems approach) in conjunction with standard research methods from the social sciences (e.g., survey research) to develop statements about the implicit objectives, functions, requirements, and operational modes of that "system." Rough estimates of the values of some of the variables which describe the performance and effectiveness of the system were made, and each major function was examined to determine its deficiencies and their impact on other functions and the system as a whole. A lack of conscious management of this complex system was apparent and the study recommended, among other things, that "management offices be established on the local, state, and national levels to assist in the development and application of the concept of the DWI Control System as a system, i.e., System Management Offices." The study concluded that the systems approach offered "a new and potentially very valuable method of handling a problem which has, until now, proven intractable."

In 1969 the National Highway Safety Bureau (later the National Highway Traffic Safety Administration) of the U.S. Department of Transportation announced a nationwide Alcohol Safety Action Project (ASAP) and established an Office of Alcohol Countermeasures to manage it. The program provided financial assistance to and coordinated the efforts of, at first, nine and, ultimately 35, individual ASAPs around the country. From the beginning ASAP embraced the systems approach, declaring that "In planning and managing an ASAP, the project director will need to use the systems approach, in order to properly integrate all of the complex aspects involved. He should consider the

project as a whole system made up of several subsystems which are related to and dependent upon each other. The project director must take these relationships and dependencies into consideration in order to maintain proper balance in the operation of the subsystems" (McKnight, Adams, and Personeus 1971).

No other alcohol safety program of comparable scope, depth, and size has attempted the systems approach to the degree employed in ASAP, although some jurisdictions have applied and are continuing to apply some of its concepts on their own. For this reason, the remainder of the discussion of the systems approach to drinking-driver control will be limited to ASAP. Emphasis is given to those aspects most relevant to the systems concept, rather than to the individual "countermeasures" which were discussed previously in this report to illustrate other approaches.

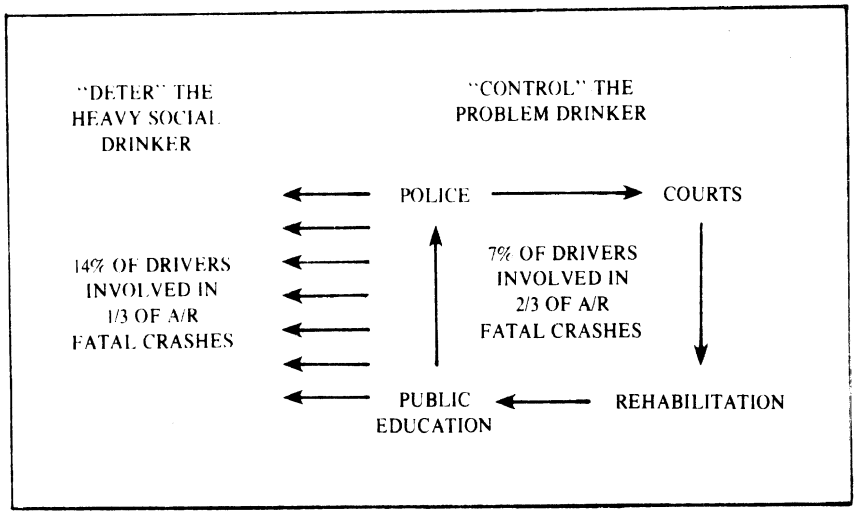
### *5.6.1 ASAP Targets*

As noted previously in this report, ASAP was heavily oriented toward the problem drinking-driver who, it claimed, is responsible for two-thirds of the alcohol-involved traffic fatalities in the U.S. and 34% of all traffic fatalities. These figures could not be justified by the authors of this report. The figures were apparently derived from DOTs 1968 report *Alcohol and Highway Safety* (U.S. Department of Transportation 1968) and have been depicted graphically in a chart which has appeared in numerous ASAP reports over the past several years (e.g., U.S. Department of Transportation 1974a; Voas 1975b). The chart also presents data from a 1971 DHEW report (U.S. Department of Health, Education and Welfare 1971) showing 21% of all American males to be "heavy" drinkers (defined as a person who drinks nearly every day, with five or more drinks per occasion at least once in a while; or who drinks about once weekly with usually five or more drinks per occasion). One-third of these heavy drinkers (7% of all males) were said to be problem drinking-drivers who could only be *rehabilitated* by a safety program, and two-thirds were heavy social-drinking drivers who could be *deterred* by a safety program (see Figure 5-5).

ASAP program personnel have cautioned against making an oversimplified distinction between problem drinking-drivers and social drinking-drivers, noting that drinking patterns vary over a continuum ranging from complete abstention at one end to alcoholism at the other (Voas 1975b). They, nevertheless, believed it useful to distinguish between problem drinkers who must drastically change a behavior over which they have little or no control, and social drinkers who need to make only a relatively minor change in their behavior.

ASAP also placed emphasis on drinking drivers who drive at night and on weekends, drawing upon research which has indicated an increased incidence of alcohol-impaired drivers using the roads and involved in crashes at such times. This policy was implemented at most ASAP sites by fielding more police units (e.g., an enforcement task force) during the hours between 6 P.M. and 4A.M., Wednesday through Saturday (U.S. Department of Transportation 1975a, ch. 2). Some ASAPs designed their enforcement efforts to intercept intoxicated drivers on main thoroughfares connecting drinking establishments with residential neighborhoods, and a few sites concentrated on areas having high rates of alcohol-related crashes.

Figure 5-5. Alcohol Safety Action Program Concept




Source: Voas 1975b, p. 34

### 5.6.2 *The ASAP Program*

The national ASAP program was an outgrowth of the Highway Safety Act of 1966, which required the Secretary of the U.S. Department of Transportation to study the relationship between alcohol and highway safety and to report the results and recommendations of the study to Congress (U.S. Congress 1966). The result was the 1968 report *Alcohol and Highway Safety*, which described a serious national alcohol-crash problem. On July 22, 1969, the Secretary of U.S. Department of Transportation announced a comprehensive countermeasure program to deal with that problem, and shortly thereafter, an Office of Alcohol Countermeasures (OAC) was established within the National Highway Safety Bureau (NHSB) (U.S. Department of Transportation 1970b).

The NHSB's Alcohol Safety Program was to encompass three major areas, identified by the acronym IDA: Identification, Decision, and Action. First, it was to develop and implement measures for identifying problem drinkers on the roads (i.e., through enforcement), from court records, from the records of health and social agencies, and from driver improvement courses. Next, the information identifying problem drinkers was to be used in decision-making about the nature and treatment of the drinking problem which led to drunk-driving. Finally, action would be taken to prevent future drinking-driving. Such actions would include both punitive measures and treatment of the drinking problem, and the nature of the actions would depend on the individual driver and available alternatives (U.S. Department of Transportation 1970a).

The ASAP program was established within OAC as a part of the overall IDA concept. Its ultimate goal was to "demonstrate and evaluate the feasibility, methodology, and

impact of comprehensive, multifaceted countermeasure programs designed to reduce the incidence of alcohol as a causal factor in motor vehicle crashes" (Crittenden 1970). It also sought to evaluate systems and procedures for dealing with the problem drinking-driver and had the following specific objectives:

- to stimulate implementation by states and communities of successful countermeasure programs;
- to provide visibility to the alcohol-crash problem and generate public support for more effective action at all levels of government;
- to study the effect of countermeasures applied individually and in combination on crash reduction;
- to evaluate cost v. effect of specific countermeasures and countermeasure combinations in order to establish a valid basis for resource allocation; and
- to document the legal, administrative, and political problems associated with countermeasure implementation (Crittenden 1970).

Individual ASAP projects were to be conducted at the local level, emphasizing improved law enforcement, traffic court procedures, public information, and special efforts to counsel and assist drivers. The local activities were to be complemented by state-level efforts in driver licensing, motor vehicle registration, traffic records and legislation. Each project would be supported by about $500,000 a year in federal funds provided to a state or local governmental agency which would act as a prime contractor to the NHSB. Federal funding support would continue for three to four years after which it was hoped that full state or local funding would be provided to continue each successful project (Crittenden 1970). The NHSB would also assist the local ASAPs by providing technical assistance, by training of ASAP personnel, and by helping to develop an evaluation methodology.

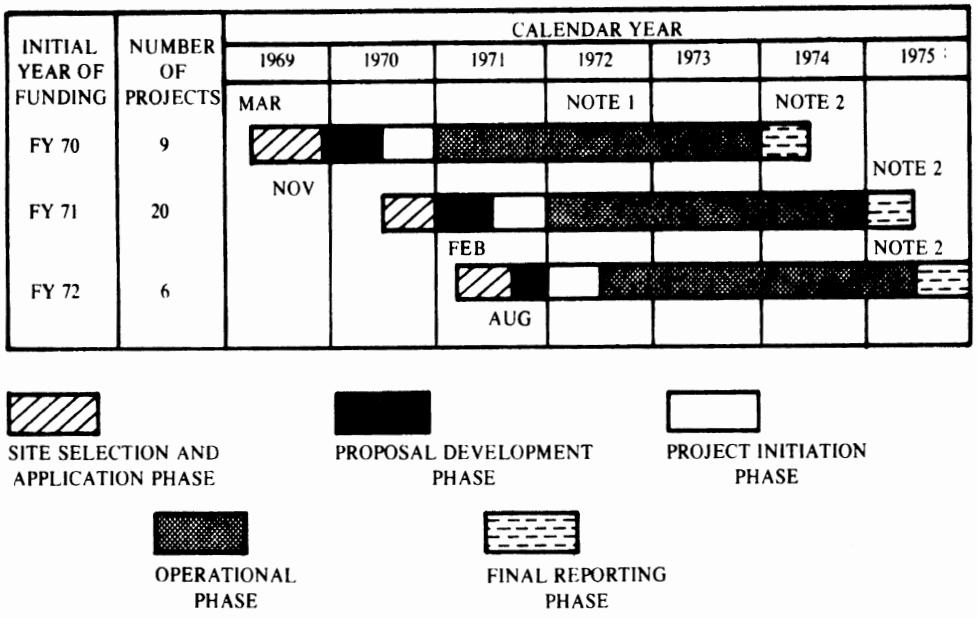
The first group of nine ASAPs began operation in 1971 (see Figure 5-6). Twenty-six additional ASAPs initiated operations in 1972. The locations were widely distributed around the U.S. and included one site in Puerto Rico (see Figure 5-7).

ASAP used a combination of the legal, health, public information and education, and technological approaches in its attack on the alcohol-crash problem. It used the term "countermeasure" to describe a separate action against the "threat" imposed by the drinking driver, terms that were drawn from the aerospace and defense sectors which originated its systems approach. Eventually, five separate categories of countermeasure activities evolved (U.S. Department of Transportation 1975a):

- Enforcement,
- Judicial and Legislative,
- Presentence Investigation and Probation,
- Rehabilitation, and
- Public Information and Education.

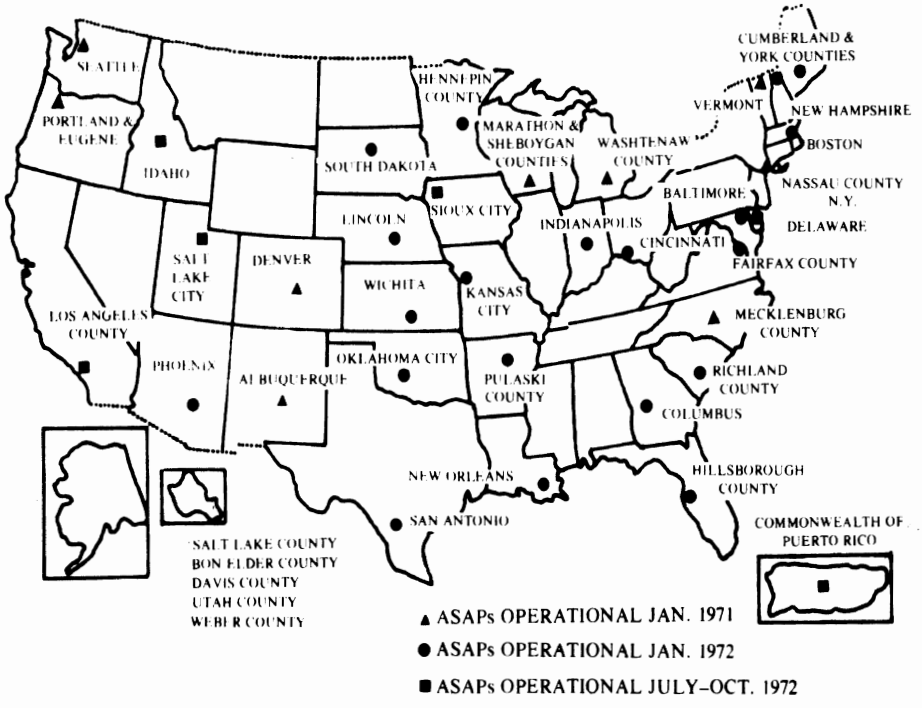
The level of activity in the various countermeasure areas is indicated by Figure 5-8, which shows planned federal expenditures for the 35 sites. The fact that the program was a demonstration effort rather than operational is indicated by the relatively large administration and evaluation components which were required to analyze and document progress and results.

Figure 5-6 Operational phasing of the Alcohol Safety Action Projects



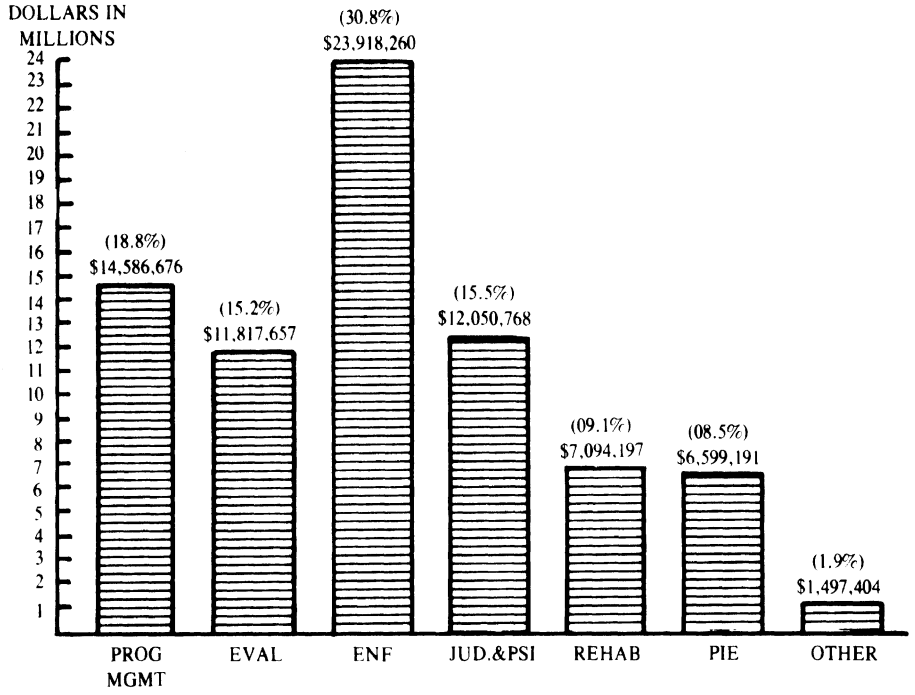

Source: U.S. Department of Transportation 1974a, p. 2

Figure 5-7. Locations of Alcohol Safety Action Projects




Source: U.S. Department of Transportation 1974a, p. 1

Figure 5-8. Planned funding of 35 ASAPs by countermeasure activity across all ASAPs.




Source: U.S. Department of Transportation 1974a, p. 5

Examples of types of countermeasures in each category are shown in Table 5-6. A typical site employed at least one countermeasure in all of the five categories shown (U.S. Department of Transportation 1974b). General descriptions of the operations of some of the countermeasures were discussed previously in this report (see Sections 5.3.2.1, 5.3.3, and 5.4).

There is little documentation in the available literature on how the system approach was actually implemented in ASAP. The Handbook for Directors of Alcohol Safety Action Projects (McKnight, Adams, and Personeus 1971) provided a one-page description of the systems approach (as a subheading under "The Detailed Project Plan") as a means for coordinating ASAP activities in the various countermeasures areas, but did not describe how to use it. A series of seminars (Nesbitt, McGill, and Lipecky 1976; Nesbitt 1975; Institute for Research in Public Safety 1972b and 1974) given to enforcement personnel, prosecutors, judges, probation officers, legislators, and other operational personnel associated with the program also stressed the systems approach and described in fairly specific terms each major element of ASAP and how it related to other elements. Notably missing from any of the material provided the new ASAPs was detailed guidance on how to design a drinking-driver control system. Apparently, the guidance on designing a system provided by OAC to the individual ASAP sites was of an informal nature (e.g., meetings, briefings, personal contracts, etc.). Two of the major tools of the aerospace systems approach (system management and system effectiveness evaluation) were, however, given much more formal emphasis.

As a first step, each project was required to set up a project structure to organize,

Table 5-6.

*Examples of ASAP Countermeasures*

| *Enforcement* | *Judicial and Legislative* | *Presentence Investigation and Probation* | *Rehabilitation* | *Public Information and Education* |
|---|---|---|---|---|
| • Special training for police officers | • Special seminars for prosecutors, judges, and legislators | • Special seminars for presentence investigators and probation personnel | • DWI schools | • Attitude surveys about drinking and driving |
| • DWI patrols and task forces | • Additional staff and support for DWI adjudication | • Additional staff | • Group therapy | • Mass media campaigns |
| • Improved methods for processing DWIs | • Special legislation to support health/legal functions (e.g., *per se* laws) | • New PSI techniques | • Referral to community treatment agencies | • Speakers bureau |
| • Special equipment to support DWI enforcement activities (e.g., breath testing equipment) | • Improved methods for processing DWIs | • Wider use of PSI | • Referral to NIAAA-sponsored Alcoholism Centers | |
| | | • Improved record systems for monitoring DWIs on probation | | |

Source: McKnight, Adams, and Personeus 1971; U.S. Department of Transportation 1975a

plan, control, operate, and evaluate its activities (McKnight, Adams, and Personeus 1971). This seemingly simple and straightforward direction provided, in one step, the most essential missing ingredient in most prior alcohol safety programs. A project director, responsible for coordinating all aspects of the project, was placed in charge of the organization and was supported by project staff who led the activities of the various countermeasure areas.

Next, it was required that each project establish a hierarchy of activities breaking down each element of project effort into smaller elements for assignment of resources and for scheduling. The term used by ASAP to describe this technique (Work Breakdown Structure) had long been used in aerospace programs to describe the build-up of components and subsystems (e.g., electronic gear, rocket engines) that culminated in a total aircraft or guided missile system (Air Force Systems Command Manual 1966). Responsibilities for developing and operating the various elements of the Work Breakdown Structure (WBS) were assigned to members of the project staff and to participating agencies.

The WBS became an integral part of a detailed project plan that described key activities, events, schedules, and costs for accomplishing specific objectives of the project. The plan was required to contain what nearly always had been missing from previous programs, a detailed description of the functions to be performed by each element of the local drinking-driver control system. Further, each function was to be related to other functions in the form of a system flow chart, thus providing a rough approximation to the Systems Requirements Analysis methodology that was the central unifying feature of the aerospace systems approach as applied by Simon Ramo and other "space age" systems engineers (Air Force Systems Command Manual 1966; McKnight, Adams, and Personeus 1971; Ramo 1971). The plan also had to describe the "data system" which would support the project (i.e., kinds of data, data flow, related equipment, facilities, and personnel).

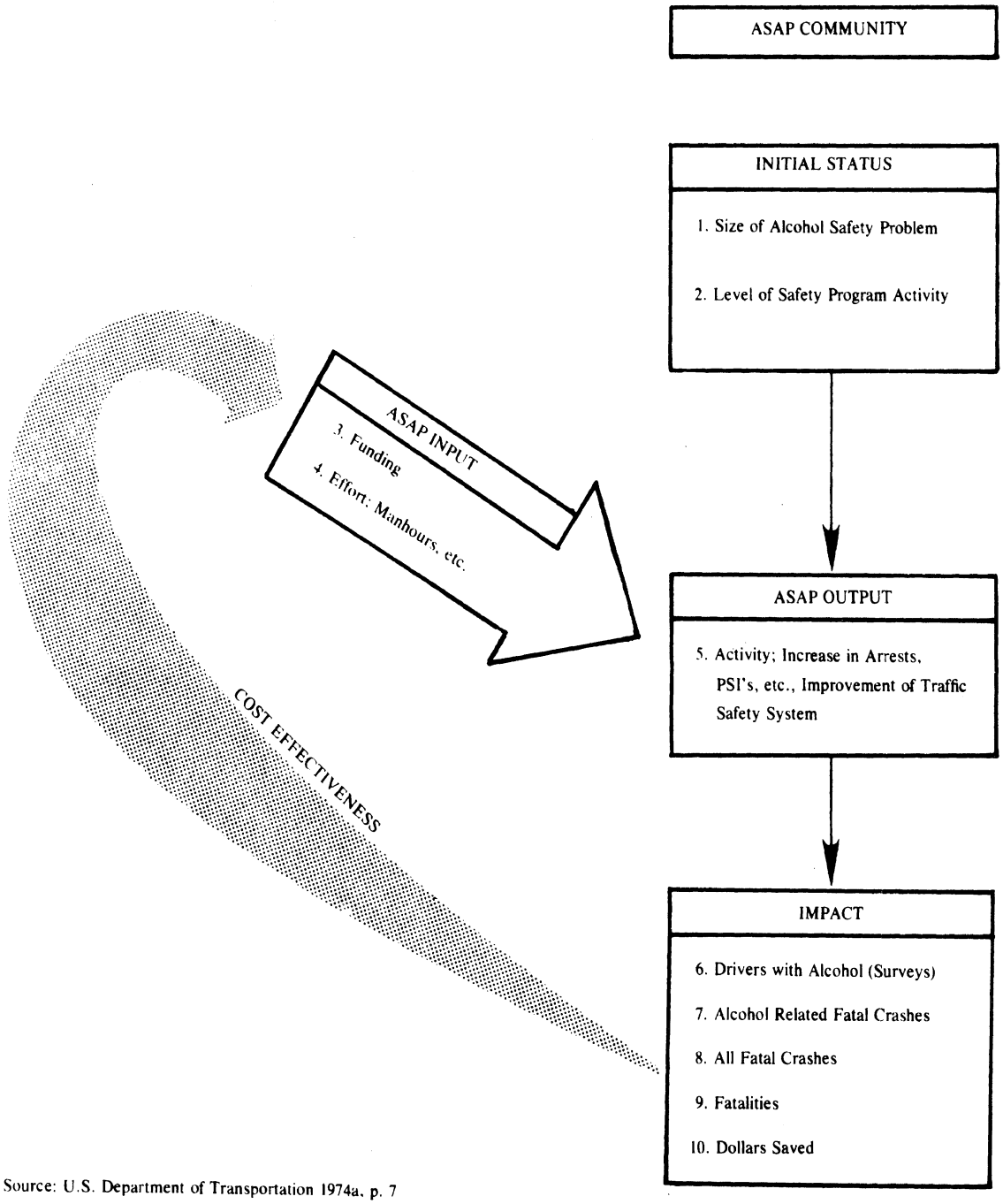
Extensive reporting requirements were established for the ASAPs. Each project was required to submit quarterly and annual reports to OAC showing how actual activities, schedule, and cost compared with those planned. Various reports related to project evaluation also had to be prepared (McKnight, Adams and Personeus 1971).

Evaluation was an integral part of ASAP from the start. Detailed evaluation requirements were placed on the individual sites, first in an "ASAP Evaluation Manual" (Promisel, Blomberg, and Oates 1971) and later in a more explicit "January 1973 Guidelines for ASAP Evaluation" (U.S. Department of Transportation 1973). The latter document required the sites to submit to OAC the following information:

- baseline data on crashes, BACs of fatally injured and arrested drivers, DWI patrol activity, and DWI case disposition,
- data on home and roadside surveys, financial expenditures, personnel and measures of outcome of the specific countermeasures and of the total project, and
- analytic studies it had conducted to determine the effectiveness and cost-effectiveness of each countermeasure activity and of the total project.

The evaluation philosophy of ASAP was based on a "chain of action" approach (see Figure 5-9).

Figure 5-9. ASAP's "A chain of action" approach to evaluation




Source: U.S. Department of Transportation 1974a, p. 7

First, an assessment was made of the severity of the alcohol-crash problem and the intensity of the safety program prior to the initiation of ASAP activity. Next, ASAP input in terms of dollars and effort was related to the problem (e.g., dollars invested per alcohol-related fatal crash) and to existing safety program efforts. The output of ASAP in terms of countermeasure activity (e.g., increase in number of persons arrested for DWI) was then measured and compared to the investment in order to obtain an estimate of the degree to which additional resources generated additional activity. Finally, an attempt was made to determine the impact of all the increased spending and activity on the alcohol-crash problem itself. These impacts were measured in terms of a number of variables, including reduction in number of drivers with high BACs using the road, reduction in alcohol-related crashes, and reduction in total highway crash fatalities. By assigning a dollar figure to the value of a human life to society ($200,000), the benefits of ASAP were calculated and compared to its cost.

The evaluation regimen imposed on the individual ASAPs was important from a systems standpoint because of its emphasis on the objectives of the project. It made it necessary for project (and OAC) personnel to think in terms of the purposes of their countermeasures and to relate project activities to those purposes.

### *5.6.3 Evaluation of ASAP*

The first results of ASAP's systems approach were published in the Alcohol Safety Action Projects Evaluation of Operations—1974 (U.S. Department of Transportation 1974a). The data were taken from eight projects that had collected three years of "baseline" data (i.e., before the start of ASAP operations) and two years of "operation" data (i.e., after the start of operations). In addition, there were three years of baseline data and one year of operational data from 21 sites that were initiated a year later than the first eight sites.

OAC followed its chain of action approach in analyzing these data. Figure 5-10 summarizes the results obtained using data from the first year of operation of 29 sites. A "proxy" measure, *night fatals in crashes*, was used as an indicator of the severity of the alcohol-crash problem prior to ASAP and the ultimate impact of ASAP. This was done because of the lack of reliable data (despite extensive evaluation reporting requirements) which would provide more direct measures (e.g., BACs of fatally injured drivers). Night fatals in crashes was considered a reasonable measure because of findings from research studies indicating larger percentages of high BAC drivers in such crashes, and also because of ASAP emphasis on nighttime drivers as a target group.

The data indicate a wide variation in the initial status of the projects, both with respect to the extent of the alcohol-crash problem and to the effort being expended in dealing with that problem. Night fatals in crashes were as low as six per 100,000 licensed drivers per year and as high as 24 per 100,000 licensed drivers per year. Arrest rates for DWI varied from essentially 0 per 1,000 licensed drivers per year in one jurisdiction to 15 per 1,000 licensed drivers per year in two jurisdictions. No correlation was found to exist between nighttime fatals and enforcement activity prior to ASAP.

After an ASAP investment predicted to be about $6.40 per licensed driver over the 3½ year period of each ASAP, large increases in alcohol-safety activities occurred. DWI arrests rose more than 100% overall and 60% of those arrested were "processed"

Figure 5-10. Data on First Year Impact for 29 ASAPs: "Chain of Action" Analysis Showing Individual Project

| Project | Size of ASAP Site | Initial Status of ASAP Community Baseline Period | | | | ASAP Imput | | ASAP Output Operational Period | | | | | | Impact on ASAP Community Operational Period | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A/R Crash Problem | | Level of Safety Program Activity | | | | Enforcement Activity | | | Judicial and Rehabilitation Activity | | | | | |
| | 1. Licensed Drivers × 1,000 | 2. Night Fatal Crashes | 3. $\frac{\text{Night Fatal Crashes}}{\text{Licensed Drivers}} \times 100{,}000$ | 4. Alcohol-Related Arrests | 5. $\frac{\text{A/R Arrests}}{\text{Licensed Drivers}} \times 1{,}000$ | 6. Funding 3-1/3 Years | 7. $\frac{\text{Dollars}}{\text{Licensed Drivers}}$ | 8. % Increase A/R Arrests | 9. Alcohol-Related Arrests | 10. $\frac{\text{A/R Arrests}}{\text{Licensed Drivers}} \times 1{,}000$ | 11. % Court Processed | 12. % Presentence Investigation | 13. % Entered Rehabilitation | 14. Night Fatal Crashes | 15. $\frac{\text{Night Fatal Crashes}}{\text{Licensed Drivers}} \times 100{,}000$ | 16. % Increase in Night Fatal Crashes |
| Albuquerque, NM | 269 | 34 | 13 | 987 | 4 | 1,482 | 6 | 76 | 1,737 | 7 | 66 | 66 | 52 | 39 | 15 | +15% |
| Charlotte, NC | 236 | 37 | 16 | 2,065 | 9 | 1,950 | 8 | 27 | 2,615 | 11 | 45 | 22 | 21 | 35 | 15 | −5 |
| Denver, CO | 630 | 60 | 10 | 2,626 | 4 | 1,720 | 3 | 122 | 5,829 | 9 | 68 | 32 | 22 | 54 | 9 | −10 |
| Nassau Co., NY | 874 | 79 | 9 | 2,047 | 2 | 1,502 | 2 | 23 | 2,528 | 3 | 69 | 0 | 30 | 78 | 9 | −1 |
| Portland, OR | 335 | 31 | 9 | 1,612 | 5 | 2,150 | 6 | 67 | 2,691 | 8 | 56 | 47 | 30 | 22 | 7 | −29 |
| Seattle, WA | 678 | 94 | 14 | 4,596 | 7 | 1,923 | 3 | 62 | 7,466 | 11 | 65 | 41 | 21 | 72 | 11 | −23 |
| Washtenaw Co., MI | 130 | 31 | 24 | 677 | 5 | 1,644 | 13 | 55 | 1,048 | 8 | 84* | 84 | 65 | 29 | 22 | −6 |
| Wisconsin | 111 | 22 | 20 | 290 | 3 | 1,749 | 16 | 129 | 663 | 6 | 100* | 100 | 100 | 20 | 18 | −9 |
| Baltimore, MD | 738 | 70 | 10 | 2,532 | 3 | 2,626 | 4 | 60 | 4,051 | 5 | 66 | 6 | 8 | 78 | 11 | +11 |
| Boston, MA | 275 | 48 | 18 | 748 | 3 | 2,489 | 9 | 17 | 874 | 3 | 29 | 27 | 17 | 44 | 16 | −8 |
| Cincinnati, OH | 509 | 39 | 8 | 460 | 1 | 2,208 | 4 | 532 | 2,906 | 6 | 57 | 48 | 28 | 41 | 8 | +5 |
| Columbus, GA | 100 | 9 | 9 | 1,469 | 15 | 1,590 | 16 | 153 | 3,722 | 37 | 41 | 3 | 21 | 8 | 8 | −11 |
| Fairfax Co., VA | 265 | 39 | 15 | 75 | 0 | 2,130 | 8 | 3,824 | 2,943 | 11 | 91 | 80 | 91 | 36 | 14 | −8 |
| Hennepin Co., MN | 537 | 42 | 8 | 3,414 | 6 | 2,511 | 5 | 53 | 5,233 | 10 | 41 | 30 | 29 | 36 | 7 | −14 |
| Indianapolis, IN | 220 | 29 | 13 | 1,309 | 6 | 2,600 | 12 | 242 | 4,474 | 22 | 32 | 26 | 14 | 31 | 14 | +7 |
| Kansas City, MO | 284 | 46 | 16 | 2,463 | 9 | 2,200 | 8 | 105 | 5,054 | 18 | 93* | 93 | — | 49 | 17 | +7 |
| Lincoln, NB | 99 | 6 | 6 | 375 | 4 | 1,600 | 16 | 148 | 930 | 9 | 59* | 59 | 57 | 5 | 5 | −17 |
| Maine | 302 | 29 | 10 | 1,236 | 8 | 2,013 | 7 | 94 | 2,401 | 8 | 69 | 10 | 7 | 23 | 8 | −20 |
| New Hampshire | 462 | 78 | 17 | 2,677 | 6 | 1,799 | 4 | 106 | 5,528 | 12 | 60 | 6 | 4 | 72 | 16 | −8 |
| New Orleans, LA | 255 | 47 | 18 | 1,520 | 7 | 2,700 | 11 | 177 | 4,217 | 17 | 48 | 27 | 22 | 33 | 13 | −30 |
| Oklahoma City, OK | 213 | 30 | 14 | 1,646 | 8 | 2,600 | 12 | 121 | 3,635 | 17 | 39 | 22 | 21 | 37 | 17 | +24 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Phoenix, AZ | 458 | 46 | 10 | 6.696 | 15 | 2.200 | 5 | 51 | 10.095 | 22 | 50* | 50 | 47 | 51 | 11 | +11 |
| Pulaski Co., AR | 184 | 19 | 10 | 963 | 5 | 2.095 | 11 | 498 | 5.759 | 31 | 97* | 97 | 25 | 19 | 10 | 0 |
| Richland Co., SC | 130 | 23 | 18 | 1.351 | 10 | 2.300 | 18 | 99 | 2.682 | 21 | 35 | 7 | 10 | 16 | 12 | -30 |
| San Antonio, TX | 207 | 47 | 23 | 1.130 | 6 | 2.206 | 11 | 373 | 5.346 | 26 | 42 | 14 | 13 | 51 | 25 | +9 |
| South Dakota | 401 | 91 | 23 | 1.667 | 4 | 2.012 | 5 | 82 | 3.640 | 9 | 58 | 56 | 29 | 108 | 27 | +19 |
| Tampa, FL | 282 | 58 | 21 | 1.420 | 5 | 2.300 | 8 | 340 | 6.249 | 22 | 68* | 36 | 68 | 64 | 23 | +10 |
| Vermont | 123 | 16 | 13 | 734 | 6 | 2.214 | 18 | 26 | 928 | 8 | 77 | 52 | 66 | 15 | 12 | -6 |
| Wichita, KS | 207 | 24 | 12 | 739 | 4 | 2.100 | 10 | 72 | 1.272 | 6 | 60* | 60 | 43 | 20 | 10 | -7 |
| GRAND TOTAL | 9.514 | 1.223 | | 48.790 | | 60.613 | | | 106.516 | | | | | 1.186 | | |
| MEAN | 328 | 42 | 12.9 | 1.682 | 5.1 | 2.090 | 6.4 | 118 | 3.673 | 112 | 60 | 39 | 28 | 41 | 12.5 | -3 |

Source: U.S. Department of Transportation 1974a, p. 14–15.

KEY to Figure 5-10.

Column Number

I. PROJECT SIZE:
- Licensed drivers, base year, in thousands — 1

II. INITIAL STATUS:
- a) Alcohol-related crash problem
  - 1. Average annual nighttime (8 pm to 8 am) fatal crashes, base years (first 8, 1968–70; second 21, 1969–71) — 2
  - 2. Nighttime fatal crashes per 100,000 licensed drivers, base years (Col. 2 divided by Col. 1) — 3
- b) Level of safety program activity
  - 1. Total alcohol-related arrests, base year (first 8, 1970; second 21, 1971) — 4
  - 2. Alcohol-related arrests per 1,000 licensed drivers, base year (Col. 4 divided by Col. 1) — 5

III. ASAP INPUT
- a) Funding
  - 1. Total budgeted for 3½ years in thousands of dollars — 6
  - 2. Budgeted dollars per licensed driver (Col. 6 divided by Col. 1) — 7

IV. ASAP ACTIVITY
- a) Enforcement activity
  - 1. Percent increase in total alcohol-related arrests (Col. 9 minus Col. 4 divided by Col. 4) — 8
  - 2. Total alcohol-related arrests, operational year (first 8, 1971; second 21, 1972) — 9
  - 3. Alcohol-related arrests per 1,000 licensed drivers, operational year (Col. 9 divided by Col. 1) — 10
- b) Judicial and rehabilitation activity
  - 1. Percent of drivers arrested in 1972 who were processed by the courts. (Number of convictions. For starred figures the number of PSIs (Col. 12) or entries to treatment (Col. 13) if higher than the number of convictions was used to estimate number processed.) — 11
  - 2. Percent of drivers arrested in 1972 given presentence investigations — 12
  - 3. Percent of drivers arrested in 1972 entering rehabilitation programs — 13

V. IMPACT
- a) Nighttime (8 pm to 8 am) fatal crashes, operational year (first 8, 1971; second 21, 1972) — 14
- b) Nighttime fatal crashes per 100,000 licensed drivers, operational year (Col. 14 divided by Col. 1) — 15
- c) Percent increase in nighttime fatal crashes (Col. 14 minus Col. 2 divided by Col. 2) — 16

(i.e., either convicted, given presentence investigations, or referred to rehabilitation) by the courts.

The increases in activity were not, however, reflected in proportionate decreases in night fatal crashes. On the average, night fatal crashes per licensed driver per year decreased from 12.9 to 12.5, or about 3%. No correlation was found between activity and impact. Further analyses of night fatal crashes, using sophisticated statistical techniques (i.e., the interrupted time series analysis similar to that which had been used previously by Ross [1973] in interpreting the results of the British Road Safety Act of 1967) indicated a statistically significant reduction in such crashes for sites with two years operational experience but no significant reduction for sites with only one year of operation. By contrast, the overall trends of night fatal crashes in the reporting states were said to be upward rather than downward. Similar results were obtained for *total* fatal crashes, that is, a statistically significant decrease in total fatal crashes for sites that had been operating for two years, but no significant decrease for sites that had been operating for only one year. It was estimated that ASAP resulted in from 64 to 174 lives saved over a period of two years in the eight initial sites. This was converted to a dollar savings to society of from 13 to 35 million, compared to an outlay of approximately 14 million dollars over 3½ years.

The chain of action approach requires that an effective safety program reduce the number of high BAC drivers on the road as well as those in crashes. ASAP-required roadside surveys, conducted at 19 sites just before and one year after the start of operations, found statistically significant reductions in percentages of drivers in three "high" BAC categories (see Table 5-7).

An obvious deficiency in the first ASAP evaluation of operations (and one that was pointed out in the NHTSA report) was the lack of control groups as a basis for comparison of the outcomes experienced at the ASAP sites. To be able to infer ASAP *causation* of the results obtained, it is necessary to show that similarly constituted jurisdictions *without* ASAP countermeasures did not enjoy similar reductions in drinking-drivers using the roads, night fatal crashes, etc. ASAP evaluation designs did not incorporate such control groups.

In 1974, Zador (1976) attempted to correct this deficiency "by comparing year-to-year variations in fatality statistics between groups of areas with ASAPs and comparison groups of areas without ASAPs." In his analysis, Zador placed 28 ASAP areas into 13 groups, five groups containing the eight ASAPs that began in 1971 and eight groups containing the 20 ASAPs that began in 1972. Factors for selecting comparison groups included geographical location, population size, and population growth rate. A statistical model was used to test whether the ratio of fatalities in an ASAP area to the combined fatalities in the ASAP area and its comparison area changed systematically from year-to-year.

The results of the test (see Tables 5-8 and 5-9) indicated that there were no systematic fluctuations and, specifically, no systematic reduction of the proportion of fatalities in ASAP areas after the introduction of the program. The year-to-year fluctuations were found to be no larger than would have been expected on the basis of chance alone. Moreover, Zador found that the decreases in the proportion of night fatal crashes to day fatal crashes in ASAP areas, while statistically significant, were equally present in the

TABLE 5-7.

*Reduction in Drinking Drivers Using the Road But Not in Crashes After One Year of Operation at 19 Sites*

| *Time of Measurement* | *BAC* .05%–.09% w/v | .10%–.14% w/v | .15% and Above |
|---|---|---|---|
| Just before ASAP | 8.0* | 3.1 | 1.8 |
| 1 year after start of ASAP | 7.6 | 2.9 | 1.4 |

*Numbers in cells are % of drivers tested
Source: U.S. Department of Transportation 1974a

comparison areas. He concluded the ASAP countermeasures could not have been responsible for the observed reductions in the ratio of night fatal crashes to day fatal crashes, and that "ASAPs, as large-scale social programs, have been ineffective" (Zador 1976, p. 48).

The latest NHTSA report on its evaluation of ASAP (U.S. Department of Transportation 1975a) did not follow the "chain of action" format in presenting its results. Various measures of ASAP activity and output in the separate countermeasure areas extracted from the NHTSA report have, in any case, already been presented in other sections of this report and will not be repeated here. It is sufficient to say that no large changes in the nature or intensity of project activity were apparent during the period between the publication of the evaluation reports for 1972 and 1974.

However, the availability of additional data on the highway safety impact of ASAP has permitted an extension of the previous effectiveness analysis which is pertinent to the evaluation of the systems approach. Specifically, these data make it possible to analyze the impact of the 21 later ASAPs after two years of operation rather than only one year as was done in the earlier evaluation.

TABLE 5-8

*Annual Proportions* of Fatalities in Areas with ASAPs that began in 1972*

| *Group* | *Year* 1969 | 1970 | 1971 | 1972 |
|---|---|---|---|---|
| | | *Pre ASAP* | | *During ASAP* |
| 1 | .30 | .26 | .24 | .28 |
| 2 | .46 | .46 | .48 | .49 |
| 3 | .46 | .42 | .45 | .45 |
| 4 | .40 | .42 | .41 | .38 |
| 5 | .60 | .60 | .57 | .55 |
| 6 | .42 | .39 | .40 | .42 |
| 7 | .27 | .26 | .36 | .37 |
| 8 | .45 | .48 | .47 | .43 |
| All | .440 | .429 | .438 | .437 |

*Numbers shown are ratio of fatalities in an ASAP Area to combined fatalities in the ASAP Area and its comparison area.
Source: Zador 1976

TABLE 5-9

*Annual Proportions* of Fatalities in Areas with ASAPs that began in 1971*

| *Group* | *Year* | | | | |
|---|---|---|---|---|---|
| | Pre ASAP | | | During ASAP | |
| | 1968 | 1969 | 1970 | 1971 | 1972 |
| 1 | .31 | .30 | .30 | .29 | .31 |
| 2 | .23 | .28 | .30 | .27 | .28 |
| 3 | .53 | .59 | .60 | .55 | .55 |
| 4 | .28 | .27 | .35 | .29 | .34 |
| 5 | .27 | .24 | .25 | .25 | .25 |
| All | .321 | .339 | .350 | .329 | .339 |

*Numbers shown are ratio of fatalities in an ASAP area to combined fatalities in the ASAP area and its comparison area.

Source: Zador 1976

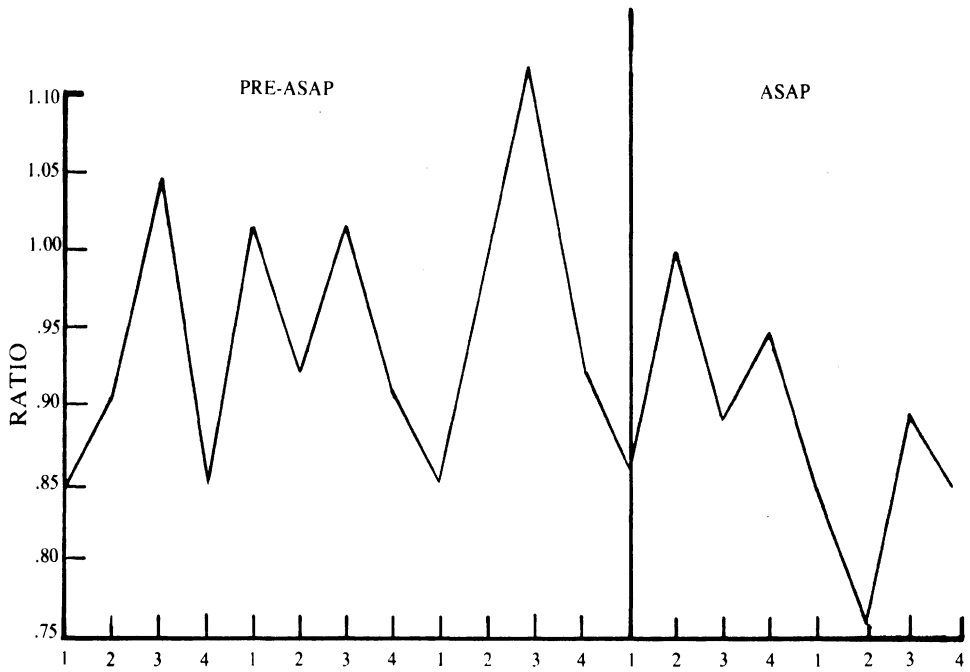
The ratio of night fatal crashes to day fatal crashes for the 29 sites with two years of operational experience is shown graphically in Figure 5-11. While the night-to-day ratios appear to decrease in the operational period, the report stated that the limited number of data points did not permit application of time series techniques to obtain "meaningful" results. However, a statistical analysis of the pre-ASAP and ASAP periods was said to show that the night-to-day ratios differed significantly for the two periods.

The 1974 evaluation found no significant decreases in the higher ranges of the BAC distribution of drivers using the roads but not involved in crashes. However, the percentage of drivers in the lower BAC ranges decreased, indicating to the evaluators that the program might have had an impact on the social drinker-driver but very little impact on the problem drinker-driver.

The 1974 ASAP report (U.S. Department of Transportation 1975a) also responded to Zador's criticism of NHTSA's previous evaluation, stating that his "control" groups were actually comparison groups that did not adequately match the ASAP groups. NHTSA stated that "special traffic safety activities conducted during the demonstration period represent serious confounding effects not considered in the conclusions drawn" and that "comparison groups matched solely on total population and population rates of growth as used in the (Zador) study are not sufficient" (U.S. Department of Transportation 1975a, ch. 1 p. 4).

A later response to Zador by Johnson et al. (Johnson, Levy, and Voas 1976) questioned his conclusion that the ASAPs were ineffective "as large scale social programs," because his analysis only tested the hypothesis that ASAP reduced fatalities and made no test of the "broader social, catalytic organization impacts of ASAP." Johnson et al. also stated that Zador's analysis was not sensitive enough to detect reductions in alcohol-related crashes of less than 20% (Johnson, Levy, and Voas 1976). In a recent article (Zador 1977), Zador repudiated NHTSAs criticisms and held to his original conclusions about ASAP's ineffectiveness as a large-scale social program.

Figure 5-11. Ratio of night fatal crashes to day fatal crashes for 29 ASAPs




Source: U.S. Department of Transportation 1975a, ch. 1, p. 35

## 5.7 SUMMARY AND CONCLUSIONS

Formal, programmatic responses to the alcohol-crash problem have nearly always been aimed at modifying driver behavior so as to prevent crashes, rather than at protecting automobile occupants during the crash or caring for them afterward. First, a *legal approach* used the mechanisms of the criminal justice system to try to deter drinking-driving through the threat of punishment. Next, increased understanding that many drinking-drivers had a drinking problem that could not be solved by punitive measures led to a *health approach*. This approach has often used the agencies of the criminal justice system as case-finders and classifiers of drinking-drivers so that the drivers would receive the most appropriate treatment, and, as such, has been called a *health/legal approach*.

All of these approaches have relied heavily on the support of a *public information and education approach* which has sought to advise the public on the crash risk inherent in drinking-driving, on the risk of apprehension and punishment for drunk-driving, on the nature of the alcohol-crash problem, and on actions that an individual could take to help solve the problem. Essential support has also been given through a *technological approach* which has provided devices and techniques (i.e., breath-alcohol analysis) for a more objective indication of alcohol-impairment.

During the early 1970s, NHTSA's Alcohol Safety Action Projects (ASAPs) sought to tie all of these approaches together into a comprehensive, integrated *systems approach* which treated the many facets of the problem as a single process. The approach used

concepts and techniques that had been developed for aerospace applications of "hard" technology, but had seldom been applied to societal "systems" of the type that have traditionally dealt with the drinking-driver.

Specific target groups for past alcohol-safety programs were ill-defined before ASAP directed its legal component toward the social drinking-driver and its health/legal component toward the problem drinking-driver. ASAP reasoned that the threat of punishment could have no effect on individuals who had "lost control" of their drinking and that only treatment of their underlying drinking problems could substantially reduce their involvement in alcohol-related crashes. At the same time, ASAP accepted the hypothesis that traditional sanctions and driver education, properly implemented, would be effective for the social drinking-driver.

A lack of adequate evaluation makes it virtually impossible to say unequivocally whether any of the above approaches have actually worked in reducing crash losses caused by alcohol-impaired drivers. Few alcohol-safety programs have conducted rigorous evaluations of their efforts. The use of an important ingredient for analyzing cause and effect relationships, the control group, has been rare, and its one application, by Zador (1976), after the fact, to a large-scale program (ASAP) has not been conclusive. Lacking a reliable inventory of what has worked and what has not worked, the program designer has had to rely on his own best judgment based on available fragmented bits of information of questionable or unknown reliability. There is no evidence that even these subjective determinations have been made in any methodical or systematic way.

The oldest response to the alcohol-crash problem, the legal approach is based on the hypothesis that the threat of punishment will deter the social-drinking driver. Yet, in only one instance (the British Road Safety Act of 1967) is there strong evidence that the hypothesis may actually be true and even there, one cannot be sure why the approach worked and what levels of what kind of activities conducted in what environment would be effective again. It is not yet clear whether relatively severe and sure punishments in the Scandinavian countries have had a significant positive effect on the problem. The ASAP experience provides no convincing evidence that even several-fold increases in enforcement levels in the U.S. will decrease rearrest rates for DWI.

A similar, if not worse, situation exists with respect to the health and health/legal approaches. Here, only the most limited applications (e.g., Lackland Air Force Base) have provided strong evidence of success. More widespread applications (e.g., ASAP) have provided some indication that problem drinker-drivers can be successfully identified and processed, but do not offer a sufficient basis for concluding that the resulting treatments (including DWI schools) will have a significant positive impact on the alcohol-crash problem.

Public Information and Education (PI&E) approaches have often been shown to be effective in conveying information, but there is little evidence that they, alone, have changed either attitudes or behaviors. When used in combination with other approaches (e.g., the legal approach as in the British Road Safety Act, or the health approach as in the Lackland Air Force Base program) there are fairly strong indications that PI&E campaigns have been a major factor in the reductions of alcohol-related crashes attributed to these approaches. Research and operational experience suggest, in fact, that one reason why some applications of the legal approach have not had much success in

reducing alcohol-related crash losses may be the lack of a strong PI&E component to promote general deterrence. There is also some evidence that PI&E campaigns are more effective in increasing knowledge about alcohol and highway safety when used in combination with other approaches.

Breath-alcohol analysis technology has had an enormous impact on the entire field of alcohol safety, providing a relatively convenient means for quantifying what is certainly the most important single variable describing alcohol-impairment: blood alcohol concentration. Without the technique, it is doubtful that either the legal or the health/legal approaches, as known today, would be possible. If the use of screening breath-testers becomes widespread, a very large impact on DWI enforcement could follow, possibly resulting in a higher fraction of social-drinker drivers being arrested and a more discernible deterrent effect. Other technological approaches (e.g., the "sober pill") could, if successful, have an even greater impact on the alcohol-crash problem, perhaps causing major shifts of emphasis and changes in program design among the various approaches.

The full results of NHTSA's ambitious Alcohol Safety Action Projects may not be described, analyzed, and digested for several more years. Present indications are that the program's methodology, the systems approach, may have a greater long-term impact on the alcohol-crash problem than its substantive actions will have. Results reported to date indicate that, on the whole, the systems approach as practiced by ASAP brought a higher degree of coordination and consistent objectivity into the field of alcohol countermeasures than existed before. ASAP's failure, thus far, to provide convincing evidence of a significant highway safety impact may be due more to the present primitive states of the technologies of drinking-driver behavior modification and alcoholism treatment than to the process by which that technology is applied.

With regard to responses to the alcohol-crash problem as a whole, the lack of a fundamental scientific or empirical basis for choosing among the various approaches is indicative of the current state-of-the-art of the field. The three major approaches, legal, health, and systems, are based on hypotheses that, while logical and appealing to reason, simply are not supported at the operational level by the available data. As a general proposition, one can accept the theory that the presence of a credible threat of suitably unpleasant punishment will deter social drinker-drivers. Unfortunately, past experience has not provided a practical operational definition of the components of such a threat or of the level of activity that would be required to achieve the desired results. Nor has it been satisfactorily demonstrated that a deterrent threat can be achieved without becoming more burdensome to society than the alcohol-related crashes it seeks to prevent.

Similarly, it is entirely reasonable to believe that problem drinker-drivers should be treated rather than punished and that use of a combined health/legal approach, employing space-age systems management techniques, could result in effective administration of such a program. The problem in applying this theory is one of determining what treatments will be effective for what classes of drivers under what circumstances. Past experience has provided little evidence that any feasible treatment program will have a significant impact on the alcohol-crash problem.

Thus, there are significant problems to be overcome in improving society's response to the alcohol-crash problem. At the research level, efforts must be undertaken to

determine how deterrent programs can be designed to prevent and how treatment programs can be designed to cure drinking driving. The specific requirements for feasible applications of the prevention and treatment approaches must be stated in operationally useful terms. At the same time, new approaches should be explored to provide new directions and a needed transfusion to the old approaches. Pending the generation of this new knowledge, there is no apparent justification for the implementation of new, large-scale operational programs. This, of course, does not imply that all operational programs which employ past approaches should immediately cease or that the exploration of new approaches should take place entirely in a laboratory setting uncontaminated by real-world influence. It means that proposed methods for dealing with the alcohol-crash problem should be regarded as hypotheses until they are adequately tested and evaluated, and that such tests and evaluations should most prudently be conducted on the smallest practicable scale.

# 6.0 FUTURE DIRECTIONS OF THE ALCOHOL-CRASH PROBLEM

Up to this point, the emphasis of this report has been on the alcohol-crash problem of the past, and an attempt has been made to summarize the state of knowledge about that problem as of the mid-1970s. In this section some speculations are made about alcohol and highway safety in the mid-1980s. Specifically, the expected magnitude of the problem and likely changes in the nature of the problem over the next 10 years are briefly discussed. Following this, the "state-of-the-art" of ways of dealing with this problem is reexamined to see what advances are needed to reduce the losses to society from alcohol-related highway crashes.

## 6.1 THE ALCOHOL-CRASH PROBLEM IN THE 1980s*

In order to estimate the future value of a variable, it is necessary to have data describing that variable at past points in time. Various techniques are available for projecting such historical data into the future (Kahn and Wiener 1967). Thus, given data describing, say, the fraction of fatal crashes involving drunk drivers at various points of time over the past 20 years, extrapolations could be made to obtain an estimate of the fraction of fatal crashes involving drunk drivers 10 years hence. Unfortunately, such direct historical data do not exist in the field of alcohol and highway safety, and one must resort to projecting indirect variables thought to be related to the variables of interest. Examples of these indirect variables are those describing drinking patterns and age distributions of drivers. Obviously, since the relationships between the direct variables and the indirect variables have not been precisely defined at any past point in time (see section 4.0) one cannot expect to obtain a precise estimate of the direct variables at some future time by projecting indirect variables.

In this section, several indirect variables suggested by past research to be related to direct variables of interest are briefly considered to see how they might change over the next 10 years and to get a rough idea of the effects of such changes on the alcohol-crash problem.

*This section is based on a recent paper published in *The HSRI Research Review* (Jones 1977).

### 6.1.1 Highway Crashes in General

Since the alcohol-crash problem is often stated in terms of highway crashes in general, it is germane to note that most recent studies (Andon et al. 1975; Energy Resources Council 1976; U.S. Department of Transportation 1975b; U.S. Department of Transportation 1976) of the Highway Transportation System of the 1980s project fairly large increases (the order of 50%) in highway crashes in the 1975–1985 time period. Two major factors contributing to these increases have been stated as:

- a larger number of small cars in the vehicle fleet, increasing the severity of the injuries to occupants of smaller cars colliding with larger cars and
- more licensed drivers driving about the same number of miles per year per driver, resulting in a larger number of vehicle miles travelled.

The studies agree that even larger increases in number of crashes could be expected if speed distributions were to return to the levels that occurred before the imposition of the 55 mph speed limit.

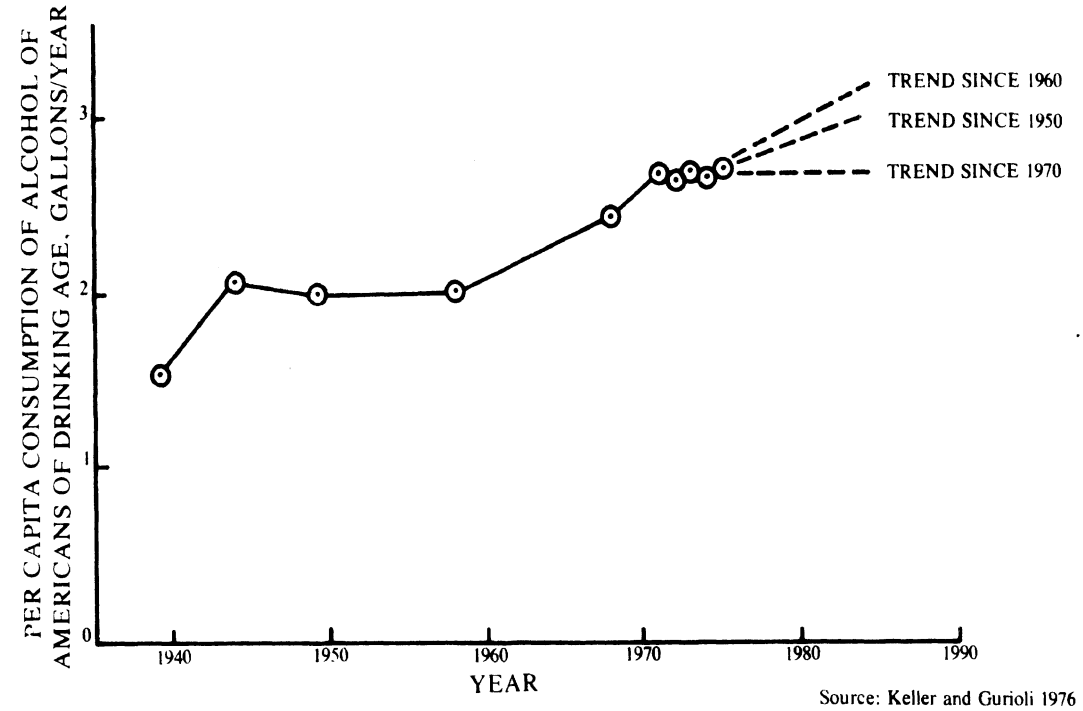
### 6.1.2 Crashes Involving Alcohol

The most obvious factor related to the alcohol-crash problem of the 1980s is alcohol consumption. If alcohol consumption per capita were to increase and such an increase were reflected in an increase in the BAC of drivers and pedestrians using the road, then an increase in alcohol-related crashes would be expected. Actually, per capita consumption of alcohol has been increasing steadily over the past 15 years and could reasonably be expected to continue its rise well into the next decade (Figure 6-1).

Unfortunately, research does not provide a sufficient basis for determining the relationship between alcohol consumption and crashes. In fact, a recent study by Smart (1976) concluded that it was "most probable that drinking in the general population and in the driving population simply are not significantly related." By contrast, NHTSA (U.S. Department of Transportation 1975b) assumed that any increase in per capita consumption of alcohol would be directly translated into a corresponding increase in crash losses and estimated a 5% increase in fatalities during the 1972–85 time period due to increased consumption.

Conceivably, changes in other characteristics of the driving population could also be reflected in the number of alcohol-related crashes in 1985. For example, sex has consistently been found to be the strongest differentiator between drivers with alcohol-related crashes and drivers as a whole. Drunk driving is an overwhelmingly male phenomenon, and any change in the ratio of male drivers to female drivers might be expected to result in a change in alcohol-related crashes. If present trends continue, the male/female ratio among drivers would decrease by about 7% during the 1975–1985 time period (see Figure 6-2). As a result of this effect, one would expect a corresponding *decrease* in alcohol-related crashes of no more than a few percent. Actually, any such decrease could be moderated by a growing tendency toward less rigidly defined roles for the two sexes. Thus, female drinkers who formerly were passengers could replace the drinking male in his driving role with the same, or possibly even worse, results with respect to crashes.

Figure 6-1 Projections to 1985 of alternative trends in per capita consumption of alcohol




Source: Keller and Gurioli 1976

Similarly, the predicted shift toward smaller fractions of very young and very old drivers by 1985 could also result in more alcohol-related crashes. Again, because such shifts will probably be of a relatively minor nature (Table 6-1), any resulting *increases* would probably be no more than a few percent.

Available data show that time of day and day of week are driving variables with the strongest relationships to drinking-driving patterns (see Section 4.2.2.1). Drinking drivers have been found two to four times as frequently in nighttime crashes as in daytime crashes. There are no apparent reasons why the primarily nighttime week-end nature of drinking-driving should change in the near-term future. Historical data would, in any case, be needed to estimate trends in these important driving variables, and such data are unavailable at present.

Some analysts believe that the cars and highways of the 1980s will be, on the whole, safer than they are today (U.S. Department of Transportation 1975b). Further increases in car crash-worthiness brought about by so-called "passive" measures (i.e., those not requiring driver actions to make them effective, for example, air bags) could be especially beneficial in reducing the severity of injuries in alcohol-related crashes. It is also possible that changes in the highway environment could have a larger effect on alcohol-impaired drivers and pedestrians than on unimpaired individuals. For example, single-vehicle crashes and certain types of head-on crashes (e.g., those caused by going the wrong way on a one-way road) involving drunk drivers could be reduced more than those involving unimpaired drivers. Unfortunately, the literature provides no evidence of any attempt to quantify the effects of improvements in vehicle and highway design on the alcohol-crash problem and there is no obvious way of obtaining any meaningful quantitative estimate from available data.

Figure 6-2 Projections of Percent Males of the Population of Licensed Drivers and of the Total Population, Aged 16 Years and Older

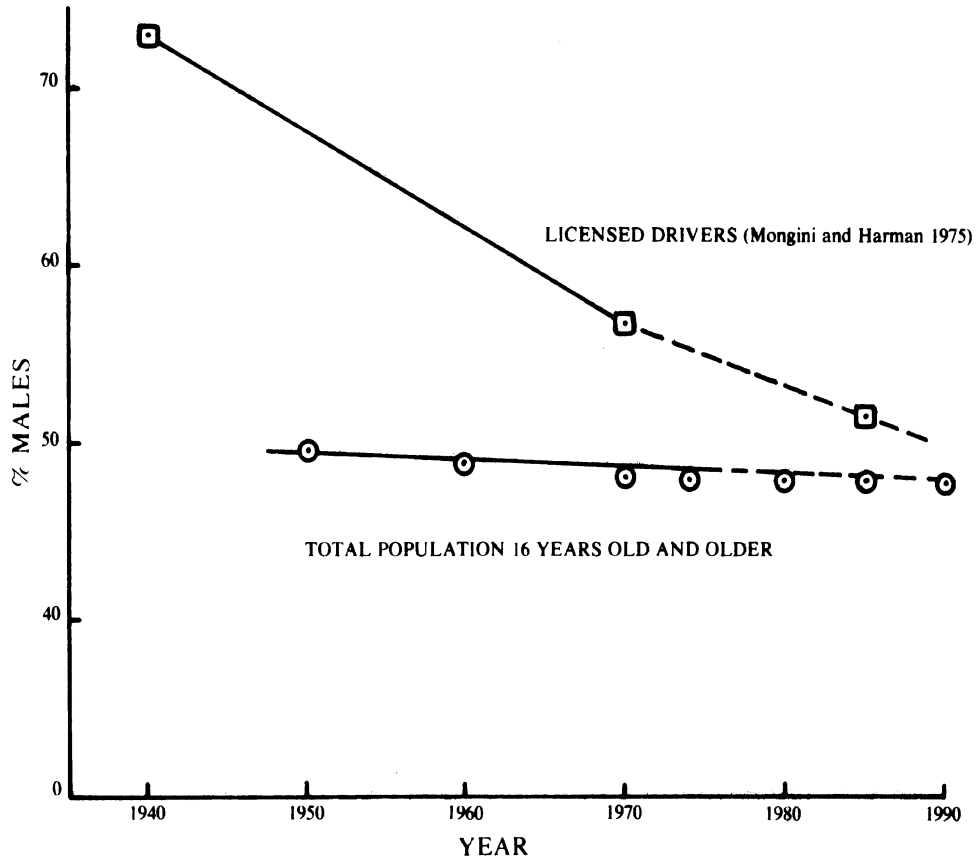


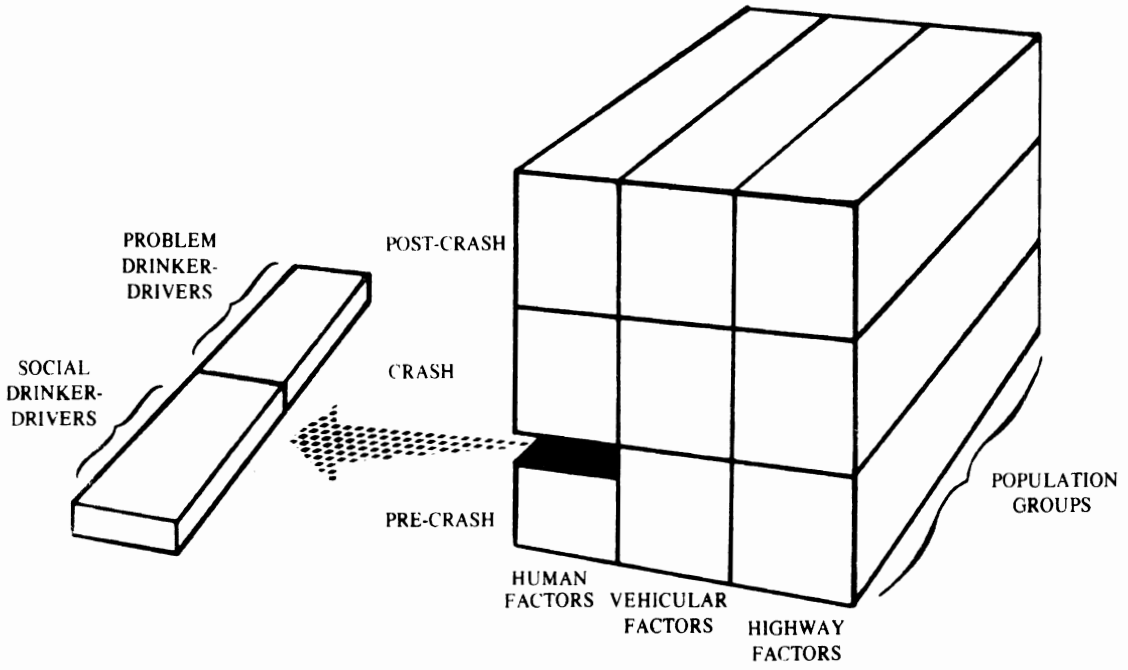

TABLE 6-1

*Age Distributions of Fatally Injured Drivers with BACs of .10% w/v and Licensed Male Drivers in 1975*

| *Age* | *Fatally Injured Drunk Drivers, %*[1] | *Male Licensed Drivers, %*[2] |
|---|---|---|
| 16–19 | 6.0 | 9.4 |
| 20–24 | 22.5 | 13.6 |
| 25–29 | 18.2 | 12.3 |
| 30–34 | 13.5 | 9.9 |
| 35–39 | 9.8 | 8.1 |
| 40–44 | 8.2 | 7.8 |
| 45–54 | 13.5 | 16.2 |
| 55–64 | 8.0 | 12.5 |
| 65–up | .2 | 10.3 |
| Total | 99.9 | 100.1 |

[1]Based on data from Filkins et al. 1970, Perrine, Waller, and Harris 1971; Waller et al. 1970
[2]Based on data from U.S. Department of Commerce 1975, U.S. Department of Transportation 1975b

Figure 6-4. Targets of past approaches to the alcohol-crash problem




The Grey Advertising survey (1975) conducted in 1975 (see Section 5.4.2) is an example of one of the more recent efforts to define target audiences in a systematic and exhaustive manner. Fifty-four percent of adult Americans, 18–55 years of age, were found to participate one or more times a month in social or business situations in which alcoholic beverages are served. If, in fact, as the researchers claim, these situations account for 87% of all situations which could result in pressures to drive after drinking, the resulting definitions of target populations for alcohol-crash-related PI&E campaigns represent a step forward in the processes of target identification and selection.

Even more indirect target groups consisting of persons who manage and operate agencies that interact with drinking drivers should also be considered in future programs. The ASAP program has addressed some of these groups (e.g., Traffic Law System personnel, including prosecutors, judges, probation personnel, and legislators) through "training" programs in alcohol safety, but a much wider spectrum of institutions and organizations (e.g., the health care delivery system, insurance companies, automobile manufacturers, highway designers) could be the targets of future actions.

Voas (1974) has suggested that detailed "models" of the drinking-driving "process" be developed to aid in identifying productive points for interdicting the series of events that culminates in alcohol-related crashes losses. Such a model could be of even greater breadth and depth than indicated by Voas in his illustrative example (see Figure 6-5), taking into account each significant activity that must be performed and each important decision point in the process (e.g., acquiring alcohol, starting a car, etc). Further, the model need not be limited to the pre-crash phase but should be extended to cover

elements of the crash phase and post-crash phase unique to or especially important to drunk driving (e.g., protecting occupants who do not take actions to protect themselves, emergency medical services for single-vehicle crashes occurring in the early morning hours).

Finally, future responses to the alcohol-crash problem should systematically search the wide range of human, vehicle, and highway environmental factors related to such crashes for targets more vulnerable to applications of current knowledge and technology. Key factors and situations that reinforce or inhibit driving after drinking should be listed and cataloged, and specific elements of driving performance that are degraded by alcohol should be identified and described. With respect to the vehicle and driver-vehicle interactions, design characteristics critical to alcohol safety should be studied to identify high priority targets. For example, vehicle handling, and the feedback of performance information to the driver (and other drivers) might be fruitful target areas for technological approaches. Similar opportunities exist in improving the interactions between the driver, the vehicle, and the highway environment through improved highway design, more effective signs, and the removal of hazardous obstacles from the roadside. Obviously, such improvements would benefit all drivers, alcohol-impaired or not, but they would be particularly beneficial in dealing with drunk drivers.

A more methodical and comprehensive approach to the definition of targets for future alcohol-safety efforts seems essential to reduce significantly the level of alcohol-related crash losses projected for the 1980's. In the short-term future, it is crucial that the problem be attacked at points that will prove the most vulnerable to current technology, and more innovative long-term responses will require the identification of new targets and new modes of attack.

### *6.2.2 Programs*

Reassessment and reformulation of the targets of alcohol-safety programs as suggested in the preceding section should help in getting better results from future programs, but key issues related to the philosophy and design of such programs will have to be resolved before really substantial progress can be made. The plain fact is that past efforts have not made much of an imprint on the alcohol-crash problem, and it seems likely that this is more due to the lack of an adequate foundation for many of the approaches that have been adopted, than to improper application of well-underst od principles.

The *legal approach* is the oldest and most widespread response to the problem. Its basic tenet is that the threat of punishment will deter people from drinking-driving. Most researchers (Zimring and Hawkins 1973; Buikhuisen 1972b) who have studied the theory of deterrence agree that the primary factors related to its successful application are (1) the characteristics of the target population group, (2) the nature and motivations of the behavior to be prevented, (3) the target population's awareness that a deterrent threat exists, and (4) the credibility of the threat to the target population (see Section 5.2.1). Scholarly discussions of these four factors are abundant in the literature, but the fundamental questions of interest to designers of alcohol-safety programs remain unanswered, namely:

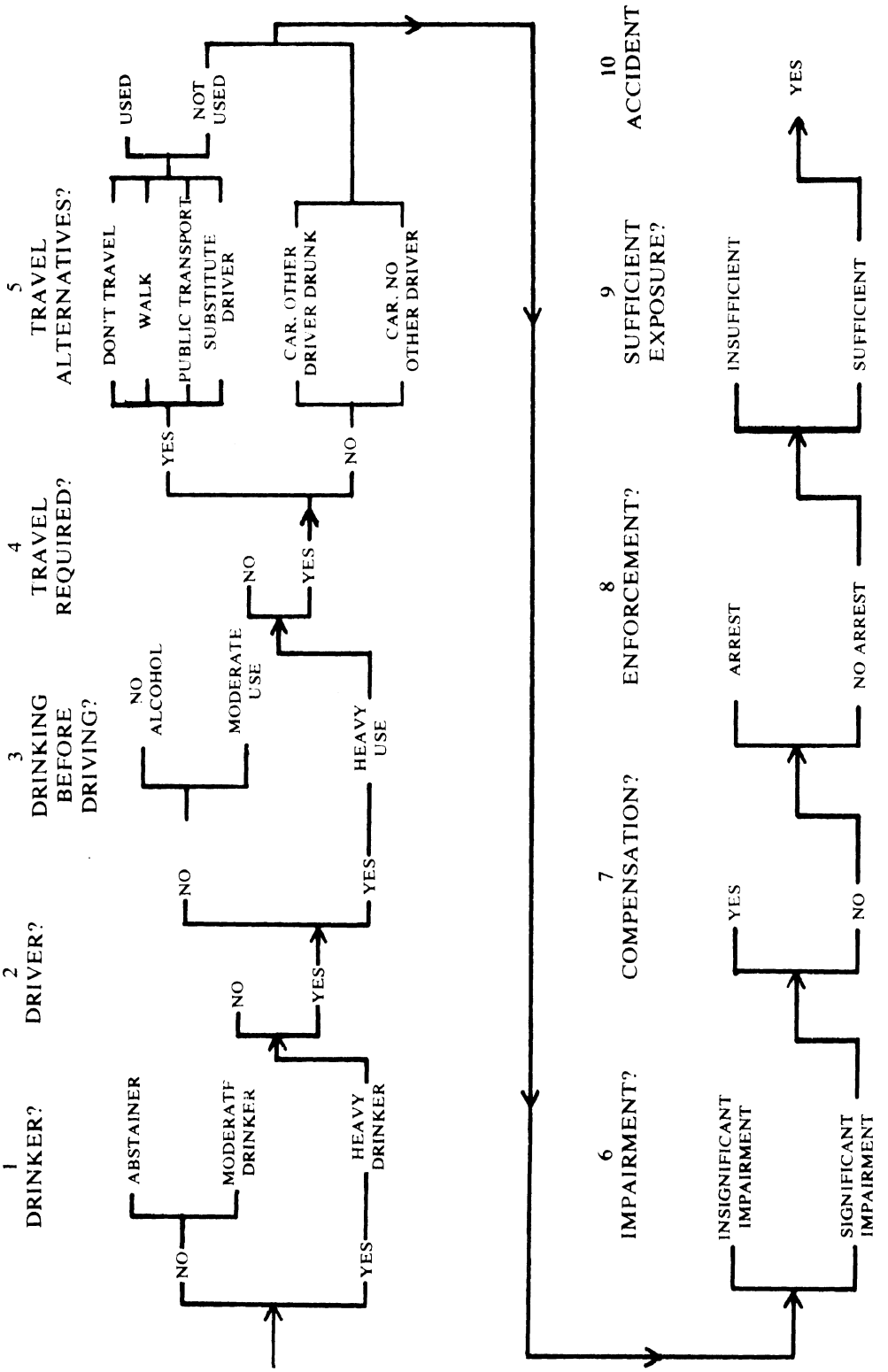



Figure 6-5 Analysis of events leading to an alcohol-related accident

Source: Voas 1974a

- What specific variables are sufficient to describe target population groups and drinking-driving behavior for operational purposes?
- What essential information must be communicated to the target population in what way to achieve an adequate level of awareness that a deterrent threat exists?
- What is the nature of the deterrent threat that will achieve a given level of deterrence among a suitably defined and informed target population?

The last question is particularly germane to the future of the legal approach. It generates two other very basic, but also unanswered questions, i.e.:

- What must the probability of detection and apprehension be?
- How much of what kinds of punishment should be involved?

Operationally useful answers must be given to all of the above questions to support the development of more effective legal approaches to the alcohol-crash problem.* In seeking such answers, it may be appropriate to regard law as a hypothesis, as suggested by Reese et al. (1974):

> If law is regarded as involving the assumption that certain consequences will follow from its enactment; then its application should be regarded as a test of its validity. The results of these tests should be used to modify or support the initial hypothesis (p. A-6).

Revision of past legal hypotheses on deterrence of drinking drivers is clearly in order, given the results of the programs that have attempted to apply the hypotheses. Further, in view of the relative insensitivity of alcohol-related crash losses to past levels of legal approach activity, it appears that rather substantial revisions may be required, for example, increasing apprehension rates by a factor of 10, or more. Finding practical ways of achieving these large changes without violating fundamental human rights and without offending citizens will obviously be a great challenge to researchers and program designers.

The *health approach* has relied on the legal approach as a case finder for drinking drivers needing treatment for a drinking problem they are unable to control. Thus, any improvement in the detection and apprehension capability of the enforcement component of the legal approach should benefit the health approach as well. More sharply-focused case-finding methods for identifying target groups of problem drinking drivers (including methods not dependent on the Traffic Law Systems) would also be helpful, as would more efficient and reliable ways of diagnosing and referring patients to treatment. However, the most fundamental barrier to successful application of the health approach is the lack of effective treatment modalities for the drivers who have been identified as problem drinkers. No treatment or rehabilitation technique has been shown to reduce crash losses measurably. Thus, an approach that has correctly identified what ought to be done (i.e., to treat rather than to punish) may have failed because it could not be

*NHTSA has recently initiated a program of research on general deterrence as applied to the alcohol-crash problem. A thorough analysis of the British Road Safety Act of 1967 is planned as a part of this program.

realistically implemented. The state of the art of identifying and "processing" problem drinking drivers is sufficiently developed to deliver large numbers of patients to treatment; but existing treatment modalities have little demonstrated effectiveness. Clearly, the priority item for improving the overall effectiveness of the health approach is the development of treatment modes that work. Lacking these improvements, the health approach will play a minor role in dealing with the alcohol-crash problem of the future.

The public information and education (PI&E) approach has tried to improve knowledge, attitudes, and behaviors associated with drinking driving. Its most widespread use has been in support of the legal approach where it has been used in an attempt to increase the public's perception of the risk of apprehension for drunk driving. In one application (the British Road Safety Act of 1967) it was believed to have played a major role in achieving a large (but short-lived) decrease in alcohol-related crash losses. This particular combination of legal and PI&E approaches is one of the few alcohol "countermeasures" that have worked. Important questions remaining unanswered are: why it worked in the British application, and under what conditions it would work as well or better in other settings. Specifically, we need to know and understand the key ingredients for using PI&E as an effective instrument for modifying drinking-driving behavior. When this is known, then other applications of PI&E not dependent on the legal system may become possible, for example, the use of intermediate population groups to influence drinking drivers, as suggested in the preceding section.

It seems paradoxical that in a technological society such as our own so little attention has been given to *technological approaches* to the alcohol-crash problem. This is perhaps less due to the inavailability of the technology per se, than to the lack of understanding of how to apply it to such a complex societal problem. For example, it appears likely that a drunk driver warning system (DDWS) could be developed for operational use in the next few years. However, such a device would probably be too expensive for installation on all cars (at least in the immediate future), requiring that it be installed only on cars used by problem drinkers. This would require (as in the case of the legal and health approaches) that the problem drinkers be identified and that the legal authority and process for requiring the installation of the devices be defined. After a DDWS device was installed on a driver's own car, means for preventing his use of other cars would still have to be provided.

On the other hand, other drivers (for example, a wife or a neighbor) might need to use a car with a DDWS, and provisions might have to be made to permit such usage without requiring the driver to provide a breath sample or to pass a performance test. Conceivably, such a device could malfunction or a non-intoxicated person faced with an emergency might fail the test and be exposed to a greater risk than drunk driving. In such cases, who would be liable for any losses suffered?

These and other questions will need to be resolved before the full potential of the technological approach can be realized. In the meantime, technological solution to the alcohol-crash problem will probably be more effective when used in conjunction with other approaches, for example, with a legal approach for identifying high-risk drinking drivers. Efforts to develop this technology should be continued, with the expectation that many of the present constraints affecting operational usage will be relaxed, for

example, cost, reliability, maintainability, and ability to discriminate the alcohol-impaired drivers from other drivers.

Among the approaches that have been tried to date, the *systems approach* appears to offer the best hope of conquering a problem as multi-faceted and pervasive as drinking-driving. The full potential of this approach will begin to be realized when it is used as a tool for system design and engineering rather than only for system management as was the case in the ASAP program. Powerful methodologies and techniques are available for developing optimal designs of total systems and have only begun to be applied to the alcohol-crash problem (Joscelyn and Jones 1972). They should now be used to develop new configurations of drinking driver control systems derived by optimal application of current knowledge and technology to the generic functions that must be performed to minimize drunk-driving crash losses. At the same time, it must be realized that the systems approach is not a panacea or even a "countermeasure" in itself, but merely an orderly way of applying what is known to accomplish a specific set of objectives. Thus, it is ultimately limited by the "current state of knowledge" in the many disciplines that relate to the alcohol-crash problem. The systems approach cannot specify what will cure problem drinking any more than it can describe the nucleus of an atom, but it can, for example, help in incorporating known treatment methods into an overall alcohol-safety program.

Other approaches (and individual countermeasures) than the five noted above have been suggested and, in some cases, even implemented on a limited scale. These range from various ways of restricting the use of alcohol (e.g., raising the legal drinking age) to imposing insurance rate increases on persons convicted for DWI to impounding the vehicles of drunk drivers (Driessen and Bryk 1973). Many others will become apparent after a comprehensive analysis of potential targets as suggested in the preceding section. Further research and, where indicated, testing of new concepts should be supported. At the same time, it should be remembered that these concepts will remain hypotheses until they have been validated and refined for operational usage. *Premature adoption of unproven approaches will nearly always be counterproductive and should be avoided in dealing with the alcohol-crash problem of the future.*

### *6.2.3 Evaluation*

Evaluation of both new and on-going programs is a key ingredient to future progress in alcohol-safety. Without it, past misconceptions and mistakes will be perpetuated; with it, successful techniques can be identified, further improved, and diffused to other users.

There are few examples of careful evaluations of alcohol-safety programs before ASAP. When programs or "countermeasures" were evaluated, this was done with rigor insufficient to provide a reliable basis for decision making on future programs. ASAP's great contribution to the field of alcohol safety was to test and evaluate on a large scale and for the first time many widely held hypotheses about how to decrease alcohol-related crash losses.

Even so, ASAP has fallen short of meeting what some evaluation specialists believe are minimal requirements for evaluating social programs. These evaluators believe that nothing short of rigorous experimental design methodologies such as those used in a labora-

tory setting will provide scientifically acceptable evidence of the success or failure of a program. Inevitably, this requires the use of a "control" group which matches the "treatment" group in every significant respect except exposure to the countermeasure.

Critics of the use of control groups for evaluating social experiments argue that it is virtually impossible to define a control group that matches the treatment group so completely. They favor so-called "quasi-experimental designs," such as time series analysis, that examine the fluctuations of crash rates and other pertinent variables over suitably long periods of time both before and after the introduction of the alcohol-safety program.

A more recent school of thought rejects both the rigorously experimental and quasi-experimental approaches as impractical and unrealistic. Experimental research as a method for evaluating complex societal programs is viewed as largely irrelevent to real world needs, often leading to unwarranted rejections of programs whose effects cannot be proved statistically "significant." What is needed, it is claimed, is a way of organizing and presenting information that will best support the practical needs of decision-makers (Edwards, Guttentag, and Snapper 1975). The science of decision theory is offered as a means for achieving this end.

Thus, though evaluation is essential to improving programmatic responses to the alcohol-crash problem, no one knows for sure how it should be conducted. In the near-term future, careful application of time-series analysis techniques seems the most practicable approach. At the same time, program designers and managers should be aware that the art of evaluation is still developing. Evaluation methodology "cults" that claim to provide sure-fire answers that exclude other approaches, and that defy common sense, should be avoided. Research and testing of innovative approaches (including decision theoretic approaches) should be strongly supported.

Finally, it is critical that the results of evaluations be carefully and thoughtfully analyzed before deciding on the worth of alcohol-safety programs. Past experience indicates that progress in dealing with the alcohol-crash problem will not come easily and that even relatively large expenditures of resources will often fail to produce an effect that can unequivocally be attributed to the programs. In many cases, effects that seem to be the result of a particular program will be disappointingly small and appear to be unworthy of the effort. Before rejecting such a program as "ineffective," one's original expectations should be critically reexamined to see if they were compatible with the enormous complexity of the problem and with the limited knowledge and technology available to deal with that problem.

## 6.3 SUMMARY AND CONCLUSIONS

Analysis of likely trends in the factors believed to be most strongly related to the alcohol-crash problem indicates that the absolute magnitude of the problem will increase substantially over the next decade. However, alcohol-related crash losses as a fraction of total crash losses will remain about the same.

A number of very basic obstacles will have to be surmounted to achieve any important reduction in these projected losses. First, the spectrum of possible *targets* of

future programs must be widened to include population groups, factors, and events not previously considered in any detail. A comprehensive methodology is needed for systematically generating and screening new targets and possible and appropriate countermeasures.

Second, approaches used in the past in alcohol safety *programs* will have to undergo fundamental changes, and new programs aimed at better defined targets will have to be developed. Specifically, further research is required to adequately define the parameters of deterrence. It is essential that one know what levels of detection and apprehension and what punishments are required to achieve given decreases in drunk driving. Of equal importance is the need to develop effective treatments for problem drinkers and to make better use of techniques developed in ASAP for using the Traffic Law System for case-finding, diagnosis, and referral. It is also important to utilize more effectively the available public information and education techniques for behavior modification, particularly in support of programs of general deterrence.

A number of innovative ways of applying modern technology to the alcohol-crash problem have been conceptualized and, in some instances, actually developed and tested under operational conditions. Such devices as the Drunk Driver Warning System offer hope for the future and should be further refined, both with respect to the technology involved and with respect to the application of that technology in the various societal systems that interact with drinking drivers. Likewise, more widespread use should be made of the methodologies of the systems approach than has been made in the past in applying complex technologies to accomplish simple objectives (e.g., rapid air transport). Particularly, the systems approach should be applied to the design as well as to the management of alcohol safety programs.

Finally, no progress or improvement can be sustained and diffused to other users without adequate evaluation. A systematic effort must be made to fill in the knowledge gaps in the alcohol-safety countermeasure programs sketched out above, and this will require a carefully designed, and rigorously implemented evaluation component. Failure to evaluate future programs will result in another decade of unanswered questions and lost opportunities.

# 7.0 CONCLUSIONS AND RECOMMENDATIONS

This section summarizes the major conclusions and recommendations of the study. It lists the most significant findings on the present state of knowledge about:

- the nature and extent of the alcohol-crash problem in the United States and
- past responses to that problem.

Recommendations relative to developing more effective future responses to the alcohol-crash problem are also stated. The section closes with some insights by the authors on the implications of the study's findings for operational agencies.

## 7.1 THE ALCOHOL-CRASH PROBLEM

Research clearly shows that a significant alcohol-crash problem still exists in the United States. With respect to the nature and extent of that problem, it is concluded that:

- Nearly one-half of all fatally injured drivers in the United States were legally too intoxicated to drive (i.e., had a BAC of .10% w/v, or more).
- Many drivers involved in less serious crashes (perhaps 5%–13%) were also legally too intoxicated to drive.
- More than one-third of all fatally injured pedestrians had BACs of .10% w/v or more.
- The number of alcohol-related crashes that are *caused* by alcohol is not known (as is the case with many other crash factors), but research indicates that:
    a. The risk of being involved in a serious crash is much greater at BACs over .10% w/v than it is with no alcohol.
    b. Many basic behaviors related to driving are impaired in most individuals at BACs of .10% w/v or more.
- Driver and driving characteristics associated with a higher than average *involvement* in alcohol-related serious crashes are:
    a. Male sex,
    b. Age of 20 to 60 years,

c. Heavy drinking and severe drinking problems,
d. Preference for beer over other alcoholic beverages,
e. Nighttime driving habits,
f. Weekend driving habits, and
g. History of prior arrests for drunk driving.

- Driver characteristics associated with a higher than average crash *risk* after drinking a given amount are:
  a. Female sex,
  b. Youth (i.e., under 20 years old),
  c. Old age (i.e., over 60 years old), and
  d. Light drinking habits.
- Knowledge of driver characteristics and driving habits is useful for identifying high-risk groups, but is not sufficient to establish that any one individual with these characteristics or habits caused or will cause a crash.

A wide range of research is required to improve the state of knowledge about the alcohol-crash problem. In the area of problem identification and definition, both epidemiologic and experimental studies are indicated. Critical *epidemiologic* research needs are:

- A nationwide controlled study to determine the alcohol-crash risk faced by various population groups at various BACs.
- Controlled studies of a more limited geographical scope to determine the crash risk of more sharply defined population groups, particularly groups defined by various drinking variables. It is critical that more be known about the alcohol-crash *risk* of certain groups (e.g., alcoholics) that are thought to have a high alcohol-crash *involvement*.
- In-depth clinical studies to learn more about the circumstances surrounding alcohol-related crashes and the interactions of alcohol with other factors to cause crashes.

*Experimental* research needs of an equally high priority are:

- Studies to identify relationships between elementary behaviors that can be tested in a laboratory and critical driving tasks.
- A coordinated experimental program on the effects of alcohol on these behaviors. A wide spectrum of populations should be investigated in this program, with particular attention to groups indicated by past research to have either a high alcohol-crash risk or a high alcohol-crash involvement (e.g., males, people with severe drinking problems).
- More realistic experiments on alcohol effects on actual driving performance.

## 7.2 RESPONSES TO THE ALCOHOL-CRASH PROBLEM

Research and operational experience in dealing with the alcohol-crash problem indicate that:

- Five approaches have most commonly been followed to control alcohol-crash losses:
    a. Legal,
    b. Health,
    c. Public Information and Education,
    d. Technological, and
    e. Systems.
- The targets of programs that have followed these approaches have usually been defined only in general terms, e.g., all drunk drivers, social drinker-drivers, problem drinker-drivers.
- To date only one large-scale alcohol-safety program, the British Road Safety Act of 1967, has clearly been shown to have reduced crash losses involving drinking drivers and the effects of that program were transitory.
- The state of knowledge about fundamental hypotheses upon which most past alcohol-safety programs have been based is totally inadequate for designing and operating effective programs. Specifically, it is not known:
    a. What kind and what amount of a deterrent threat is required to achieve what level of results in a specific application of the *legal* approach.
    b. What treatments are required for what classes of drivers to achieve what level of results in a specific application of the *health* approach.

  This lack of knowledge is not unique to the field of alcohol-safety. Efforts to apply the legal and health approaches to controlling other forms of individual and societal risk (e.g., crime, drug dependence) are also hampered by similar informational deficiencies.

With regard to future responses to the alcohol-crash problem, it is believed that:

- The absolute magnitude of the problem will increase substantially in the 1975–1985 period, but that alcohol-related crashes as a fraction of total crashes will remain about the same.
- A wider spectrum of targets of future alcohol-safety programs must be developed to address more relevant and responsive population groups, factors, and events.
- Present alcohol-safety programs should be evaluated to provide a knowledge-base for designing new programs.
- Future alcohol-safety programs should be carefully tested and evaluated before being placed into full-scale operation.

In order to develop more effective programs for dealing with the alcohol-crash problem of the future, the following research is indicated:

- A comprehensive analysis of targets of possible alcohol-safety programs.
- Studies to identify deterrent threats and treatment and rehabilitation regimens most appropriate to drinking drivers.
- Studies to better understand the principal elements of public information and education relative to modifying drinking-driving behavior.

- Efforts to develop and refine technologies that could be used to support legal, health, and other approaches to controlling alcohol-crash losses. Barriers (e.g., legal, political, economic) to operationalizing such approaches should be thoroughly analyzed.
- Research on how best to apply the systems approach to the design of alcohol-safety programs as well as to the management and evaluation of such programs.
- Studies to develop more appropriate techniques and methodologies for evaluating alcohol-safety programs and for applying the results of such evaluations to the design and operation of new programs.

It has often been said that the most predictable outcome of a research study is the recommendation for more research. This result was inevitable in the present study because an explicit objective of our contract was to recommend "future research activities that are considered likely to produce the most significant results" in reducing alcohol-crash losses. It was also hoped that an objective review of existing information on alcohol and highway safety would identify approaches that were effective in reducing the risk of crashes that could be recommended to state and local operational agencies. Regrettably, this cannot be done. There are no approaches whose efficacy has been objectively established. In part, this may be attributed to the general lack of evaluation of the effect of efforts to reduce alcohol-related crash losses. The lack of information on effectiveness can also be attributed to a general tendency at all levels of government to implement programs to deal with drinking and driving on the assumption that the particular strategies chosen will work. The selection of strategies in the past has not been based on the findings of a carefully designed research and development program. This suggests that two important lessons should be drawn from the existing literature:

- The present efforts of state and local jurisdictions to deal with the drinking driver should be carefully evaluated.
- New efforts or strategies should not be implemented by state and local jurisdictions until an adequate foundation has been established through an objective research and development process.

## 7.3 INSIGHTS FOR OPERATIONAL AGENCIES

It is recognized that state and local jurisdictions are faced with the immediate problem of managing the risk created by the drinking driver. Decisions are being made and must be made on the basis of current knowledge. Better information is certainly needed for the future, but actions must be taken now. Thus, we offer some suggestions for the present. In view of the lack of objective evidence to support recommendations, these suggestions must be understood to represent judgments of the authors flowing from the synthesis of the existing literature and our experience. They were not derived directly from objective evidence as were the prior conclusions and recommendations, but represent our insights and are offered only in that context.

The risk of traffic crashes from the use of alcohol in our society is a complex social phenomenon. The approaches that have been developed to manage that risk are equally

complex. Given the unique characteristics of many local situations, no single prescriptive approach can be recommended. We believe, however, that each jurisdiction should approach the problem in a systematic manner. We believe that a program to manage the risk of the drinking driver should address the following areas:

- *Risk Identification*—Information on the nature and extent of the alcohol-related crash problem within the jurisdiction should be established. This information should be made available to the public and the individuals, agencies, and institutions responsible for dealing with the alcohol and highway crash problem.
- *Priorities for Resource Allocation*—The alcohol-related crash problem should be compared with other public safety and public health problems faced at the state and community level. Conscious decisions to allocate existing and future resources to the alcohol-crash problem commensurate with its relative magnitude should be made.
- *Selection of Control Strategies*—A formal method for identifying control strategies and selecting those most appropriate for the local situation should be established. This suggests a "systems approach" and deliberate local coordination of the involved agencies and institutions. As noted previously, specific strategies or tactics cannot be recommended on the basis of established effectiveness. Certain approaches, however, are suggested as representing the most promising now known. These include:

  *Special Deterrent Approaches*—These approaches are focused on an individual who has been identified as a drinking driver. This usually occurs through law enforcement action. The use of the legal system to detect and sanction drinking drivers appears justified. The available sanctions should be sufficiently broad to deal effectively with the needs of individual cases. In particular, individuals who are clearly identified as having severe drinking problems should be referred to the health care system. (This has been described as the "health/legal" approach.)

  *General Deterrent Approaches*—These approaches are designed to reduce the incidence of drinking-driving and are broadly targeted. For example, public information and education efforts to convey information about the risk of a crash after drinking, the risk of law enforcement action, and the probable sanctions—both direct and indirect (e.g., insurance costs)—should be undertaken to complement law system actions.
- *Control System Management*—Implementation of the "systems approach" suggested earlier requires coordination of the various elements of the drinking driver control system. In most jurisdictions many different agencies of government from the executive, legislative and judicial branches and are involved in the management of the risk of alcohol-related crashes. While appointment of an individual to "manage" this loosely knit system is not feasible, structures can be created that enhance communication and improve operating efficiency.
- *Evaluation*—The clear need for objective evaluation of present and future efforts has been stressed throughout this report. The lack of present knowledge is directly attributable to the lack of evaluation of past efforts. Evaluation must be

accomplished to operate a local program effectively and to increase the general knowledge base. What is known about drinking driver behavior and accidents suggests strongly that an evaluation program should include measurement of alcohol involvement in the general driving population as well as in the accident population.

The elements identified above are believed to be necessary for programs intended to reduce the risk of alcohol-related crashes. The present "state of the knowledge" does not allow us to state with certainty that a program encompassing all these elements *will* be effective in reducing crash losses. Based on the current knowledge, however, we believe that such a program would be the best use of existing resources.

As previously noted, introduction of new approaches and new technologies should flow from a carefully structured research and development effort so that significant funds are not spent on large-scale implementation of unproven approaches.

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## THE PRINCIPAL INVESTIGATORS

The principal investigators for this project have worked together for the past ten years on research in the field of highway safety. Through this work, they developed a special interest in the role of alcohol and drugs in highway crashes and have analyzed and helped design methods for dealing with that problem. Their backgrounds and research interests are summarized briefly below.

Ralph K. Jones, is president of Mid-America Research Institute, Inc., and a staff consultant to the Highway Safety Research Institute of The University of Michigan. He received his B.S. in mathematics from Drury College in 1950 and studied afterward at Wichita State University, The University of Michigan, and Purdue University. He is currently involved in research and research management in the areas of transportation, health, and safety. He has directed and participated substantively in a wide variety of NHTSA-sponsored research and demonstration projects dealing with the human component of the Highway Transportation System.

Kent B. Joscelyn is head of the Policy Analysis Division of The University of Michigan Highway Safety Research Institute. He received a B.S. degree in physics from Union College in 1957 and a J.D. degree from Albany Law School in 1960. He is a member of the bar of the State of New York and the District of Columbia. Mr. Joscelyn is a member of numerous professional societies and advisory committees and is the editor of the international *Journal of Criminal Justice*. His research interests span a broad spectrum of subject matter areas related to the analysis of societal systems, including law, public safety, and systems analysis. In his present position he manages and participates in public policy research focused on transportation, health, and safety issues.