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

SUMMARY VOLUME

Ralph K. Jones
Kent B. Joscelyn

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 summarizes 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 the full report, of which this is a summary, *Alcohol and Highway Safety 1978: A Review of the State of Knowledge*, 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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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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Kent B. Joscelyn
Principal Investigator

Ralph K. Jones
Principal Investigator

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Chapter 1

INTRODUCTION

This report summarizes the results of a study sponsored by the National Highway Traffic Safety Administration (NHTSA) and conducted by The University of Michigan's Highway Safety Research Institute. It is a condensed version of a more detailed report, which is contained in a separate volume.

The objective of the study was to review, evaluate, and summarize the existing knowledge on alcohol and highway safety in the United States. This report describes what is presently known about the role of alcohol in highway crashes and what has been done to reduce crash losses believed to be caused at least in part by alcohol. The report projects the problem of alcohol-related crashes over the next ten years, suggests what is needed in response to the problem, and recommends priorities for future research.

The first comprehensive review of the state of knowledge about the alcohol-crash problem, the U.S. Department of Transportation's landmark report in 1968 on Alcohol and Highway Safety (U.S. Department of Transportation 1968), described a problem of major proportions and recommended a wide range of activities to bring that problem under control. The present report represents an attempt to update and expand on the earlier report. Although the emphasis here is on research conducted since 1968, earlier studies are also included to provide perspective and new interpretations of their findings.

The material in this report was selected from an extensive list of literature developed through a survey of some 450 individuals who have participated in research and operational programs in related areas and through traditional search techniques. Although the project staff has reviewed all the literature identified in this way, space limitations do not permit all of it to be discussed here. The overall quality, relevance, representativeness, and availability to the reader were the main criteria used in selecting material for inclusion in the report. Research reported in the archival literature is discussed where possible. Studies with clearly serious methodological or analytical deficiencies are not included. The report covers:

1. the general approaches that have been followed in studying the alcohol-crash problem and the methodological problems attendant upon each,
2. previous efforts to define the nature and extent of the alcohol-crash problem,

3. what attempts have been made in the past to ameliorate the alcohol-crash problem,
4. what directions the attempts to resolve the problem of alcohol and highway safety might take in the future, and
5. the major conclusions and recommendations arising from this study.

To provide a convenient, comprehensive bibliography, the references listed in the last section of this volume include not only the materials cited in the text of this summary, but also all the material cited in the full report. The reader is encouraged to refer to the full report for a more thorough discussion of these topics.

Chapter 2

GENERAL APPROACHES AND METHODOLOGICAL PROBLEMS

Alcohol has been suspect as a factor in highway crashes almost since the appearance of the automobile. A 1904 study of fatal crashes involving "automobile wagons" found that a large fraction of the drivers had been drinking before their crashes and observed that:

> Inebriates and moderate drinkers are the most incapable of all persons to drive motor wagons. The general palsy and diminished power of control of both the reason and the senses are certain to invite disaster in every attempt to guide such wagons (*Quarterly Journal of Inebriety* 1904, quoted in U.S. Department of Transportation 1968, p. 147).

By the 1930s, a scientific basis for defining this suspected alcohol-crash problem had begun to evolve as a result of increasing research activity in the field. Four basic approaches to the problem were followed then—and now (Heise 1934).

The first and most fundamental approach has been to determine the amount of alcohol in the body. For this, researchers have developed instruments and techniques for measuring the amount of alcohol in various bodily fluids (e.g., urine, saliva, blood) and in the breath. They have studied also the relationships between the amount of alcohol so determined and the amount of alcohol consumed prior to the measurement.

Secondly, the behavior of individuals with known quantities of alcohol in their bodies, as determined by the measurements cited above, are studied in a laboratory setting to define the relationships between the effect of alcohol on the behavior so studied, such as the ability to stand erect without excessive swaying, and the effect of alcohol on behavior critical to safe driving.

In the third approach, an extension of the second, the effect of alcohol on actual driving performance is studied in an instrumented car on a closed driving course or in a driving simulator.

The fourth approach is the study of the use of alcohol among different populations of drivers. It is often referred to as an "epidemiologic" approach because it employs techniques commonly used by scientists in the study of the diseases in populations. A variety of such techniques are used, the most important being the controlled study, in which the incidence of drinking drivers in crashes and the incidence of drinking drivers

among all those using the roads are studied and compared. The determination of whether and to what extent drivers have been drinking is made by using the methods developed in the first approach. Driving records, health records, results of interviews with the drivers and others, results of psychological tests, and other information are often used to learn more about the drinking-driving behavior of these populations of drivers.

The ultimate objective of these four approaches is to provide the information necessary for determining whether combining drinking with driving presents a significant societal problem and, if it does, for defining that problem. To decide whether alcohol-related crashes constitute a serious problem for the society, it must first be estimated how many crashes involve drinking drivers. If there are only a few, then the problem is not serious. If there are many, then there is reason for further analysis to determine whether drinking drivers are more often involved in crashes than other drivers. If they are not, there is no basis for suspecting alcohol any 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 there is reason to suggest that there is, indeed, an alcohol-related crash problem.

Next, one must determine whether the overrepresentation of drinking drivers in crashes is actually due to the impairment of driving performance by alcohol rather than to some coincident factor. A strong enough indication that alcohol causes impairment justifies the final step of the problem identification process: the more detailed definition of drinking-driving and drinking drivers so that effective methods can be devised for dealing with the problem.

The most troublesome difficulties in following this process have occurred in behavioral research on the effect of alcohol on the ability to perform critical driving tasks and in epidemiologic studies of driving populations.

The difficulty with applying research on the behavioral effects of alcohol to highway safety is the lack of a clear and explicit relationship between the behavior tested and driving tasks. This is particularly true of behavior that has been studied in the laboratory, where most of the tasks examined have been much simpler than those involved in driving. Thus, a gross effect on the laboratory tasks must be found in order to infer an effect on driving tasks. Obviously, in such cases, one cannot quantify the effect alcohol may ultimately have on driving performance.

Other problems with research on alcohol and human performance include:

- Lack of adequate and consistent controls.
- Inadequate definition of subject populations with respect to variables known to influence alcohol-related behavior (e.g., sex, weight, age, drinking patterns).
- Variations in alcohol dosages administered to subjects.
- Lack of consistency or definition of type of alcoholic beverage used in the experiments.
- Inconsistent definitions or control of time variables, such as the time allowed to consume alcohol, the time of day alcohol is consumed, and the time between ingestion and start of testing (Levine, Greenbaum, and Notkin 1973; Perrine 1974a).

Different but equally serious problems exist in the epidemiologic literature on alcohol and highway safety. Foremost among these problems is the lack of current, comprehensive studies comparing the characteristics of drivers in crashes with those of a control group of drivers exposed to the same driving environment (the road, the time) as the crash-involved drivers. Such studies are essential for estimating the effect of alcohol on the risk of crashing faced by any given sub-group of drivers that can be defined by the data (such as males, young persons, married persons, social drinkers, alcoholics. Although many well-designed and carefully executed controlled studies have been conducted (Lucas et al. 1955; McCarrol and Haddon 1968, Borkenstein et al. 1964; Perrine 1974a; Farris, Malone, and Lilliefors 1976), none provides sufficient detail for calculating up-to-date, nationally representative estimates of alcohol-crash risk as a function of crash severity and a broad range of driver characteristics. In addition, there is a lack of consistency in the characteristics analyzed in the various studies, and in the definitions of terms (e.g., "problem-drinker") used to describe such characteristics. Finally, some epidemiologic studies have introduced bias into their data by deliberately or unknowingly excluding from their sample certain segments of the population studied.

Studies that have attempted to delve deeply into the characteristics of drinking drivers have encountered another set of problems. Some studies rely on self-reported information about drinking and driving habits and are limited by the subjects' ability and proclivity to recall accurately and report such information. Certain characteristics, such as drinking habits, are sometimes estimated by interviewing relatives, friends, or co-workers of the drivers. The perceptions of such persons, obviously, may not provide an accurate picture of the actual characteristics of the drivers. Also, the analyses of information collected from the records of both public and private organizations are constrained by the accuracy, completeness, and currency of that data.

These problems have occurred with studies attempting to define alcohol-related crashes and to identify target groups of drivers for programs to reduce the number of these crashes. Many other problems beset studies attempting to assess the results of alcohol-safety programs. Of these problems, the most basic is a failure to evaluate rigorously a program to determine whether it or some other factor was most likely to be responsible for the observed effects. The use of properly constituted control groups for analyzing cause-and-effect relationships has been rare in the field of alcohol and highway safety.

It is important to keep these limitations in mind when studying the literature on alcohol and highway safety (including the literature discussed in this report). The main value of research in the field lies not in providing irrefutable proof of hypotheses about drinking and driving, but in providing data on which to base informed decision-making. Thus, the literature should be interpreted by the individual reader in light of his individual needs and situation. It is better that he be skeptical of research findings and conclusions than that he unquestioningly accept them because they were proclaimed by a reknowned expert in a prestigious journal.

Chapter 3

DEFINING THE ALCOHOL-CRASH PROBLEM

What follows in this section of the report is a review and summary of what we know now about the nature and extent of the alcohol-crash problem in the United States. Paralleling the process of defining the problem as outlined in the preceding pages, this section of the report:

- determines whether there is good reason to believe that an alcohol-crash problem exists,
- estimates the likely magnitude of any such problem in the mid-1970s, and
- defines drinking drivers and drinking-driving in greater detail to support the development of methods for dealing with the problem.

The information from a wide range of epidemiologic, behavioral, and other research studies make these determinations possible.

ALCOHOL AND THE HUMAN BODY

First, an understanding of the basic concepts about the nature of alcohol and its interaction with the human body is helpful. 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, just "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 (its specific gravity is .79) and has a lower boiling point than water (78.3° C) (AMA Committee on Medicolegal Problems 1970; Leake and Silverman 1971).

Although alcoholic beverages come in a greater 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

three quarters of an ounce of alcohol, is provided by a "shot" of distilled spirits (one and one-half ounces of 100 proof alcohol), a glass of fortified wine (three and one-half ounce of 20% alcohol), a larger glass of table wine (five ounces of 12% alcohol), or a pint of beer (sixteen ounces of 4.5% alcohol).

Absorption of alcohol into the body occurs through the simple process of diffusion: alcohol does not have to be digested before entering the blood. The rate of absorption of alcohol taken orally depends on the quantity taken, its concentration, and especially on the other contents of the gastrointestinal tract. Food in the tract delays absorption. When alcohol is taken with a heavy meal, up to six hours may be required for complete absorption (Wallgren and Barry 1970).

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

The amount of alcohol present in the blood is commonly measured in terms of the *weight* of the quantity of alcohol in a given *volume* of blood (Voas 1970). In the U.S. 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 measurement showed .01 grams of alcohol in a 100 milliliter sample of the same blood, the result would be interpreted in the U.S. as .01% w/v blood alcohol concentration (BAC).

Alcohol is eliminated from the body almost entirely through the process of oxidation. Typically, the rate of elimination is about .015% per hour (Wallgren and Barry 1970). 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.

There are many methods of measuring the amount of alcohol in the blood. The most accurate and reliable of these test the blood directly, rather than some other fluid or tissue (for example, urine or saliva). Blood collected from an artery 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 for Medicolegal Problems 1970).

In 1927 Bogen introduced breath-alcohol analysis as a medical tool in the United States. Since then, several devices have been developed for use both in the laboratory and in the field. Modern breath tests can be quite precise in their quantitation of breath alcohol. Tests of one such device (the Breathalyzer), conducted over nearly 20 years, indicate that it is quite precise when compared to calibrated devices which measure blood alcohol directly (AMA Committee on Medicolegal Problems 1970). Other less expensive and highly portable breath testers are available for screening purposes in the field where less precision is needed (Moulden and Voas 1975).

Alcohol intoxication is most commonly apparent through observation of the behavioral and emotional effects of alcohol consumption. Although these effects vary among individuals and among cultures, 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.

The behavioral and emotional effects of alcohol consumption are caused by the 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, the presence of alcohol in the body is most commonly measured through chemical tests performed on samples of blood, urine, and/or breath.

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 the stomach, physical health, and the tolerance 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 all people will show signs of gross intoxication. Many people appear to be intoxicated at a much lower BAC (AMA Committee on Medicolegal Problems 1970).

It is interesting that there is no generally accepted explanation of how intoxication is caused by alcohol nor is there an adequate basis for pinpointing the components of the central nervous system which are most susceptible to the influence of alcohol (U.S. Department of Health, Education and Welfare 1971). The major conclusion that can be drawn from existing research on the fundamental nature of alcohol's effect on the nervous system is that there is insufficient knowledge to develop any practicable model for predicting a specific effect on behavior. Without a general, unifying theory, it has been necessary to turn to empirical data obtained through laboratory and field experiments to describe how alcohol affects behavior (The major findings of these experiments relevant to the alcohol-related crash problem will be discussed later in this report.)

THE PRESENCE OF ALCOHOL IN CRASHES

This section presents the results of several important epidemiologic studies of the incidence of drinking drivers in crashes. The primary objective is to determine approximately how many crashes of various levels of severity involve drivers who were known to have alcohol in their blood at the times of their crashes. A secondary objective is to estimate the incidence of drinking in pedestrians who were fatally injured by being struck by an automobile. In no case should the data presented here be interpreted as showing that the crashes which *involved* drinking drivers were necessarily *caused* by the impairment of those drivers by alcohol. Much more evidence than the mere presence of alcohol in the bodies of people who have been in accidents is required to imply cause.

Data Collection Methods and Problems

In epidemiologic studies, information on crashes and on crash-involved drivers has been collected through the joint efforts of researchers and police officers over a period of one or more years. The usual arrangement is that as soon as possible after a crash has occurred, police officers or dispatchers inform the interested researchers, who then send 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 ideal, since police departments are usually understaffed and the data needs of researchers and the police are not the same.

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. The conventional psychomotor tests for intoxication used by physicians have been shown to be inaccurate as much as 50% of the time (Mason and Dubowski 1976). Moreover, an intoxicated driver with a high motivation to avoid arrest may have an increased ability to mask the influence of alcohol on such things as body sway, walking a straight line, and other tests of coordination used by police officers to identify drunk drivers. 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.

Several problems, however, have been associated with the measurement of blood alcohol concentration 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 the accuracy of this measurement, the sample should be obtained for preservation as soon as possible after the occurrence of the crash or, in the case of studies of the BACs of drivers who have not crashed, as soon as possible after their interception for roadside interview. But drivers may refuse to provide the sample. Legally, in most states, unless the driver has been arrested for driving while intoxicated, no sample may be taken without his permission. His refusal to provide a sample, especially if he also refuses to provide other information, may introduce unknown bias into the results of the epidemiologic studies.

Beyond that, once the driver's permission has been obtained, there must be action 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 resulting from the failure of hospital attendants to obtain samples from all the drivers who are treated, or from delay in obtaining a sample because a driver has 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 from or selected for the tests.

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 difficulty 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 incidence of alcohol in crashes 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. The data on non-fatal injury crashes are taken from studies in which breath samples were obtained at the scene of the crash. The data on fatal crashes are from studies in which nearly all of the deceased drivers were tested for BAC within six hours after the crash.

Alcohol in Fatal Crashes

Figure 3-1 summarizes the range of findings of four well-designed and well-executed studies of fatal crashes. The data were collected in California (two studies), Vermont, and Michigan during the period of 1962 to 1969 (Neilson 1969; Waller et al. 1970; Perrine, Waller, and Harris 1971; Filkins et al. 1970). Each study involved at least 100 drivers who were fatally injured in single-vehicle and multi-vehicle, non-pedestrian crashes.

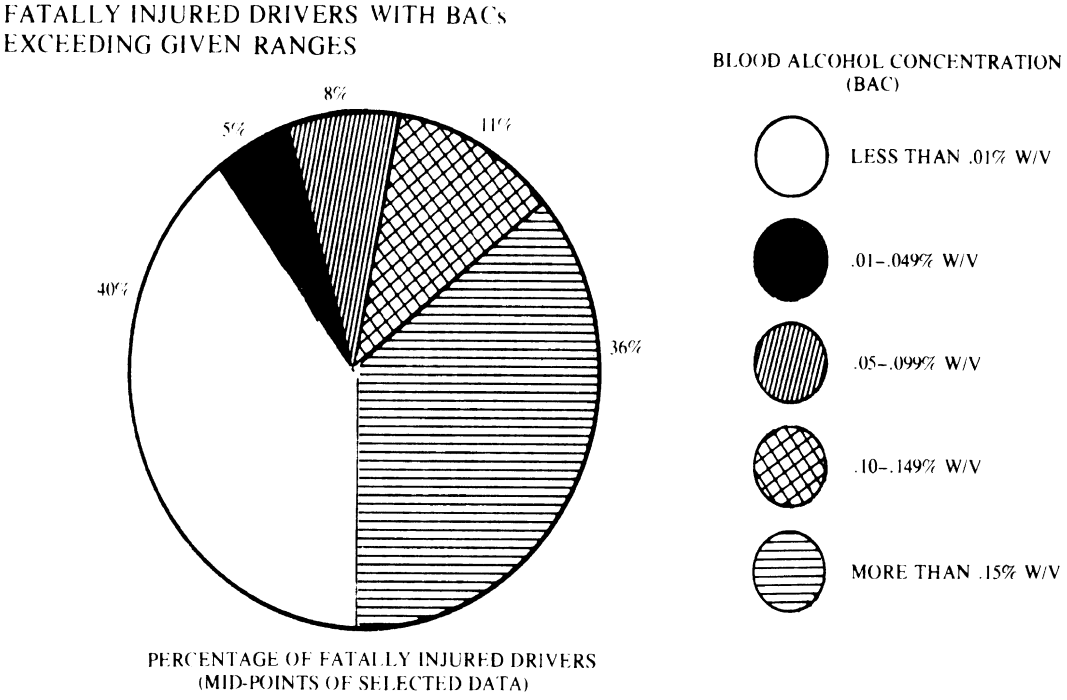
It can be seen from the figure that 40% to 55% of all the fatally injured drivers tested had a BAC of 0.10% w/v or more. These drivers were too intoxicated to drive a motor vehicle under the laws of most states. A large percentage of the drivers (29% to 43%) had BACs in the very high range of .15% w/v or greater.

The data on driver fatalities in single-vehicle crashes (Neilson 1969; Waller et al. 1970; Perrine, Waller, and Harris 1971; Filkins et al. 1970; Haddon and Bradess 1959) show even higher percentages of individuals with BACs above the legal limit for driving (Figure 3-2). 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 studies.

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

Note that all of the above figures apply to fatally injured *drivers*. The figures cannot be applied to *all drivers* in fatal crashes, because the BACs of surviving drivers in fatal crashes were not measured. If, as the Baker and Spitz study (1970) suggests, surviving drivers in fatal crashes have lower BACs than non-surviving drivers, then applying the above percentages to all fatal crashes would tend to overestimate the number of fatal crashes involving drivers at the higher BACs.

Figure 3-1. Blood alcohol concentrations of drivers killed in non-pedestrian crashes (U.S.)



FATALLY INJURED DRIVERS WITH BACs IN GIVEN AMOUNTS

BAC	PERCENTAGE OF FATALLY INJURED DRIVERS	
	RANGE	MID-POINT OF RANGE
.15% W/V OR MORE	29–43	36
.10% W/V OR MORE	40–55	47
.05% W/V OR MORE	50–60	55

DATA FROM CALIFORNIA, VERMONT, AND MICHIGAN, 1962–1969 (Neilson 1969; Waller et al. 1970; Perrine, Waller, and Harris 1971; Filkins et al. 1970).

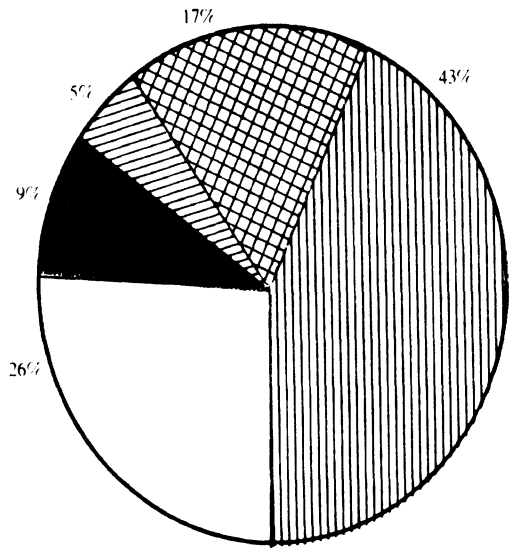
Alcohol in Nonfatal Crashes

The involvement, or frequency, of drinking drivers in nonfatal personal-injury crashes in the United States has been examined in two of the more comprehensive and reliable epidemiologic studies of the alcohol-crash problem. The first of these is the Grand Rapids study (Borkenstein et al. 1964). Its site was Grand Rapids, Michigan, and its time period was July 1962 through June 1963. The BACs of 5,986 drivers were taken at the scenes of crashes of all degrees of severity, except fatal crashes, seven days a week, 24 hours a day.

The second study was conducted more recently (1974–1975) in Huntsville, Alabama (Farris, Malone, and Lilliefors 1976), where data were also collected seven days a

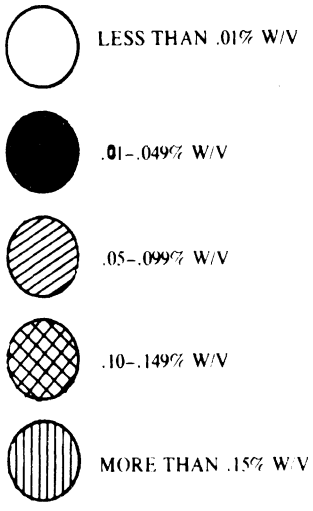
Figure 3-2. Blood alcohol concentrations of drivers killed in single-vehicle, non-pedestrian crashes (U.S.)

FATALLY INJURED DRIVERS
WITH BACs IN GIVEN RANGES



PERCENTAGES OF FATALLY INJURED DRIVERS
(MID-POINTS OF SELECTED DATA)

BLOOD ALCOHOL CONCENTRATION
(BAC)



FATALLY INJURED DRIVERS WITH BACs EXCEEDING GIVEN AMOUNTS

BAC	PERCENTAGE OF FATALLY INJURED DRIVERS	
	RANGE	MID-POINT OF RANGE
.15% W/V OR MORE	34–53	43
.10% W/V OR MORE	55–65	60
.05% W/V OR MORE	60–70	65

DATA FROM CALIFORNIA, VERMONT, MICHIGAN AND NEW YORK, 1958–1969 (Neilson 1969; Waller et al. 1970; Perrine, Waller, and Harris 1971; Filkins et al. 1970; Haddon and Bradess 1959).

week, 24 hours a day. The BACs from 596 drivers in personal injury crashes were taken at either the scene of the crash (about two-thirds) or hospitals. The BACs measured at hospitals were carefully monitored by a researcher to avoid biases in sampling and inaccuracies due to delays in taking the BACs.

The results of the two studies show that from 9 to 13% of the drivers in these crashes had BACs of .10% w/v or more (Figure 3-3). Five to 7% had BACs of at least .15% w/v.

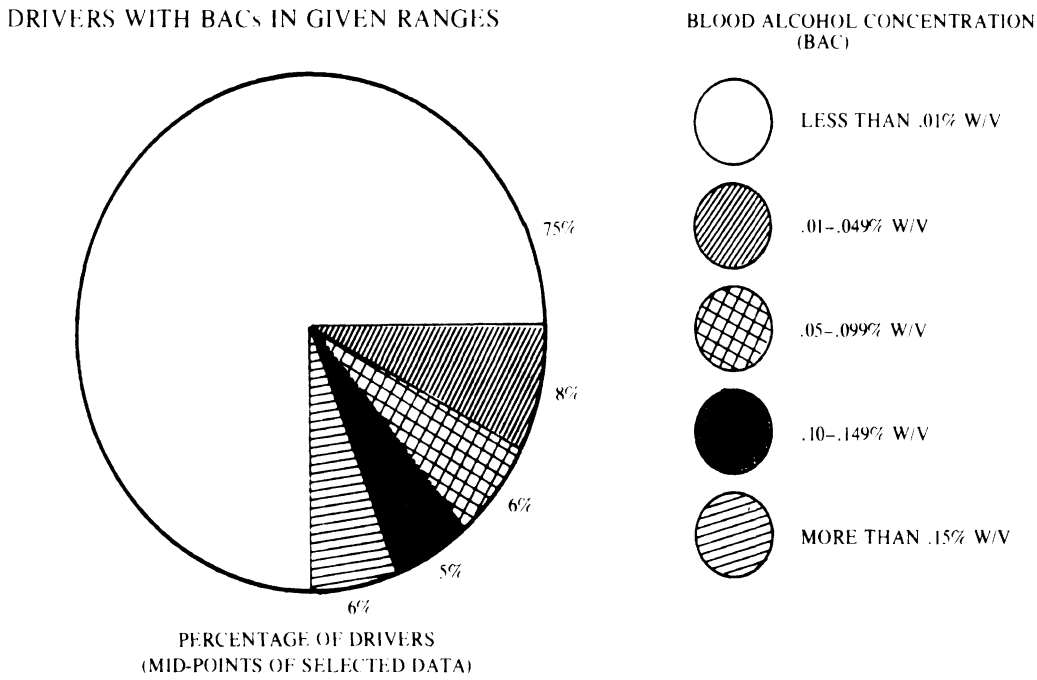
The Grand Rapids study also measured the BACs of 4,570 drivers involved in crashes where there was "no indication of injury," that is, property damage crashes. About 5% of these were at or above a BAC of .10% w/v (Figure 3-4).

Alcohol in Adult Pedestrian Fatalities

As is the case with driver fatalities, BAC measurements for pedestrian fatalities have been made by coroners or medical examiners. Thus, these studies are subject to the same biases as driver fatality studies. Further, the data on pedestrians may suffer from an additional bias because of the common practice among coroners of measuring the BACs only of victims at least 15 years old. This will cause the alcohol involvement to be overstated if the data are erroneously applied to all pedestrian fatalities rather than only to fatalities of pedestrians at least 15 years old.

Figure 3-5 presents the known pedestrian fatality data believed to be the least affected by measurement biases. Two excellent studies conducted by Perrine and associates

Figure 3-3. Blood alcohol concentrations of drivers involved in personal injury crashes (U.S.)



DRIVERS WITH BACs EXCEEDING GIVEN AMOUNTS

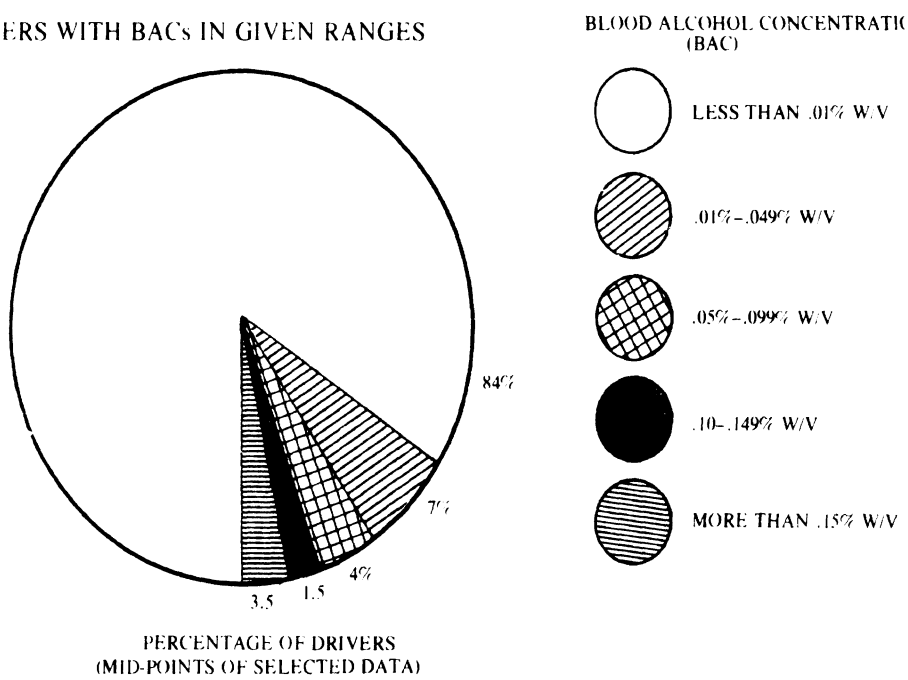
BAC	PERCENTAGE OF INJURED DRIVERS	
	RANGE	MID-POINT OF RANGE
.15% W/V OR MORE	5–7	6
.10% W/V OR MORE	9–13	11
.05% W/V OR MORE	14–19	17

DATA FROM HUNTSVILLE, ALABAMA (Farris, Malone, and Lilliefors 1976) AND GRAND RAPIDS, MICHIGAN (Borkenstein et al. 1964).

(1971) and by Haddon and associates (1961) are not shown because of the very small sample sizes they employed: 14 and 19, respectively. 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.

Unfortunately, there are no published studies of the incidence of alcohol involvement in nonfatal pedestrian collisions. The useful analysis of this aspect of the alcohol and highway safety problem must, therefore, be deferred until more data become available. (The National Highway Traffic Safety Administration is currently sponsoring research to provide such data.) The incidence of pedestrian collisions involving drinking drivers

Figure 3-4. Blood alcohol concentrations of drivers in property damage crashes (U.S.)



DRIVERS WITH BACs EXCEEDING GIVEN AMOUNTS

BAC	PERCENTAGE OF DRIVERS
.15% W/V OR MORE	1.5
.10% W/V OR MORE	5
.05% W/V OR MORE	9

DATA FROM GRAND RAPIDS, MICHIGAN, 1962–1963 (Borkenstein et al. 1964).

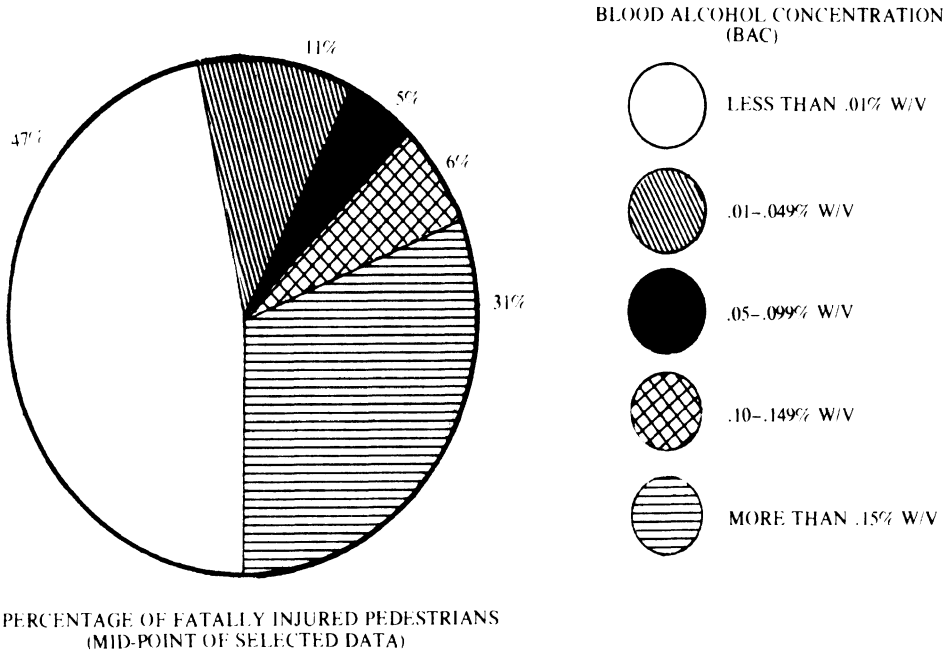
is also unknown. Such data would have the effect of raising the percentages of pedestrian collisions involving alcohol.

National Implications of Epidemiologic Studies of Alcohol's Presence in Crashes

The epidemiologic studies described above were designed as separate research projects to learn more about the alcohol-highway safety problem in specific locations around the United States. Yet, despite wide differences in the study designs and in their geographical locations and dates, the same trends have consistently been observed:

Figure 3-5. Blood alcohol concentrations of adult pedestrians fatally injured by a motor vehicle (U.S.)

FATALLY INJURED PEDESTRIANS WITH BACs IN GIVEN RANGES



FATALLY INJURED PEDESTRIANS WITH BACs EXCEEDING GIVEN AMOUNTS

BAC	PERCENTAGE OF FATALLY INJURED PEDESTRIANS	
	RANGE	MID-POINT OF RANGE
.15% W/V OR MORE	25–37	31
.10% W/V OR MORE	31–43	37
.05% W/V OR MORE	25–48	42

DATA FROM CALIFORNIA AND MICHIGAN, 1962–1968 (Neilson 1969; Waller et al. 1970; Filkins et al. 1970).

- Substantial fractions of the more serious crashes involve drivers whose BACs exceed the usual legal limit of .10% w/v and over.
- Small but not negligible fractions of "minor" crashes involve drivers who are legally too intoxicated to drive.

The implications of these findings for the society as a whole are anything but negligible. A rough idea of the highest possible magnitude of the alcohol-crash problem in the United States in the middle-seventies can be determined by assuming that all crashes that involve drinking drivers are in fact caused by alcohol. This is not to say that alcohol did in fact cause these crashes; obviously, the actual magnitude of the problem will be much less than that calculated under such an assumption, particularly at low BACs. Also, the use of BAC data on fatally injured drivers to estimate alcohol involvement in all fatal crashes will, as indicated previously, possibly further inflate the role of alcohol in such crashes.

Figure 3-6 shows the maximum numbers of different classes of crashes that could have been caused by alcohol in 1975 if all crashes involving alcohol had been caused by alcohol. The numbers in the table are based on the midpoints of the percentages shown in Figures 3-1 and 3-3, and on National Safety Council estimates (1976) of the number of crashes that occurred in 1975. It can be seen that no more than 15,200 fatal crashes, 120,000 serious injury crashes, and 765,000 property damage crashes could have been caused by drivers whose BACs exceeded the legal limit of .10% w/v. In addition, some 2,300 adult pedestrians with BACs of .10% w/v or more were killed in 1975.

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

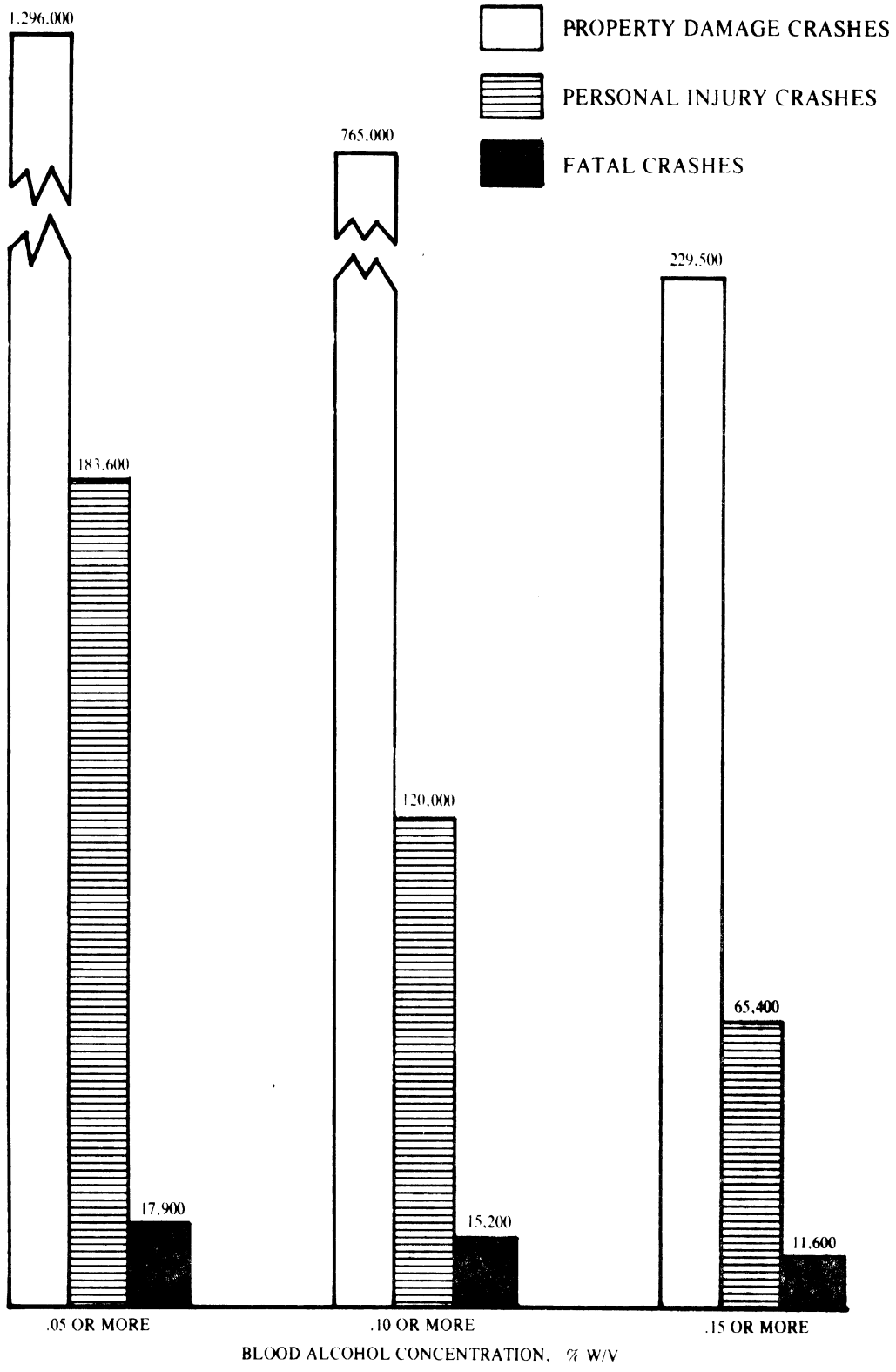
Fatal injury—$287,000
Average personal injury—$3,200
Property damage crash (per vehicle)—$520

The resulting societal costs are presented in Figure 3-7, which indicates that some 6.5 billion dollars in societal welfare losses could have been prevented in 1975 by preventing all non-pedestrian crashes involving drivers with BACs of .10% w/v or more. The upper limit to the societal cost of alcohol-related collisions involving only fatally injured adult pedestrians with BACs of .10% w/v or more was more than half a billion dollars in 1975.

ALCOHOL AND CRASH RISK

These estimates suggest only how large the alcohol-crash problem might be; they cannot be used to support more specific statements. Ideally, one would like to know

Figure 3-6. Estimated maximum number of non-pedestrian crashes in 1975 by drivers with BACs equal to or exceeding given amounts (U.S.)



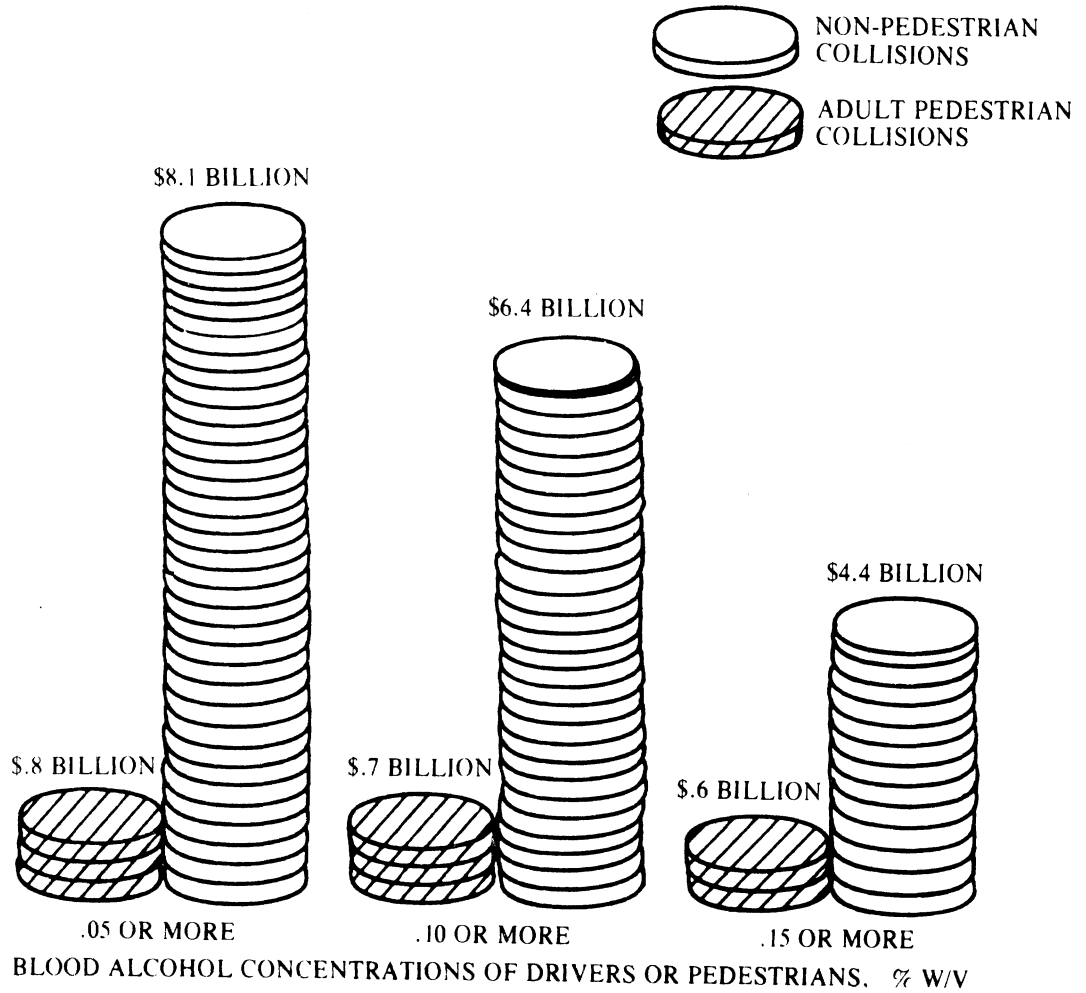
how many crashes each year are caused by alcohol so that a priority could be assigned to the problem and resources could be allocated to programs to reduce the number and consequences of such crashes. Unfortunately, traffic crashes are far too complicated to permit such a simplistic statement to be made. Most traffic crashes involve so many factors that alcohol can be considered only one of many. The most that can be hoped for at present is to be able to describe the crash risk, that is the probability of a crash given a particular set of factors.

Both epidemiological and behavioral approaches have been widely used in attempting to describe how alcohol affects the chances of being in a highway crash. The objective of this part of the report is to summarize what has been learned from such studies.

Epidemiologic Studies

Epidemiologic studies of alcohol-crash risk compare the conditions and characteristics of crash-involved drivers with those of the larger driving population. Such studies

Figure 3-7. Annual economic cost of alcohol-related crashes (U.S.)



are usually called controlled studies or case-control studies. 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 distinguish drivers in crashes from those not in crashes 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 at Evanston, Illinois, in 1938 (Holcomb 1938). Holcomb's study compared the BACs of a sample of drivers who had been in personal injury crashes with those of a sample of drivers who had not been in crashes but who had been using the same roads as the crash-involved drivers. This is a crucial comparison. Without it, Holcomb's finding that 25% of the crashed drivers had been legally too drunk to drive by today's standards would have had little meaning, since it could have been possible that the same percentage of drivers who had not crashed had also been legally drunk. Holcomb's finding that only 2% of the drivers who had not crashed were drunk, while 25% of the crash-involved drivers were drunk, suggested that drunk drivers are twelve and a half times more likely to be in crashes than sober drivers.

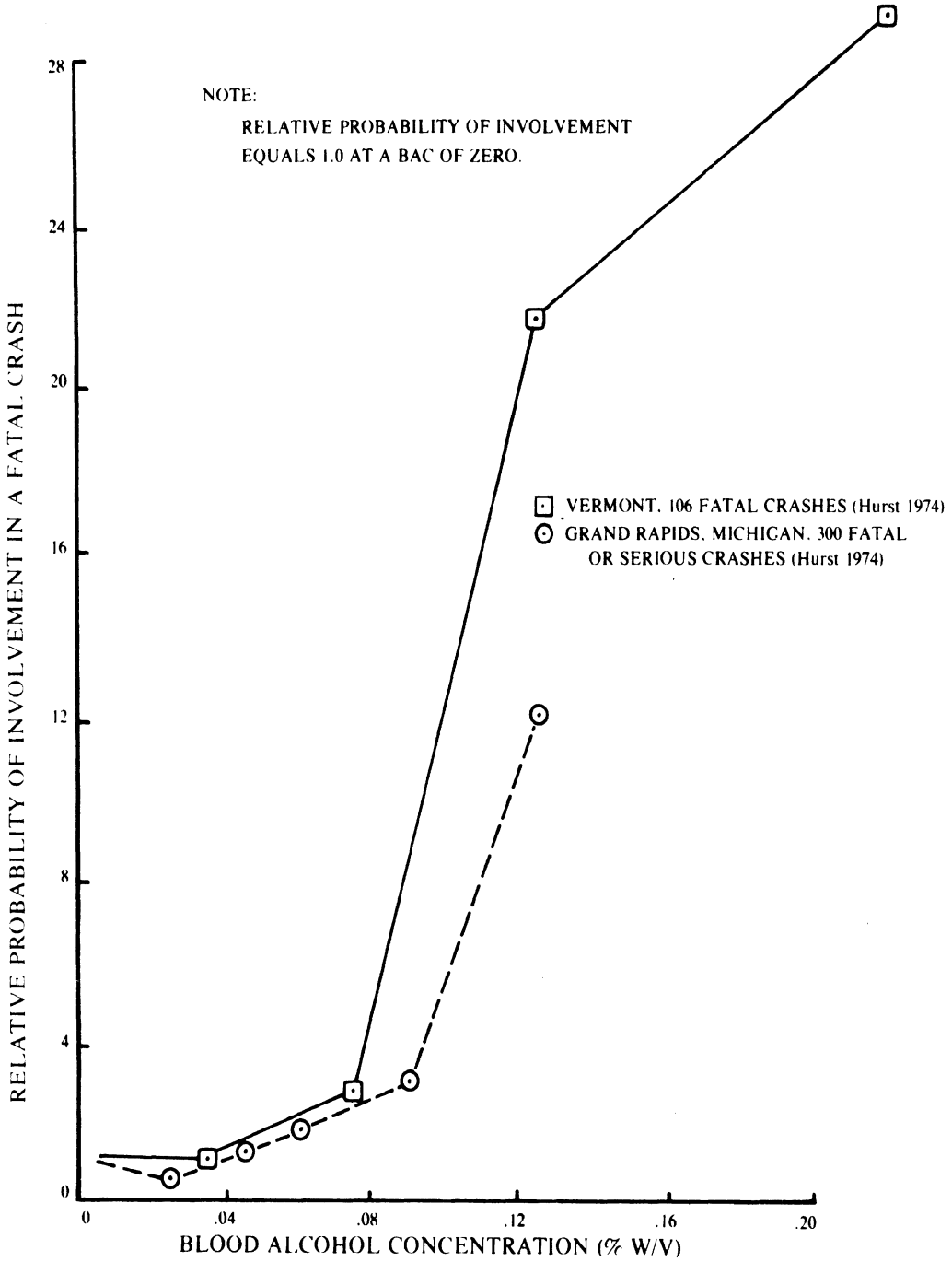
Holcomb's data were still not sufficient to conclude that consumption of alcohol "caused" the crashes. Rigorous statements about cause could be made only if the crashed and the non-crashed drivers and their driving situations had been exactly the same in every respect except blood alcohol concentration. Because of the impossibility of meeting this condition, epidemiologic data can never prove cause, but only imply it. The more closely the two groups match each other on relevant variables, the stronger the implication of causality.

Data on the behavior and characteristics of the larger driving population have been obtained through roadside surveys (Sterling-Smith 1976). In epidemiologic studies, roadside surveys are designed so that the environmental conditions under which crashes occur are matched, that is, controlled for. The procedure is to stop a sample of non-crash-involved drivers using the roads under these conditions (usually by a uniformed police officer) and ask them 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 day 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.

The results of the controlled studies relative to alcohol-crash risk are most meaningfully presented in terms of "relative probability of a crash." This measure was first used in the Toronto study (Lucas et al. 1955) in 1952. Most recently (in 1970) Hurst derived a more rigorous theoretical basis for this measure (Hurst 1970) and has applied

Figure 3-8. Relative probability of involvement in fatal crashes for drivers with BACs at given levels



it to relevant controlled studies up to and including the Vermont study (Hurst 1974). His interpretation 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 3-8 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. The calculations show that the probability of being involved in the Vermont fatal crashes for those too intoxicated to drive legally (BAC at .10% w/v or more) 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 a greatly increased crash risk for legally intoxicated drivers over nondrinking drivers but they indicate the risk to be much lower than that calculated for the Vermont study. The figure shows that the risk of being in a crash begins to increase very rapidly at BACs in the neighborhood of .08% w/v and becomes extremely high at the very high BACs, a greater than 20 to 1 relative probability of crashing at BACs over .15% w/v.

The data from the controlled studies also indicate an increased probability 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 3-9). The Toronto study, conducted only during evening hours, indicates a relative probability of nonfatal crash involvement of about 1.5 at a BAC of .10% w/v. The Huntsville study of personal injury crashes revealed relative probabilities of crashing somewhere in between those found in Toronto and Grand Rapids (Figure 3-9).

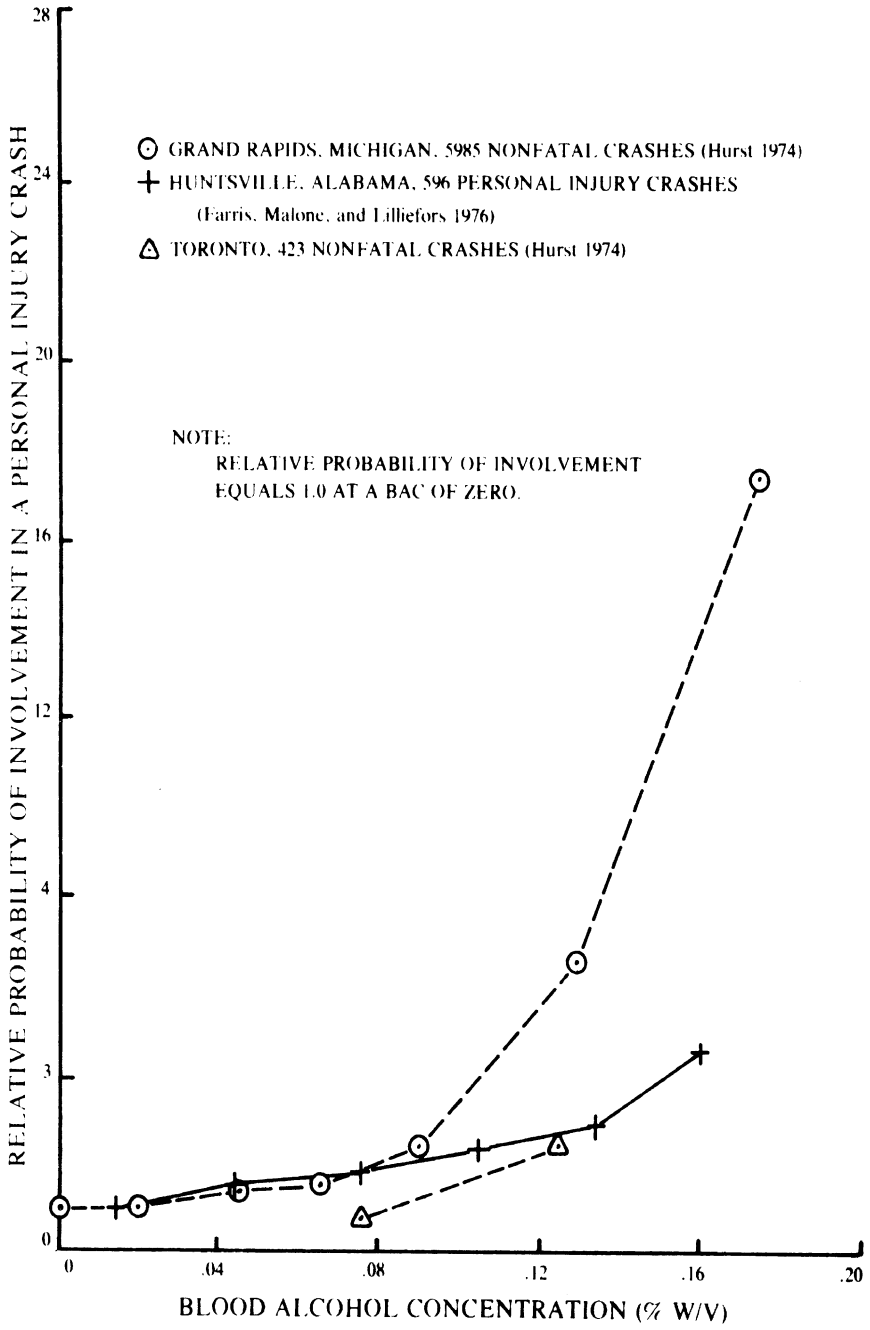
Behavioral Studies

In contrast to the epidemiologic studies, which examine crashes after they have occurred, behavioral studies follow an experimental approach to determine how alcohol might cause future crashes. From a scientific standpoint, it would be ideal to conduct these experiments under real-world driving conditions, measuring the ability of individuals of different ages, drinking habits, personalities, etc., to drive an automobile in various highway environments (e.g., nighttime, daytime, heavy traffic, light traffic) after drinking various amounts of alcohol. For obvious reasons, such realistic experiments are not possible, necessitating experiments that only approximate actual driving conditions and behavior.

This lack of a clear connection between laboratory behavior and driving tasks seriously limits the usefulness of all laboratory studies of the effects of alcohol on human behavior. Because most of the laboratory tasks have been much simpler than those in driving, only a gross effect on the performance of tasks in the laboratory could be safely interpreted to imply an effect on driving performance. In such cases, of course, we cannot precisely describe—quantify—the ultimate effect alcohol would have on driving performance.

A wide range of behavior thought to be related to driving has been studied in these experiments. For the purposes of discussion, we have categorized the experiments as those conducted in laboratories, and those conducted in driving simulators and on closed driving courses.

Figure 3-9. Relative probability of involvement in personal injury crashes for drivers with BACs at given levels



Laboratory experiments. Behavioral studies in the laboratory investigations have been concerned with (1) simple processes, involving the ability to perform relatively uncomplicated tasks not requiring much motivation or understanding, and (2) complex processes involving verbal performance, problem solving, learning, memory, mood, and emotions.

Most of the scientific studies of simple processes concern one or more of the following:

- Interactions of nerves and muscles, such as those that 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 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.
- Attention, such as the ability to maintain concentration on the roadway ahead while driving.

The classical technique used in studying neuromuscular effects is the Romberg test, which measures the ability to stand upright without swaying. Several studies using this technique have found 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 increase significantly was between .04% w/v and .05% w/v (Franks et al. 1976; Fregly, Bergstedt, and Graybiel 1967; Goldberg 1943; Ideström and Cadenius 1968). Other studies, however, indicate that experienced drinkers can, if motivated, overcome these impairing tendencies at BACs as high as .20% w/v (Laves 1955; Prag 1953). The exact relationship between these tests and drinking performance is not known.

Much research has been conducted on the influence of alcohol on vision. It indicates that 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 (Honneger, Kampschulte, and Klein 1970; Mortimer 1963; Newman and Fletcher 1941). However, the ability to distinguish close, but separated, moving objects seems to be consistently impaired at much lower BACs, sometimes as low as .03% w/v (Honneger, Kampschulte, and Klein 1970). Studies of the effect of alcohol on other modalities of vision show little or no impairment at low to moderate BACs, but increasing impairment at BACs above .08% (Lewis, Dustman, and Beck 1969; Lewis 1972; Mortimer 1963; Moskowitz 1974; Newman and Fletcher 1941).

Studies indicate that "simple" tracking performance does not appear to be seriously degraded at BACs of less than .10% w/v (Chiles and Jennings 1969; Colquhoun 1962; Newman 1949; Talland, Mendelson, and Ryack 1964), but the performance of "complex" tracking tasks has been degraded in many individuals at BACs in the .05% to .10% w/v range (Binder 1971; Levine, Greenbaum, and Notkin 1973; Mortimer 1963).

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 (Billings and Wick 1972; Gruner, Ludwig, and Domer 1964).

Studies of the higher, more complex processes of the brain point to a dichotomy in the effect of alcohol on mood and emotion (Wallgren and Barry 1970; Warren and Raynes 1972; Kelly, Myrsten, and Goldberg 1971). Some individuals are stimulated by alcohol and become exhilarated, cheerful, and friendly; but others are depressed and become quiet, relaxed, sleepy, and unable to think clearly.

Other studies of more complex behavior indicate that risk-taking may be increased at moderate BACs for introverts and light drinkers (Coldwell et al. 1958; Cutter, Green, and Harford 1973; Goodwin, Powell, and Stein 1973). Moreover, low doses of alcohol have been observed to improve the intellectual performance of heavy drinkers and alcoholics while having the opposite effect on light drinkers (Mello 1972; Wallgren and Barry 1970). Alcohol has been found detrimental to memory, particularly the long-term memory of heavy drinkers (Ehrensing et al. 1970; Wallgren and Barry 1970; Weingartner and Faillace 1971a and 1971b).

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 1969). 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).

What all these findings mean is that some behavior that appears to be related to driving performance is impaired by alcohol, but the exact nature and extent of the impariment and its frequency of occurrence among different individuals at given BACs cannot be stated. But the most serious shortcoming of all studies of this type, as indicated earlier, is the lack of any clear relationship between the behavior studied in the laboratory and driving. 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 pertain to the tasks that must be performed in driving an automobile on a busy expressway at night. Without an explicit relationship, it cannot be said precisely how an observed impairment affects the probability of having an automobile accident. The most that can be said is that some behavior studied in the laboratory is consistently and significantly impaired in most 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.

Experiments using driving simulators and closed driving courses. In order to observe the effects of alcohol in more realistic conditions, researchers have tried to approximate actual driving conditions by using driving simulators in the laboratory or 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 above, the usefulness of the findings of these studies—especially simu-

lator studies—is also limited (Edwards, Hahn, and Fleischman 1969). In simulator and closed-course driving experiments, the speeds achievable are much lower than average highway speeds and the tests last for a relatively short time. The tests also require much simpler skills than ordinary highway driving.

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 reviewer did note 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).

Closed-course driving experiments indicate that the ability of many drivers to perform parking maneuvers becomes impaired at BACs as low as .04% to .06% w/v (Bjerver and Goldberg 1950). 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 (Goldberg and Havard 1968). Closed-course driving performance at moderate speeds has been shown to be impaired at BACs as low as .05% to .07% w/v (Lovibond and Bird 1970; Seehafer, Huffman, Kinzie 1968).

Some recent studies of driver performance at the University of Vermont have indicated that moderate amounts of alcohol, producing BACs of .07% to 10% w/v, increase accelerator reversals and, possibly, steering inaccuracy (Huntley and Centybear 1974; Perrine and Huntley 1971). The Vermont studies also suggest that the driving performance of extroverted persons may be more degraded by alcohol than the performance of other persons. The latest Vermont study (Damkot et al. 1977) suggests that drivers with high BACs (i.e., .08% to .149% w/v) may drive faster and perform stopping less smoothly than other drivers.

As with laboratory experiments, simulator and close-course driving experiments have not been useful in developing quantitative estimates of the crash risk associated with drinking and driving. They tend to support the epidemiologic findings that alcohol-crash risk starts to rise at a BAC of about .08% to .10% w/v, but they do not inform us on the magnitude of these increases in risk.

THE PEOPLE WHO DRINK AND DRIVE

The data presented earlier in this chapter indicate that the consumption of alcohol is a major factor in a large number of highway crashes and that it does impair driving performance. The objective of this section is to summarize what is known about the behavior and characteristics of people whose combined patterns of drinking and driving appear to create an abnormally high risk of their being involved in a crash.

Two basic types of research provide the data necessary to define the problem of alcohol and highway safety more sharply. The first is the epidemiologic study, used previously in this report to develop broad statements describing the drinking-driving problem and to be used now for a more detailed definition of groups of drinking drivers. Research of the second type surveys and tests selected groups of people to learn more about the demographic characteristics, the drinking and driving habits, the physical and psychological attributes, and the attitudes of drinking drivers. Studies that attempt to relate such survey and test data to findings from epidemiologic studies are also considered here.

The specific findings about the people who drink and drive are preceded in the paragraphs that follow 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.

Drinking and Drinking-Driving Patterns

Over the last several decades, the consumption of alcoholic beverages in the United States has increased among members of the drinking-age population, 15 years and over. This 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). Table 3-1, shows 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 may be higher than these figures reflect.

TABLE 3-1

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).

The U.S. ranked 16th in per capita consumption of absolute alcohol among 26 selected countries (mostly western and industrialized) surveyed in 1975 (Keller and Gurioli 1976). Each drinking-age person in the U.S. consumed about half as much alcohol as his counterpart in first-ranking Portugal, and about three times as much as an average drinker in last-ranking Israel.

Patterns of alcohol consumption in the U.S. vary among members of the drinking age population on the basis of a number of sociocultural variables which appear to influence the reasons that people drink, the types and amounts of beverages they consume, and the settings in which they drink. Using data collected in a national survey of the drinking patterns of adults (21 years and older) conducted in 1964–65, 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.

Researchers have been unable to agree on functional definitions of significant types of drinkers and drinking patterns. Consequently, many definitions are used in the literature on the effect of alcohol on human behavior. Three categories of drinkers are commonly of concern to researchers: the social drinker, the problem drinker, and the alcoholic. Although social drinkers and problem drinkers tend to be seen as mutually exclusive categories at a given time, any one individual may be a problem drinker at one time in his life and a social drinker at others. Moreover, there is a considerable overlap between the problem drinker and the alcoholic categories. Not every problem drinker is an alcoholic, but the alcoholic is certainly a problem drinker.

The definitions of social drinkers, problem drinkers, and alcoholics used here are 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, alcohol enhances the occasions when it is used. Alcohol 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" refers to 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 inter-personal problems who also drink immoderately.

The "alcoholic" is a person whose nervous system has developed a tolerance to alcohol; over a period of time, he requires more and more alcohol 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 drinking at which the benefits of drinking have begun to decline rapidly 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.

Characteristics of Drinking Drivers

Researchers contributing to the literature on the alcohol-crash problem categorize the variables for describing drinking drivers in several ways. For this report we have adopted the three categories Perrine used in his recent review (1975), and added a fourth, to describe the results of epidemiologic research:

1. variables that are primarily biographical, including such demographic characteristics as sex, age, race, etc;
2. variables that relate particularly to driving, such as the number of previous crashes, driving experience, number of driving interactions with law enforcement agencies, etc;
3. variables that describe an individual's drinking practices, such as the quantity and frequency of his drinking and the type of beverage he consumed; and
4. variables which have been analyzed in various psychometric studies and which are classified here as personality and stress variables.

Of course, there are interactions among these four categories of variables, and these cannot be ignored.

The purpose of examining the variables in these categories is to determine:

- The extent to which sub-groups of drivers contribute to the total alcohol-crash problem.
- The alcohol-crash risk—that is, the relative risk of crashing after drinking—of each sub-group.

The data on the extent of crash-involvement of drivers (when available) are presented first to estimate the importance of the variable to the overall alcohol-crash problem and to give a rough idea of the risk associated with that variable. Next, the available data on drivers using the road but not involved in crashes (i.e., data from roadside surveys) are presented to refine the initial rough estimate of alcohol-crash risk. Lastly, the data from controlled studies are provided as a final basis for assessing crash risk.

It would be preferable to use controlled studies exclusively when discussing crash risk, but such studies do not provide enough data on the relevant sub-groups of drivers to calculate their risk. Note that without data from controlled studies, no explicit quantitative statements can be made about crash risk after drinking.

Considerable care is required when interpreting the findings of studies of individuals who drink and drive. The studies are useful in developing a better understanding of groups of drinking drivers but of course they cannot be used to identify a given individual as a certain alcohol-crash threat. Moreover, different characteristics that have been associated with alcohol-crash risk are difficult to combine to form a composite picture or "profile" of "high-risk" drivers. The reader is advised to use caution in creating such profiles even as an aid to understanding common characteristics of high-risk

drivers. Particularly, the use of simplistic profiles to describe priority targets for countermeasures should be avoided.

The reader should also be aware that many of the variables which describe drinking drivers are not independent. Thus, an effect that may seem to be due to one variable may just as well be due to another variable that is closely related to the first variable. These "confounding" effects often make it difficult to infer which variable is most associated with an observed effect.

Biographical variables: sex. Among those variables classified as biographical, sex has been found to be one of the best differentiators of drinking drivers. Males are consistently over-represented in all kinds of drinking-driver populations, particularly among crashed drivers with high BACs, that is with BACs greater than .08% w/v. Studies in California (Waller et al. 1970) and Michigan (Filkins et al. 1970) found that about 90% of the 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 found that 63% of all drivers in such crashes were male and 81% of all crashed drinking drivers were male (Farris, Malone, and Lilliefors 1976). The Grand Rapids study of crashes of all types (most of which were of the less serious property-damage variety) showed 78% of the drivers to be male and 88% of the 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 3-2). 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, the 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 3-2

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. The data show that although a male's crash risk at a BAC of .08% w/v was about twice his crash at zero BAC, the relative crash probability of females at a BAC of .08% w/v was nine, or about 4.5 times higher than that of males. The study found little difference between the relative probability of males' crashing and females' crashing at the lower BACs. If anything, females have slightly less risk at such BACs. A recent study of nighttime drivers (Carlson 1972) found, however, 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 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.

Biographical variables: age. With respect to age, both the youngest and the oldest persons have been found less frequently than others among drinking drivers. In the study of fatal crashes in California (Waller et al. 1970) "only" 18% of fatally injured drivers under age 20 were legally intoxicated by today's standards (BAC of .10% w/v or more), 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).

Studies of drivers not involved in crashes but stopped for roadside surveys have shown the same general trend with regard to age, although the differences are usually exaggerated. For example, the Vermont study of drivers surveyed at the 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. The Huntsville study of drivers using the roads at the times and places of injury crashes found that about 4% of its under-20 drivers had been drinking (BAC of at least .03% w/v) but 11% of its over-20 driver had been drinking (Farris, Malone, and Lilliefors 1976). The combined results of a National Roadside Survey and the nighttime surveys conducted under NHTSA's Alcohol Safety Action Project 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 these studies; that is, 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).

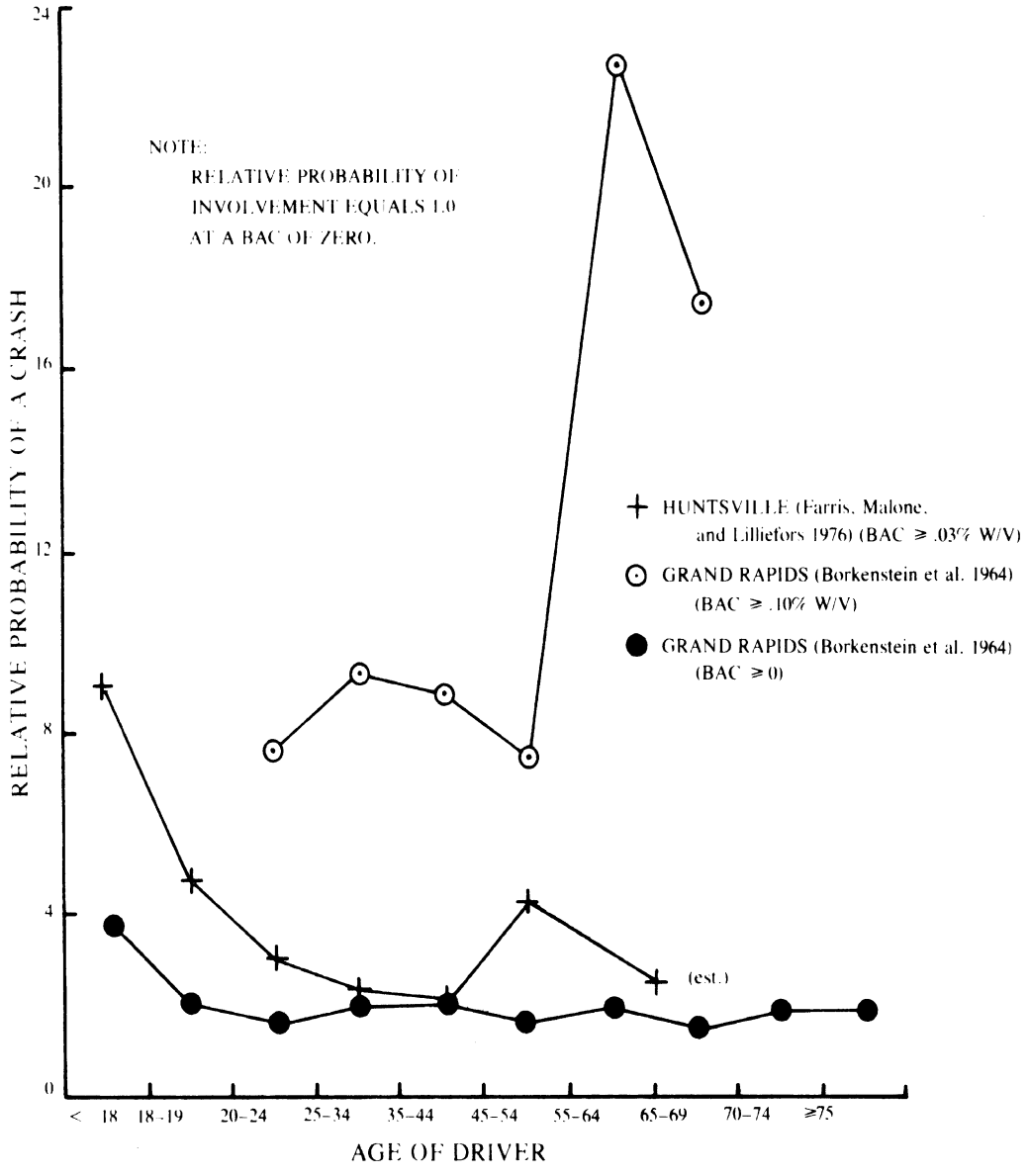
The effects of age on alcohol-crash risk are completely opposite to the effects observed above. Data from the Huntsville study (Farris, Malone, and Lilliefors 1976) and the Grand Rapids study (Borkenstein et al. 1964) indicate that the crash risk of very

young drivers is much higher after drinking than it is for drivers from other age groups (Figure 3-10). 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 younger drivers is their relative inexperience with driving after drinking, but there are few behavioral data on the differential effects of age to support this hypothesis.

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

Figure 3-10. Relative probability of crash involvement for drivers, by age



several states indicate that, indeed, such an effect does exist, but they leave some question as to the amount of the effect (Douglas, Filkins, and Clark 1974; Whitehead et al. 1975; Zylman 1976; Williams et al. 1975; Smart and Schmidt 1976; Ferreira and Sicherman 1976; Douglas and Freedman 1977).

Biographical variable: marital status. Studies of drivers' marital status have shown that married persons comprise the largest percentages of drinking drivers who have crashed and of drivers using the road. For example in the California study 17% of the fatally injured drivers were divorced or separated, 16% were single, and 61% were married (Waller et al. 1970). The Vermont study found that 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," 13 (72%) were married, and four were single (Perrine, Waller, and Harris 1971). The Grand Rapids data on less serious crashes also found that married drivers appeared most frequently among crashed drinking drivers (Borkenstein et al. 1964, Table 39).

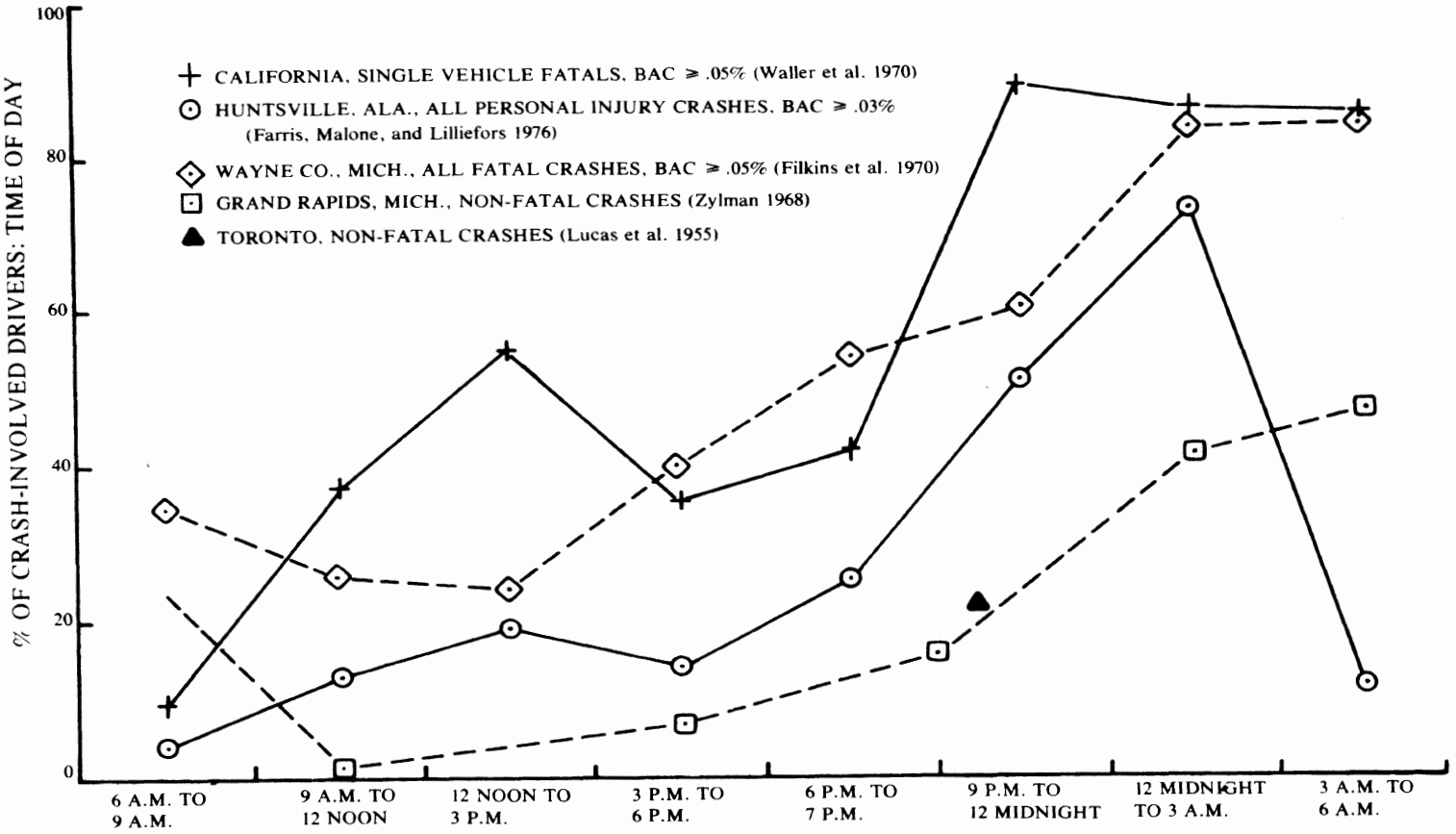
The Grand Rapids data also showed that separated or divorced drivers with BACs of at least .05% w/v had a slightly higher relative crash probability than married drivers who, in turn, had a slightly higher relative crash probability than single drivers. Other studies have found that divorced or separated fatally injured drivers were more likely to have been drinking than other fatally injured drivers (Waller et al. 1970; Filkins et al. 1970).

Unfortunately, many of the studies that have investigated the effect of marital status on alcohol-related crashes have not attempted to control 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. Certainly, research conducted to date does not prove that marital status is strongly related to crash risk.

Other biographical variables. 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 (Borkenstein et al. 1964; Wolfe 1975; Perrine, Waller, and Harris 1971). Increased alcohol involvement among nonwhites has been explained in one study as a socioeconomic rather than a racial effect (Zylman 1972a). 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 (Wolfe 1975). Less educated persons were found more frequently among drinking drivers in some older studies (Borkenstein et al. 1964), but more recent studies show less of an educational effect except at high BACs (Perrine, Waller, and Harris 1971; Farris, Malone, and Lilliefors 1976; Wolfe 1975). No research provides any convincing evidence that occupational level, race, income, or education has any significant relationship to alcohol-crash risk.

Driving variables: time of day and day of week. It would be logical to expect that crashes involving drivers who have been drinking would occur with higher relative frequency at the times of day when people tend to drink more, i.e., the evening hours.

Figure 3-11. Percentage of crash-involved drivers who had been drinking, by time of day



The findings of past studies are in general agreement with this expectation (Figure 3-11). 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 (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.

Less serious kinds of crashes exhibit this same trend. The Huntsville study (Farris, Malone, and Lilliefors 1976) showed that 73% of all drivers in personal injury crashes occurring from midnight to 3:00 a.m. had been drinking (that is, they had BACs of .03% or more), but that fewer than 20% of such drivers had been drinking from 6:00 a.m. to 6:00 p.m.

A similar trend might be expected with respect to weekend versus weekday crashes. Such a trend has in fact been noted in several studies (Filkins et al. 1970; Waller et al. 1970; Farris, Malone, and Lilliefors 1976), but it is much less pronounced than that observed for nighttime hours versus daytime hours (Figure 3-12). The largest differences were found in Wayne County, Michigan (Filkins et al. 1970), 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.

There is also a trend toward higher frequencies of noncrash-involved drinking drivers in the nighttime driving population. 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 (Farris, Malone, and Lilliefors 1976; Zylman 1973b; and Wolfe 1975). 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.

Only one study, Grand Rapids, has collected enough detailed data to estimate the effect of the time of day on crash risk. Zylman (1973b) states that these unpublished data show that the risk of BACs over .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 because the higher density of daytime traffic increases the demands on drivers, resulting in increased crash probability even at low BACs.

Driving variables: annual mileage and origin of trip. Conflicting results have been obtained with respect to the relationships between the annual mileage driven and drinking driving (Borkenstein et al. 1964; Wolfe 1975). 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 (Borkenstein et al. 1964). The relative risk of a crash after drinking may also be higher for the very-low-mileage driver (Borkenstein et al. 1964). The origin of the trip which occasioned the illegal drinking-driving is most frequently a bar or tavern or another person's home (Wolfe 1975; Carlson 1972).

Driving variables: previous crashes and enforcement actions. Research suggests that drinking drivers have had slightly more previous crashes than other drivers. The Wayne

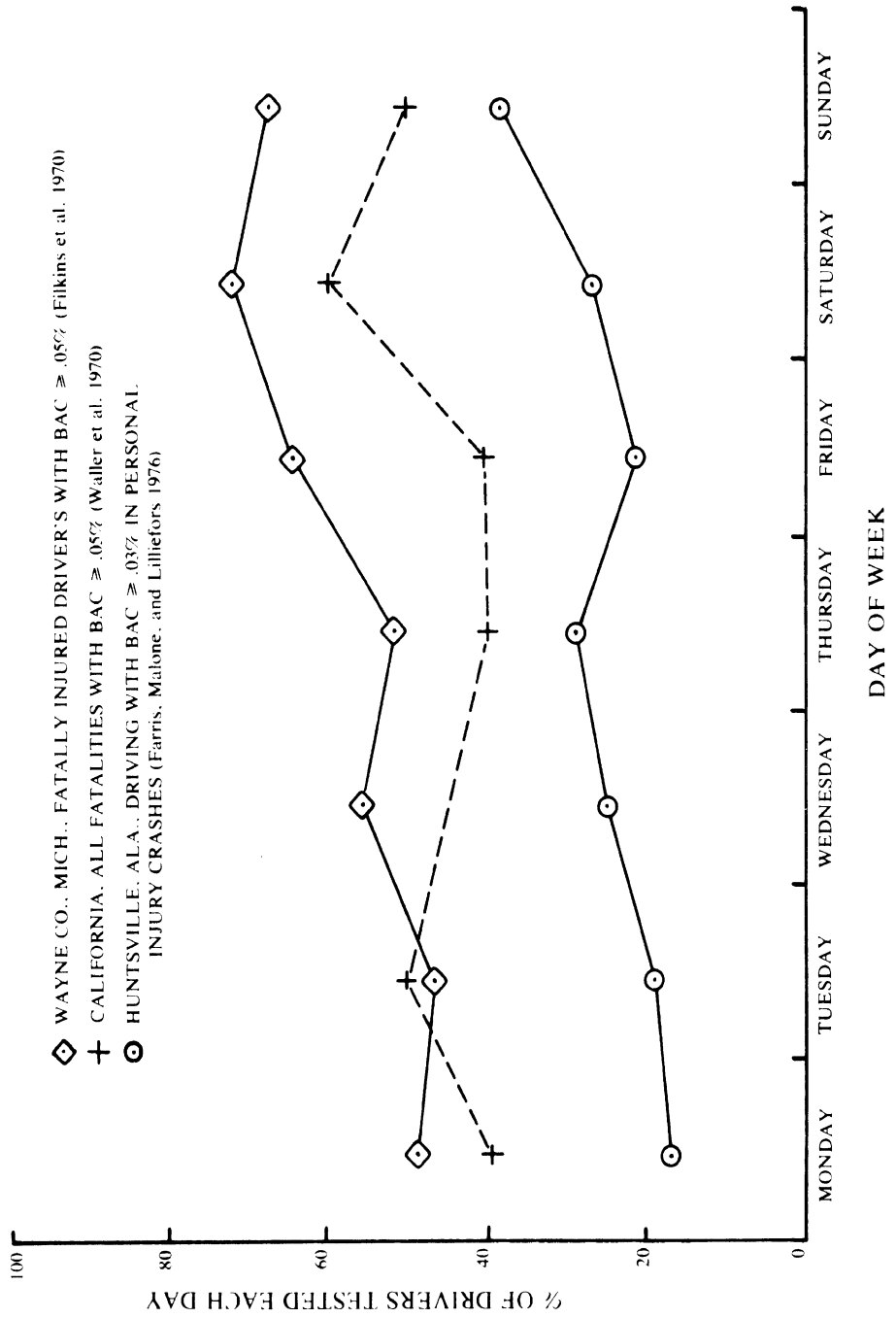


Figure 3-12. Percentage of drivers who had been drinking, by day of week

County, Michigan, study found that 59% of its fatally injured drivers who had experienced one or more crashes in the preceding six and one-half years had BACs of at least .10% w/v when killed, but that only 53% of the fatally injured drivers who had 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 had two or more crashes in the past five years, and 13% of the drivers with BACs of 10% w/v had 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).

Drinking drivers also tend to have more enforcement actions against them. The Wayne County study of fatally injured drivers found intoxicated drivers had nearly nine times the percentage of convictions for driving under the influence of liquor as nonintoxicated drivers (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 or for public drunkenness or for both (Sterling-Smith 1976). Neither study, of course, provides a sufficient basis for concluding that the number of previous citations or previous crashes is somehow a causal factor in alcohol-related crashes.

Persons arrested for driving while intoxicated (DWI) generally have more prior driving convictions than other persons and perhaps more prior crashes (Filkins et al. 1970; Perrine, Waller, and Harris 1971). Their driving records have been found to be similar to those of fatally injured drivers with high BACs, but their 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 (Shupe and Pfau 1966). 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 (Filkins et al. 1970; Perrine, Waller, and Harris 1971). There are no data from controlled studies to provide a quantitative estimate of the alcohol-crash risk of persons arrested for DWI.

Drinking variables. Several studies have examined various variables that describe an individual's drinking patterns. They have attemped 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.

Because the information sought is frequently highly sensitive (about problems with alcohol, such as the frequency of driving while intoxicated), respondents may conceal or distort their habits. Thus, to obtain scientifically significant 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 assess them here. The reader should keep in mind the inherent limitations of research on drinking patterns when reviewing the material presented below.

Drinking variables: frequency and quantity of drinking. The Grand Rapids study (Borkenstein, et al. 1964) 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 the times and places of the crashes. The data permit one to calculate the crash risk of drivers with various self-reported drinking habits. 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 3-13). 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.

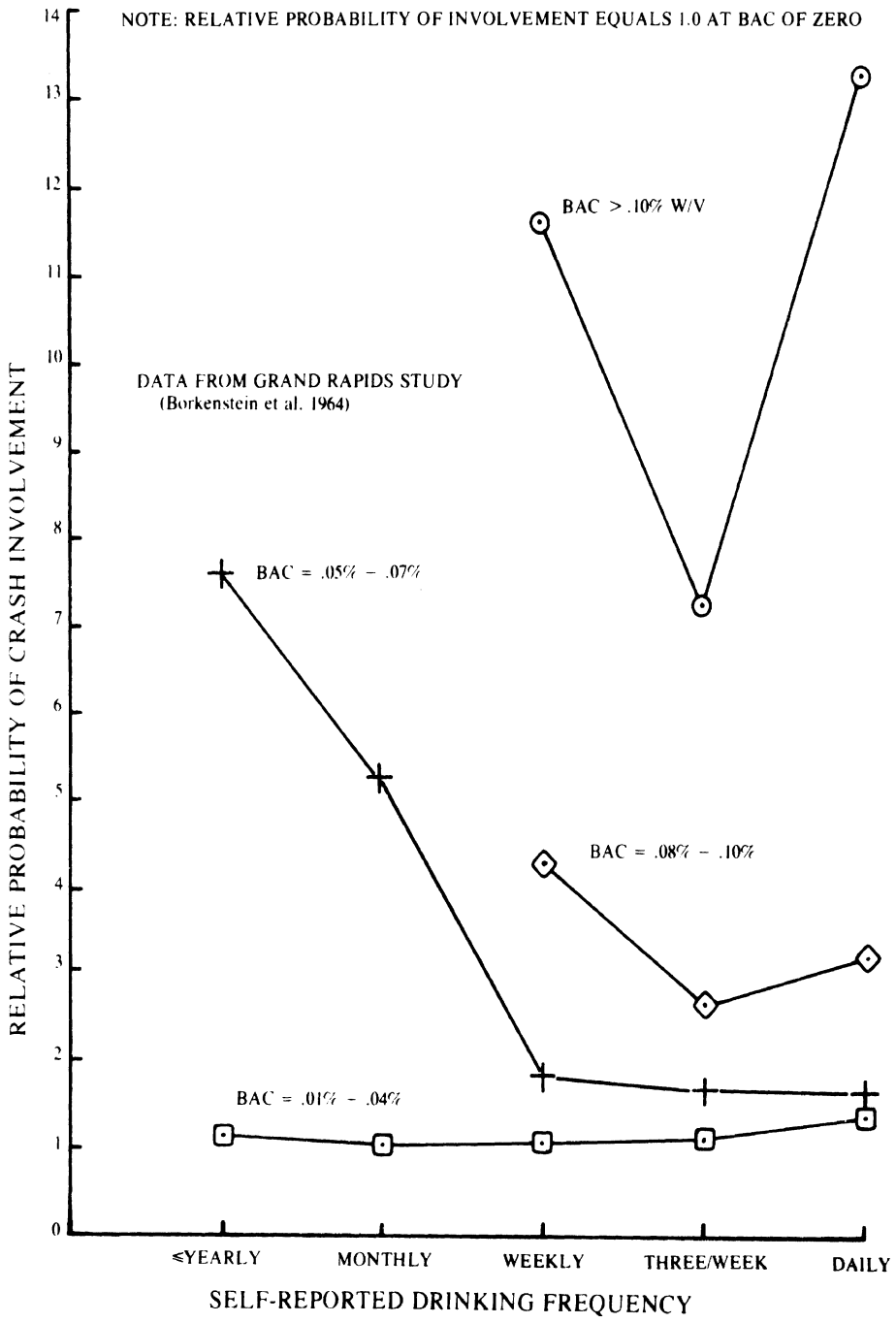
An interesting trend can also be observed for the daily drinkers, who had a higher crash risk at the higher BACs (.08–10% w/v and ≥ .10% w/v) than individuals who said they drank three times a week. In any case, a positive BAC increased the probability of a crash, regardless of drinking frequency.

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 3-11 (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 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 crash risk of all drivers (including frequent drinkers) increased with increasing BACs. Further, the trends were such as to suggest the existence of very high relative risks for even the frequent drinkers at high BACs (greater than .15% w/v).

The Vermont study (Perrine, Waller, and Harris 1971) investigated the combined effects of frequency and quantity on drinking driving and 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 other persons. Heavy drinkers were more likely than others to engage in drinking-driving 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.

Drinking variable: type of beverage and place of drinking. 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 (Borkenstein et al. 1964; Perrine, Waller, and Harris 1971; Wolfe 1975). An especially high preference for beer

Figure 3-13. Relative probability of crash involvement at given BAC levels for drivers, by self-reported drinking frequency



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) (Borkenstein et al. 1964; Perrine, Waller, and Harris 1971). 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. None of these studies shows that beer drinkers have a higher alcohol-crash risk than other drinkers, nor do they show any strong, direct relationship between the place of drinking and the risk of crashing.

Drinking variables: alcoholics and problem drinkers. The terms "alcoholic" and "problem drinkers" have been defined generally in an earlier section of this report. More specific measures of the severity of drinking-related problems experienced by such individuals have been stated as (Cahalan and Room 1974):

1. heavy intake—frequency of drinking five 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—physician's warning to cut down on drinking, giving up drinking for health reasons, injuries in accidents due to drinking, and
13. financial problems related to drinking—drinking seen by subject as harmful to his financial position.

Because of the severity of their drinking problem, alcoholics are relatively easy to identify by applying these measures. Problem drinkers are more difficult to identify both because they occupy a wider portion of the spectrum of drinking patterns and because

"problem drinking" has not been precisely defined. This lack of precision in defining the term "problem drinker" makes it impossible to determine the role of such individuals in highway crashes. Obviously, programs to deal with such a broadly defined group are difficult to design, and no single approach (such as treatment and rehabilitation) will be appropriate for all so-called problem drinkers.

No one knows exactly how many alcoholics and problem drinkers there are in the United States. A figure often used is that about 7% of the drinking-age population are either alcoholics or have severe drinking problems (Efron, Keller, and Gurioli 1974; Keller 1977).

Within the field of highway safety, the most widely used techniques for screening drivers for alcohol-related problems is the Mortimer-Filkins test. The questionnaire, interview, and scoring procedure which make up this technique and variations of them 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). On the basis of a summary score he is categorized as a social drinker, presumptive problem drinker, or problem drinker. In three ASAPs in which full use was made of the Mortimer-Filkins Test, 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).

There is a wide range of views on the role of persons with drinking problems in crashes. This range is illustrated by the different conclusions reached by two long-time researchers in the field of alcohol and highway safety, 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, alcoholic drivers could be involved in 41% to 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."

Zylman, on the other hand, has stated that the role of alcoholics in crashes has been exaggerated. He cautions against branding all alcoholics as "high-risk drivers" and cites studies which indicate to him that the driving records of alcoholics are not as bad as others have stated. He notes that many studies have suggested that other psychological and social stress factors often interact with alcoholism to create behavior that leads to crashes and that "the misuse of alcohol is only one manifestation of deviant behavior" (Zylman 1976a).

The issue is complicated by the lack of a precise, commonly accepted definition of the term "problem drinker", and by the lack of controlled studies of problem drinkers who have crashed and problem drinkers who are merely using the roads. There is a dearth also of behavioral studies to differentiate the effect of drinking on the driving performance of alcoholics and problem drinkers from the effect of drinking on the performance of other types of drinkers. Without such research, it is impossible to state conclusively that impairment of the ability to perform critical driving tasks by alcohol

has caused any given fraction of crashes involving alcoholics or problem drinkers. Past research merely shows that, for whatever reasons (not necessarily impairment by alcohol), alcoholics as a group are more frequently involved in crashes and enforcement actions than non-alcoholics as a group and that alcoholics are, therefore, a logical subject for further study.

To provide clues or "indicators" about the involvement of alcoholics and problem drinkers in alcohol-related crashes, the research of Waller, Zylman, and others have had to rely on data from many, not necessarily reliable, sources such as hospital records, driver records, accident reports prepared by police officers, and interviews with surviving relatives of fatally injured drivers. One such indicator, fatty degeneration of the liver, has been associated with excessive drinking over extended periods of time. Studies in California (Waller et al. 1970), Michigan (Filkins et al. 1970), and Vermont (Perrine, Waller, and Harris 1971) have found that fatally injured drivers with high BACs were much more likely to have fatty livers than fatally injured drivers who had not been drinking. The Vermont study found that the distribution of fatty liver changes among highway fatalities with zero BAC was more similar to that found among persons in the general population than to the distribution found in highway fatalities who had been drinking.

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 (Filkins et al. 1970). The study found that the crash rate (not necessarily alcohol-related crashes) 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. Convictions for driving while intoxicated 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. 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.

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-related crashes had a history of problem drinking (Sterling-Smith 1976). Only 25% of the drivers in the crashes not related to alcohol had a history of problem drinking. Of the drivers with BACs of .20% w/v or greater, 72% were said to have had known problems with alcohol. The validity of these findings is not known because of the manner in which a history of problem drinking was determined: through interviews with relatives of deceased drivers.

In summary, studies indicate that persons with severe drinking problems are disproportionately involved in all kinds of crashes, including alcohol-related crashes. Unfortunately, the studies do not permit quantitative statements to be made about the alcohol-crash risk or alcohol-crash involvement of such drivers.

Variables describing personality and exposure to stress. Studies of personality and stress variables that may be related to drinking-driving have not been conclusive and offer little basis 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 (Pelz and Schuman 1974). Such persons who are also low in personal efficacy may run an even greater risk of being in a traffic incident. Further, research suggests that drivers who are inordinately tense, depressed, fatigued, and given to risk-taking may be especially likely to cause serious alcohol-related crashes (Sterling-Smith 1976). Studies of drivers convicted of driving while intoxicated found them to be more agressive, more depressed, less self-esteeming, less responsible, and less in control of themselves than drivers in general (Selzer, Vinokur, and Wilson 1977; Selzer and Barton 1977). Some personality characteristics commonly thought to be much associated with highway crashes in general (belligerence, negativism, etc.) have not been found to occur more frequently in alcohol-related crashes (Fisher 1976; Schmidt 1972).

SUMMARY AND CONCLUSIONS

A major tool for studying the role of alcohol in highway crashes is the epidemiologic study of the incidence of drinking among various populations of drivers, particularly drivers who have crashed and drivers who have been exposed to highway environments similar to those of the crashes without crashing. 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 incident to highway crashes. For the most part, it appears that 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 largely unable to generate sufficiently rigorous data for wider application.

As a result, the first step commonly taken in such programs—problem identification—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 for the driver to be considered legally too intoxicated to drive in most states (i.e., BAC at .10% w/v or above). An even higher percentage (55–65%) of the drivers who were killed in single-vehicle crashes had BACs of at least .10% w/v. Nine to 13% of all drivers in

personal-injury crashes and 5% of drivers in property-damage crashes were legally intoxicated.

The national impact of these figures is enormous. If one assumes that the national percentages of drivers in accidents who had BACs of .10% w/v lie at the midpoints of the ranges found in the studies summarized here, then intoxicated drivers were involved in the following numbers of crashes in 1975:

- Fatal crashes: 15,200 (47% of all fatal crashes)
- Personal injury crashes: 120,000 (11% of all personal injury crashes)
- Property damage crashes: 765,000 (5% of all property damage crashes)

The societal costs of these crashes is estimated to be in the order of $6 billion. The losses would be even higher if one counted the hundreds of thousands of crashes that involved lower but possibly impairing BACs, and the thousands of pedestrians who are killed or seriously injured each year. Of course, not all of these crashes can be said to have been caused by alcohol, but these figures do provide a rough idea of the upper limit to the alcohol-crash problem in the United States.

The epidemiologic studies do indicate that the risk or relative probability of being in a crash increases as the concentration of alcohol 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 .15% w/v, the relative probability of a fatal crash could be as high as 15 to 20. The probability of being in less serious crashes also increases after drinking, but not to as great an extent.

Experimental studies of the effect of alcohol on human behavior lend support to these epidemiologic findings about crash risk. More important, the experiments provide evidence that many of the crashes that involve alcohol occur because the drivers are impaired by alcohol. The experiments do not, however, provide any basis for determining how many crashes may be attributed to alcohol impairment. The usefulness of experimental data in defining and dealing with the alcohol-crash problem is, in fact, severely limited by the lack of explicit relationships between the behavior studied and critical driving tasks.

A number of variables describing drinking drivers and drinking driving have been studied in the literature. Variables which appear to be strongly related to alcohol-crash involvement, alcohol-crash risk, or both are:

sex,
age,
time of day of crashes,
day of week of crashes,
number of prior arrests for DWI,
frequency and quantity of drinking,
type of beverage preferred, and
history of alcoholism or problem drinking.

Variables which research has shown to be less related to the alcohol-crash problem are:

marital status,
occupational level,

race,
income,
education,
annual mileage driven,
origin of trip which involved illegal drinking-driving,
place of drinking, and
number of previous crashes.

Of the variables that have been studied in the literature, sex is one of the best differentiators of drinking drivers. Males occur far more frequently than females in alcohol-related crashes. 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, faced four to five times a greater crash risk 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.

In the second category of variables, those specific to driving history, research suggests that drinking drivers have had 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.

Among the third category of variables, those related particularly to drinking practices, 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 the 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 weekdays, although the effect is not nearly as great as it is for time of day.

The relationships that have been studied with respect to quantity and frequency of drinking indicate that, as might be expected, crashed drivers are 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 increased drinking frequency, indicating that the more experienced drinkers are somehow better able to cope with the effects of alcohol in driving. Nevertheless, even more frequent drinkers have a higher crash risk at high BACs than they do at low BACs. Studies also show that beer is the beverage most preferred by drinking drivers, especially those with high BACs and those who report that they are heavy drinkers.

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; that is, greater than .10% w/v. 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. The literature does not provide a reliable basis for quantitative estimates of the alcohol-crash risk of alcoholics and problem drinkers, or of the number of alcohol-related crashes that involve alcoholics.

While it is important that operational programs be based on knowledge gained through research, extreme caution must be used when applying research findings on the characteristics of drinking drivers to operational programs. 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.

Chapter 4

DEALING WITH THE ALCOHOL-CRASH PROBLEM

From the survey of the literature conducted for this report and summarized on the preceding pages, it is clear that excessive drinking plays a major role in a large number of crashes. Moreover, the literature has provided clues for identifying the characteristics of groups of drivers who are involved in such crashes. The objective of this section is to summarize and review critically what has been done in the past to remedy the alcohol-crash problem. Generic approaches to the problem are examined with respect to their targets, their methods, and their results.

Targets

This discussion of the targets of programs to reduce the losses from alcohol-related crashes is concerned with the extent to which the programs have identified precisely what they have attempted to control. At the most general level, their targets are the crash losses from alcohol-related crashes, but more specific definitions (both explicit and implicit) are sought in reviewing these programs. Thus, an attempt is made here to determine what kinds of "losses" were to be reduced by the programs and whether such losses were to be reduced by decreasing the number of alcohol-related crashes or by decreasing the number of fatalities and injuries resulting from the crashes once they occurred. The review also attempts to determine whether the control measures used in such programs were directed primarily at the driver (e.g., convincing him not to drive after drinking), at the vehicle (e.g., designing devices to warn other drivers about the presence of a drunk driver), or at the highway environment (e.g., designing signs more likely to be comprehended by intoxicated drivers). Finally, the review attempts to identify any specific groups of drivers that were addressed by the programs, such as social drinkers, young drivers, nighttime drivers, etc.

Methods

The discussion of methods is limited to those used by alcohol-safety programs that have specifically addressed drinking drivers only, rather than programs aimed at drinkers or drivers in general, such as prohibition, state and local measures to restrict alcohol use among sub-populations of drinkers, and programs to treat alcoholism or to

educate the general public on the symptoms of alcoholism. Programs aimed specifically at drinking drivers include campaigns to enforce laws against driving while intoxicated and public information campaigns on the greater crash risk faced by drinking drivers. For purposes of discussion and analysis, we have grouped such programs according to their general approach:

- legal,
- health,
- public information and education,
- technological, and
- systems.

The 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 behavior believed to present unacceptably high risks to society. Failure by a driver to comply with such rules would, should he be caught, result in such punishment, as a fine or jail sentence, the threat of which is believed to act as a deterrent to the prohibited behavior. The deterrence is accomplished, according to the theory, either through the effect of the punishment in preventing the punished parties from repeating the act (called "special deterrence" in the literature) or by preventing most or all members of a given group from driving while drinking even if they are not caught and punished, called "general deterrence" (Zimring and Hawkins 1973).

Programs approaching the problem as a matter of health 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, such as classes for those convicted of driving while intoxicated, for all types of drinking drivers are also included in this category.

Public information and education, the third way of approaching the problem, 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.

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 BAC under field conditions.

Most past and proposed programs for dealing with the drinking driver employ two or more of these four approaches simultaneously. There are few examples of programs using one approach exclusively. Programs which methodically employ several approaches have been called "systems" approaches in the literature (Voas 1975b). Only one example of a full-scale systems approach has been documented (the National Highway Traffic Safety Administration's Alcohol Safety Action Project).

Evaluations

The present report's discussion of the specific programs representative of each of these approaches is concerned with how well they have worked in accomplishing their stated or implied objectives relative to reducing crash losses. Such judgment is essential to the design of better control programs in the future. Programs using each approach described above are discussed with respect to targets, actions directed at the targets, and evaluation.

The Legal Approach

Concept and Theories of Deterrence

Deterrence is the basis for the legal approach to controlling the drinking driver. The premise of deterrence is that a behavior can be prevented by the threat of punishment (Zimring and Hawkins 1973). 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 1966).

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

- the characteristics of the target population (e.g., impulsiveness, assessment of risk, willingness to take risks, attitudes about authority, social status) (Zimring and Hawkins 1973; Joscelyn and Jones 1972; Raiffa 1968),
- the nature of the behavior to be prevented (e.g., type of offense, moral seriousness of the offense, motivations behind an offense) (Andenaes 1966; Morris 1951),
- the target population's knowledge of the presence of the deterrent threat (Zimring and Hawkins 1973), and
- the credibility of the deterrent threat to the target population (i.e., sure and universal application of a suitably unpleasant punishment) (Zimring and Hawkins 1973).

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 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 traffic law system performs four basic functions: law generation, enforcement, adjudication and sanctioning.

The function of law generation 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 how the traffic law system should deal 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 legally 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 traffic law system 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 the legal approach, no single component exists within the traffic law system, nationwide, 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 disseminate information to both the general public and the members of the traffic law system (Joscelyn and Jones 1972). The National Highway Traffic Safety Administration has performed this function for jurisdictions that have been involved in its Alcohol Safety Action Project.

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.

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. 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).

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 aimed at all types of alcohol-impaired drivers who were defined most typically (though not always) in terms of BAC (Birrell 1975; Carr, Goldberg, and Farber 1975; Ross 1973; Ross 1975).

Applications of the Legal Approach

As stated above, the formal mechanism for applying the legal approach is the traffic law sytem, 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 the traffic law system's activities relevent to controlling alcohol-crash losses is discussed below. The activities of agencies that have been involved in various aspects of *public information* related specifically to deterrence are also discussed.

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 risky behavior, usually in terms of what constitutes impairment 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, impairment was described 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. Today, all states define impairment in terms of BAC measured by a chemical test. In 48 states, the Virgin Islands, and American Samoa, a BAC of .10% w/v or higher is considered to be impairing. In Idaho and Utah the maximum 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 offenses defined by the higher BAC are more severe than the lower BAC penalties.

A distinction is made in the laws as to whether a specified maximum BAC is "presumptive" or "per se" evidence that he was actually impaired at the prohibited BAC. In states that have per se laws, driving with a BAC exceeding a given value is in itself illegal. As of 1975, 10 states had per se laws, and nine of these states specified .10% w/v as the maximum 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).

As noted, the punishment specified by 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 driving while intoxicated 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.

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 driving while intoxicated. 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 1974b).

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).

Foreign countries have tended to set lower BAC limits for impairment and to specify more severe punishments for driving while intoxicated 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 Farber 1975). The state of Victoria in Australia has had a limit of .05% w/v since 1969 (Birrell 1975). Norway, Sweden, and Denmark all have BAC limits of .05% w/v and relatively strong punishments for violators.

Enforcement. Several studies have reviewed enforcement practices in the United States during the early 1970s (Joscelyn and Jones 1971; Planning and Human Systems, Inc. 1976; Oates 1974). Major steps that have been described include:

- detection,
- apprehension,
- initial observation,
- decision-making on further processing,
- booking,
- administering BAC test,
- processing refusals to submit to a BAC test, and
- releasing the accused violator to await trial.

The most common mode of detection is said to be an officer's observation of such manifestations of driving while intoxicated as "chronically high or low rates of speed, erratic weaving, 'jack rabbit' starts, 'screeching' stops, and dramatic over-corrections of driving errors" (Joscelyn and Jones 1972). Some Alcohol Safety Action Project sites have 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 (Planning and Human Systems 1976).

It has been common practice for an officer to make initial observations to help him decide if he should arrest the person he suspects of driving while intoxicated. Field tests requiring the driver to pick up a coin, walk a straight line, etc., were commonly employed for this purpose. A recent study (Burns and Moskowitz 1977) found that, when properly given, such tests can be highly accurate in correctly classifying individuals as at or above .10% w/v BAC. In some cases preliminary breath tests have been used (Planning and Human Systems 1976). Other factors relevant to officers' decisions on arresting drivers for driving while intoxicated have been:

- the 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 (Joscelyn and Jones 1971); Planning and Human Systems 1976; Oates 1974).

Following his arrest for driving while intoxicated, the suspect has often had to be transferred to police headquarters for booking and then taken to a facility to have a BAC test administered. Typically, considerable paperwork 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 is released to await trial (Joscelyn and Jones 1971).

Post arrest processing at some of the Alcohol Safety Action Project sites has been reduced by making BAC testing more convenient. Often the breath testing devices in such jurisdictions have been located at the law enforcement agency (Planning and Human Systems 1976).

Studies of the enforcement of the laws against driving while intoxicated prior to the Alcohol Safety Action Projects 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). Borkenstein estimated that on the order of 2,000 DWI violations occur for every arrest (Borkenstein 1975).

The effect of the Alcohol Safety Action Projects has been to increase DWI arrests overall by a factor of two to three for participating sites (U.S. Department of Transportation 1975a). Enormous increases occurred in several jurisdictions. In Virginia, for example, Fairfax County 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% per licensed driver during ASAP (U.S. Department of Transportation 1975a), 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.

Adjudication and sanctioning. Adjudication and sanctioning are functions performed by the so-called "lower" courts in the United States. The process 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, that is, 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 the National Highway Traffic Safety Administration (Joscelyn and Jones 1971; Institute for Research in Public Safety 1972; Jones et al. 1976).

Note that 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 driving while intoxicated, 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).

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, lack of understanding of the alcohol-crash problem, and lack of sufficient resources to prepare and present cases (Joscelyn and Jones 1971; Voas 1975b; Institute for Research in Public Safety 1972; Wagner 1976). Similar factors have been found to have an adverse effect on the adjudication and sanctioning functions. The effect of overly severe punishments is claimed by some experts to be especially serious (Joscelyn and Jones 1971).

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), reporting case studies in two jurisdictions that later became Alcohol Safety Action Project sites, found that nearly all of those arrested for driving while intoxicated (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; jail sentences averaged only one and one-half weeks per conviction. License suspensions averaged about 6 months in one jurisdiction and 10 months in the other. A nationwide mail survey in 1970 by Joscelyn, Maickel, and Goldenbaum (1971) indicated that most of the responding jurisdictions imposed a fine for a DWI conviction and jail sentences were relatively infrequent. 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 purposely "diverted" from the legal system in the pretrial phase to participate in treatment and rehabilitation programs, and this undoubtedly resulted in a lower conviction rate than could have been obtained under a strictly legal approach.

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).

Public information. The primary objective of information campaigns used in legal approaches to controlling drinking-driving has been to increase the probability of apprehension as it is perceived by the public (Ross 1973; Wilde 1975). One of the best examples of the use of such a campaign is the British Road Safety Act of 1967. It undertook actions 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 perceived probability of apprehension was apparently increased by the Act, 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 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.

Similar legislation in Canada was less successful. Some possible reasons for this have been stated as:

- Canadian police officers must have evidence of impairment before requesting a breath test; in Great Britain, the only prerequisite is evidence of drinking, evidence of a 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).

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. Evaluations that have been performed indicate that most applications of the legal approach have not been effective in deterring drinking-driving.

Buikhuisen and his associates at Gröningen 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 1972).

In the U.S., the so-called "Chicago crackdown" in 1971 was evaluated after the fact by 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).

The National Highway Traffic Safety Administration's Alcohol Safety Action Project program found no correlation between the rates of arrests for DWI and for crashes. Their evaluation of the 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 ASAP evaluators speculated that a possible explanation for this disappointing result was that the target population had not perceived the increased enforcement threat or that the threat was still not high enough.

Post hoc evaluations of the effects of increasingly severe drinking-driving legislation in the Scandanavian countries have resulted in conflicting conclusions. Ross (1976) found no significant changes in crash rates in any of the four countries. A recent analysis of the Scandinavian data by Votey (1976) concluded that legal sanctions strongly reinforced an individual's tendency not to drive after drinking. The data suggested to Votey that the legal approach does influence the level of crashes.

The British Road Safety Act of 1967 is the one alcohol safety program that has clearly been shown to reduce losses from alcohol-related crashes. Using the interrupted time series techniques, Ross (1973) determined that the 1967 law was effective for a period of three years in decreasing the rate of accident casualties. He also found evidence 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 at or above .05% w/v) using the road immediately following the introduction of the legislation, followed by a rise in drunk driving one year later.

A likely reason for the lack of success of most past legal approaches is that the risk of apprehension is very low. Research suggests that a driver in the U.S. would have to commit some 200 to 2,000 DWI violations to be caught, after which he would still stand only a 50-50 chance of being punished—mildly at that. Such a risk is apparently acceptable even to most social drinkers, who are able to control their drinking.

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 aftercare resources.

Paralleling the movement to treat rather than punish drunkenness, some highway safety specialists were recommending a health approach for dealing with the drinking drivers. 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 to treat and rehabilitate drunken drivers.

Targets of the Health Approach

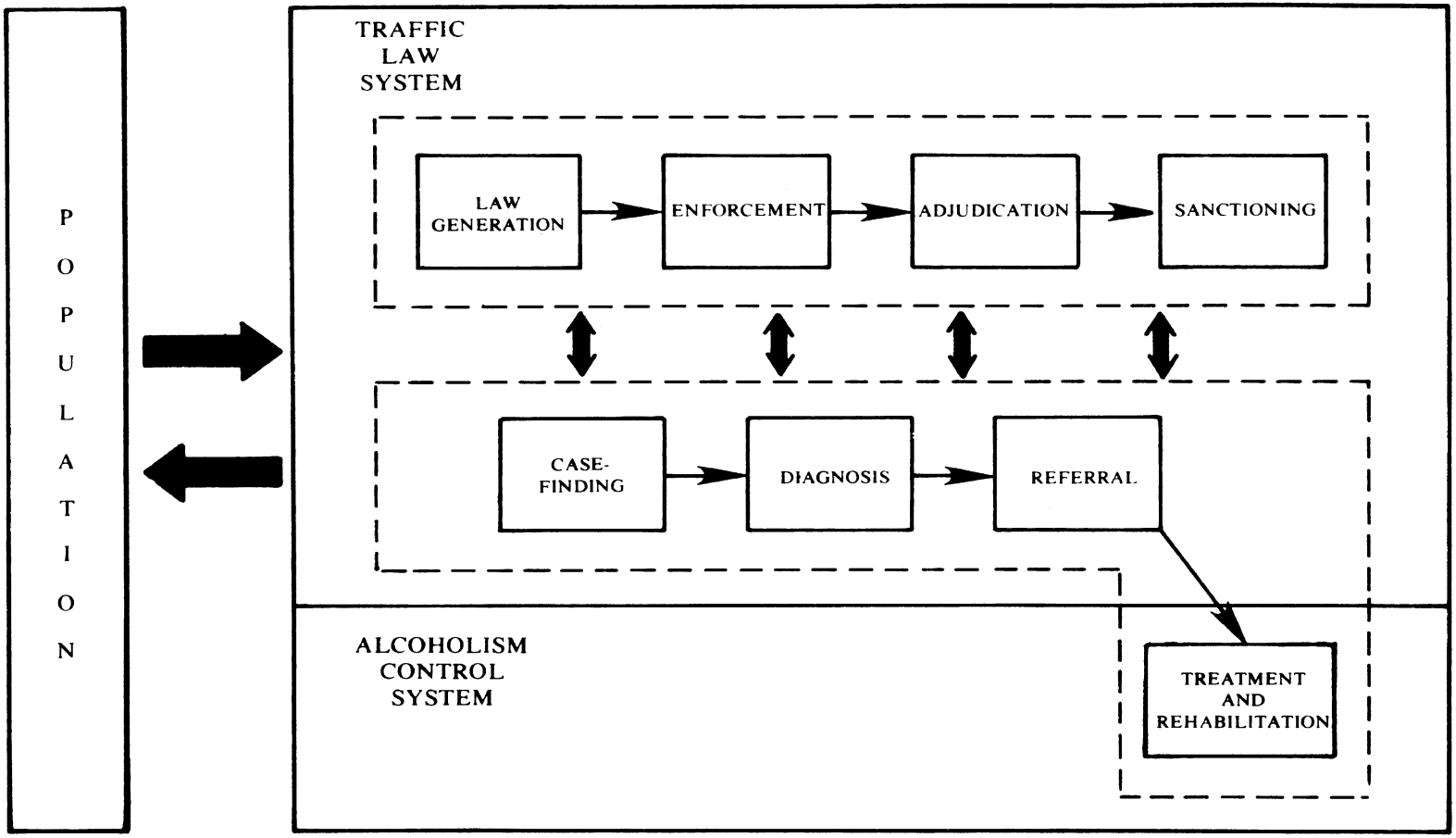
By its very nature, the health approach is directed at controlling the precrash behavior of drivers. The population group dealt with is predetermined by its most common mode of entry into treatment and rehabilitation programs and is, therefore, composed of persons arrested for and, for the most part, convicted of driving while intoxicated or some similar offense. As such, nearly all members of the group will have been legally drunk with BACs of .10% w/v or more at the time of their arrest, and some 50 to 75 percent of them can be classified as problem drinkers.

A 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. Some jurisdictions, however, have made some implicit attempts to deal differentially with sub-groups of persons arrested for driving while intoxicated, and several Alcohol Safety Action Projects have used the Mortimer-Filkins Test to classify individuals beyond the usual distinction between problem drinkers and social drinkers (U.S. Department of Transportation 1975a).

Applications of the Health Approach

Many of the functions of the health approach in the United States 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." In addition to its unusual functions of law generation, enforcement, adjudication, and sanctioning, the TLS takes on the public health functions of casefinding, diagnosis, and referral (see Figure 4-1). The final health functions of treatment and rehabilitation are performed by another, less organized societal system, termed the "alcoholism control system" in one

Figure 4-1. The drinking driver control system



study (Joscelyn and Jones 1971). The functions, processes, and interfaces of various forms of this conceptual drinking-driver control system are described in the following section.

Health and legal functions of the traffic law system. The initial health function of the traffic law system (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 strictly legal approach, TLS legislative and enforcement components have been the primary performers of the case-finding function, proscribing risky behavior by laws and regulations and by arresting violators of the laws. In general, these laws and the manner in which they have been enforced have not differentiated drivers according to whether they are subsequently to be dealt with through a legal approach or a health approach.

The diagnosis and referral functions are concerned with determining the problem that brought the individual into the drinking-driver 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 TLS 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.

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 and Jones 1972). By contrast, referral to nonmedical rehabilitation (schools for persons with DWI convictions) 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 the Alcohol Safety Action Project (see Table 4-1). 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 driving-while-intoxicated 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.

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

TABLE 4-1

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.

cases just prior to sentencing (Reese et al. 1974). 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).

The sources of information for diagnosis and referral at Alcohol Safety Action Project sites were listed in the National Highway Traffic Safety Administration's 1974 *Evaluation of 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).

In ASAP, the Mortimer-Filkins Test (and local variations of it) have been used for identifying the problem drinkers among drivers who have been arrested for driving while intoxicated. 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 and more than 80% of persons undergoing PSIs in those two years.

Treatment and rehabilitation. In a 1971 review, Joscelyn, Maickel, and Goldenbaum (1971) categorized the treatment modalities for problem drinking as 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, transactional analysis, for example, and motivational therapies (U.S. Department of Health, Education, and Welfare 1974).

Examples of treatment and rehabilitation programs aimed specifically at problem-drinking drivers are rare in the literature. Most of 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 and Simon 1974). Between 1966 and 1973, over 15,000 people convicted of driving while intoxicated attended the course.

The course consisted of four sessions at weekly intervals, each session lasting about two and a half hours. The 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 to assist with referrals to community agencies. Probation officers and counselors participated in discussions.

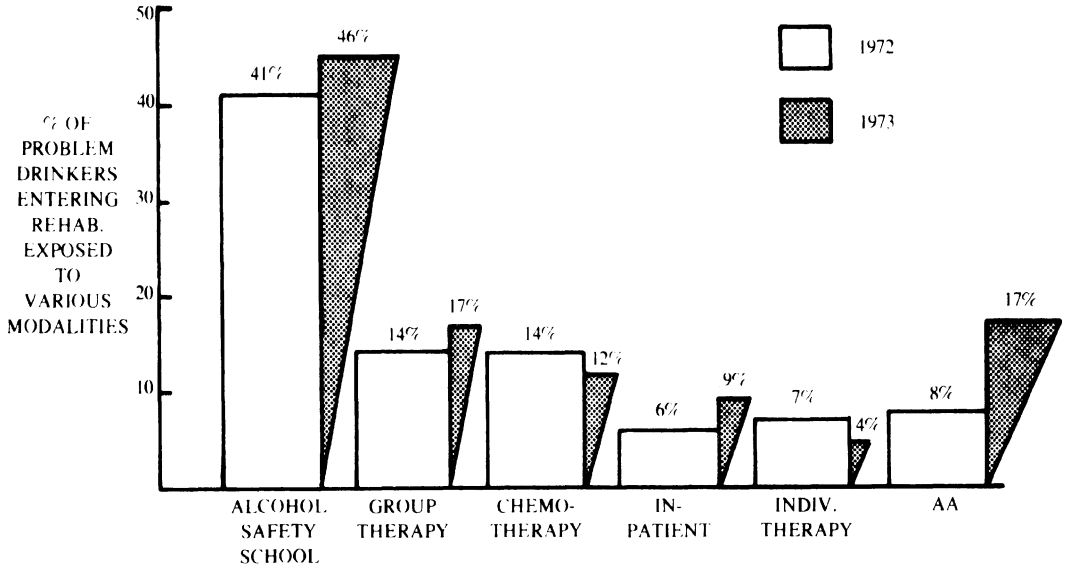
Over 70% of the nearly 49,000 persons who entered rehabilitation programs at 26 ASAP sites in 1973 attended DWI schools (U.S. Department of Transportation 1975a, ch.5). Twenty-seven percent of the drivers were classified as problem drinkers and 45% as social drinkers. The problem drinkers were referred 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 (see Figure 4-2).

Evaluation of the Health Approach

The only documented evaluation of a health approach program aimed at a general population of drinking drivers occurred under the ASAP program. This program attempted to estimate the effect of its individual health/legal activities on a wide range of variables thought to be measures of the program's results. The 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 DWI schools were the most commonly used modality and have also received the most attention by ASAP evaluators. Seventeen project level evaluations of the schools were summarized by Ellingstad (1976). The schools were evaluated with respect to their effectiveness in influencing accident involvement; rearrest for DWI; and life changes, knowledge changes, and attitude changes relative to drinking and driving. Of the evaluations which used "adequate comparison groups and a statistical comparison," none showed any positive effects on accident involvement and only one showed a positive

Figure 4-2. Use of basic treatment modalities for ASAP problem drinkers in 1973



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

effect on rearrest rate. A rigorous evaluation of one ASAP DWI school found no difference in subsequent drunk-driving conviction rates between drivers who had attended the school and drivers who had not.

In summarizing the results of the Alcohol Safety Action Project's schools for people guilty of driving while intoxicated, the National Highway Traffic Safety Administration concluded that the schools were effecting increases in knowledge and positive changes in attitudes 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 produced similar conclusions (Crabb et al. 1971; Malfetti and Simon 1974).

NHTSA's conclusion on the effectiveness of other ASAP treatment modalities was that while some positive effect might exist, no firm evidence could be offered that rehabilitation was effective in reducing rearrest 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 and rehabilitation modalities. The evaluations of treatment and rehabilitation provided by agencies not funded by ASAP have been inconclusive about the effects of their efforts on the alcohol-safety problem (Eagleston, Rittenhouse, and Towle 1974).

Other evaluations of treatment and rehabilitation efforts have been mostly negative. Didenko et al. (1972) compared the driving records of 1,306 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.

PUBLIC INFORMATION AND EDUCATION CAMPAIGNS

Public information and education campaigns have been developed for use as distinct countermeasures to the drinking-driving problem and for use in conjunction with other types of countermeasures. In the following subsections of the present report, several examples of public information and education programs are described in terms of their targets, their methods, and their findings.

Targets of Public Information and Education Campaigns

Most past alcohol highway safety public information and education 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, must decide whether to drive.

Two efforts at defining target populations for public information and education campaigns against drinking and driving are particularly worthy of note. The Vermont ASAP

(Wordon, Miller, and Riley 1975) used the results of a roadside survey to identify the high-risk group, to determine the characteristics of the 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 thus defined by the Vermont ASAP consisted of males 16–30 years of age (45% teenage males), who were beer drinkers; were single, divorced or separated; had less than high school educations; worked as laborers, operatives, farm workers, in service occupations, or were unemployed; had one or two traffic citations in the previous three years; went to drive-in movies with other young males; listened to the radio in their cars; looked at TV news; read newspapers; and went to auto races.

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

The second particularly noteworthy attempt to define a target population was made by Grey Advertising (1975). As a result of nationwide surveys in 1974, Grey concluded that campaigns on alcohol safety should focus on so-called "social conformers" and "aggressive restrainers," since these groups were found to account for both most of the people exposed to alcohol-related situations and for most of the situations. The groups were defined as follows:

- social conformers: 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, and
- aggressive restrainers: males, less than 35 years of age, less educated than social conformers, less income, residing in the northeastern U.S.; have positive attitudes towards alcohol, are less knowing of alcohol's effects, can identify potential DWI situation and take action; one-third find themselves in alcohol-related situations two or more times a week; one-half drink most often at home; are heaviest drinkers, prefer beer; friendships and affiliations are very important; willing to use physical restraint with intoxicated friends who decide to drive.

The objectives of programs aimed at these two groups should be, according to Grey Advertising:

- to correct misinformation about alcohol consumption,
- to identify potential DWI situations, and
- to persuade people to take appropriate action in potential DWI situations (Grey Advertising, Inc. 1975).

The extent to which the intended users of the Grey study, ASAP sites, actually adopted its recommendations is not known.

Applications of the Public Information and Education Campaigns

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 discussed earlier in connection with the legal approach 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 the apprehension, arrest, and charging of drinking-driving; and the penalties associated with conviction were the major variables about which information was disseminated in these campaigns.

Many other information campaigns conducted in the United States, Canada, England, and Australia have been run when it was determined that although drinking-driving laws were not new, the public was poorly informed about the dangers of drinking and driving, entertained attitudes not conducive to the maintenance of safe highways, or was 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 driving after consuming alcohol. Researchers at Lackland Air Force Base (Barmack and Payne 1961b), having examined the relevant customs and values concerning consumption of alcohol by airmen stationed at the base, and having found that reckless driving after drinking was not only tolerated by the group but was seen as courageous and daring, decided that assigning a different and conflicting value to this behavior was essential. Reckless driving after drinking was recharacterized as sick, disturbed behavior. This characterization was supported by a policy requiring that airmen 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. The enforcement of this policy was preceded by an educational program to inform airmen of the details of the new policy.

An Australian campaign (Australia's Unique Press 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 strategy was to use social sanctions. In the existing social climate there were frequent pressures to drink before driving and the intoxicated driver was sometimes treated sympathetically or with amusement. The campaign assumed that a driver's desire to avoid a negative label and the resulting shame 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.

Both the 1967 British and the 1969 Canadian campaigns also measured attitudes, 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. 1970).

In the United States, 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). The objectives for these campaigns were defined in terms of waves or phases. The objective of the first wave was to develop an aware-

ness 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.

Evaluation of Public Information and Education Campaigns

In a 1971 review of road safety campaigns, 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. In another review, Swinehart (1972; Swinehart and Grimm 1972) concurred in this conclusion, stating that the mass media are not effective in changing attitudes or inducing action, but are good in conveying information. Any alterations of individual drinking-driving habits which result from such campaigns were seen as an unexpected side effect. 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 Air Force Base (Barmack and Payne 1961b), and, to a lesser extent, the 1969 Canadian case (Kates, Peat, Marwick and Co. 1970) are the three major examples of campaigns whose impact went beyond the gain of knowledge.

The inadequacy of the designs for evaluation and of other features of campaign development has made it difficult to determine the exact nature and extent of the impact of most alcohol-highway safety media campaigns. Pre- and posttesting has been done for almost all campaigns, but very few of them have used 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 Air Force Base were not randomly selected, nor were 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.

Media campaigns in Edmonton (Farmer 1975; Farmer and Stroh 1973) and Ontario (Morton et al. 1975; Pierce et al. 1975) used control groups which, in each case, were cities selected to match treatment cities in terms of size and relative isolation from the media of the treatment cities. Both campaigns were successful in transferring factual information about the contents of drinking-driving laws. A media campaign in Sidney, Australia (Freedman, Henderson, and Wood 1975), did not use a control group, but it did claim statistically significant positive changes in the public's knowledge of the role alcohol 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 text, 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.

In the U.S., the public information and education campaigns conducted by the NHTSA-sponsored ASAPs (U.S. Department of Transportation 1975b, ch.6) concentrated their efforts on:

- the awareness by the public of the drunk-driving problem and the relationship between levels of blood alcohol and the risk of a crash,
- the public's interpretations of myths about alcohol,
- the public's perception of personal responsibility for drinking-driving behavior, and
- the reduction of alcohol-related crashes and resultant death or injury.

The ASAP evaluation concluded that "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 1975a, ch. 6, p. 1). It should be noted that all of the ASAPs conducted other types of countermeasures concurrently with the public information and education campaigns and that few used more than pre- and posttesting in their evaluation of campaign effectiveness.

On nine questions asked in pre- and posttest surveys, sites with public information and education campaigns indicated greater gains in knowledge than sites without such campaigns. The questions dealt with the nature of the alcohol-crash problem, the effect of alcohol on the body and BAC, and the perceived probability of apprehension for drunk driving.

To conclude, there is some evidence the public information and education campaigns can increase the public's knowledge about drinking-driving laws and its understanding of the effect alcohol has on the body and on driving skills. There is little evidence to show that public information and education campaigns change either attitudes or behavior. In the few cases in which behavioral change occurred, that is, accident rates were reduced, especially for alcohol-related accidents, public information and education campaigns were conducted in conjunction with other countermeasures. In most cases, the impact of the public information and education campaign could not be isolated from the impact of other countermeasures.

Thus, research does not show that informational campaigns in general are ineffective; it indicates merely that they have not been successful in reducing crashes when used alone. There is evidence that they have been effective in supporting other alcohol-safety approaches, particularly the legal approach.

TECHNOLOGICAL APPROACHES

In the past, specific applications of technology to the control of the drinking driver have been limited almost entirely to devices that support the legal and health approaches described above. 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 the greatest impact on the alcohol-crash problem: breath-alcohol analysis. A brief description of some other possible but untried applications of technology are also provided here.

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 the concentration of alcohol in the blood (AC) from breath samples. This requires air from deep within the lungs where blood circulates through the pulmonary capillaries. Deep lung air is needed because it is the only type from 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). 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.

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. 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 determined 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 from .10% w/v to .11% w/v from a blood tester.

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.

The U.S. Department of Transportation has field tested several types of electrome-

*The ASIS concept is no longer being considered by NHTSA. It has been replaced by the drunk driver warning system (DDWS).

chanical 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 admissible in court as evidence. Three basic types are in use: gas chromatography, photometric, and infrared.

Although EBTs have been used 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 an evaluation performed now could be useful.

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 remaining three classes of breath testers have not yet been used operationally. Passive breath testing devices (now called "non-cooperative breath testers") might help overcome the objection that prearrest 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 to enable drivers to test their own breaths to determine if their BACs had reached levels indicating impairment. They could be low-cost, individual, diposable devices that could be distributed by liquor stores, schools, etc., or reusable self-breath tests 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 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. One possible use of the DDWS would be to install it on the cars of persons with convictions for DWI 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 feasibile 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.

Other Technology-oriented Concepts

Devices other than the critical tracking task 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 these devices for assessing impairment could be used in conjunction with other devices which might prevent an impaired driver from starting his car (the alcohol safety interlock system) or warn other drivers of the presence of impaired drivers (the drunk driver warning system). 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 an unacceptably high impairment, on the part of the driver, a warning signal would be given (perhaps 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 someone convicted of driving while intoxicated 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 it induced unpleasant side effects, in this instance nausea and vomiting. Research is continuing, but no practical drug for canceling the effect of alcohol has yet been discovered.

There would be serious problems in using any of the technological devices mentioned here. In some cases, such as the sobering pill, feasibility has not been demonstrated. Devices to prevent a drunk driver from starting his car could face considerable public resistance and are no longer being considered by NHTSA. The drinking driver might decide not to use the self tester, the cost of which might be prohibitive anyway. Continuous monitoring devices could cause rather than prevent crashes if their warning signals were to startle or upset drivers. All of these devices would pose the risk of being defeated by ingenious drivers. Moreover, they could present substantial legal problems. None would appear to be effective by itself, but would have to be used in combination with or in support of other approaches (Voas 1970).

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 pro-

jects (Jones and Joscelyn 1976). Its distinguishing feature is its concentration on the whole problem rather than its component parts. One of its most successful practitioners, Simon Ramo, has 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 (Ramo 1971, p. 11).

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 the "system."

In 1969 the National Highway Safety Bureau (later the National Highway Traffic Safety Administration) of the U.S. Department of Transportation announced the nationwide Alcohol Safety Action Project (ASAP), many of whose activities have been reported earlier in this report, and established the 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 same degree as 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, with particular emphasis on what is most relevant to the systems concept, rather than on the individual countermeasures discussed previously in this report to illustrate other approaches.

ASAP Targets

As noted previously in this report, ASAP was heavily oriented toward the problem-drinker driver who, it claimed, is responsible for two-thirds of the alcohol-related traffic fatalities in the U.S. and 34% of all traffic fatalities. These figures are difficult to justify, but were apparently derived from the Department of Transportation's 1968 report on Alcohol and Highway Safety (U.S. Department of Transportation 1968). They 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 Department of Health, Education, and

Welfare report (U.S. Department of Health, Education, and Welfare 1971) showing 21% of all adult American males to be "heavy" drinkers. One-third of these heavy drinkers (7% of all adult 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.

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 (U.S. Department of Transportation 1975a). 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.

The ASAP Approach

The ultimate goal of the Alcohol Safety Action Program 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).

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 NHTSA. 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).

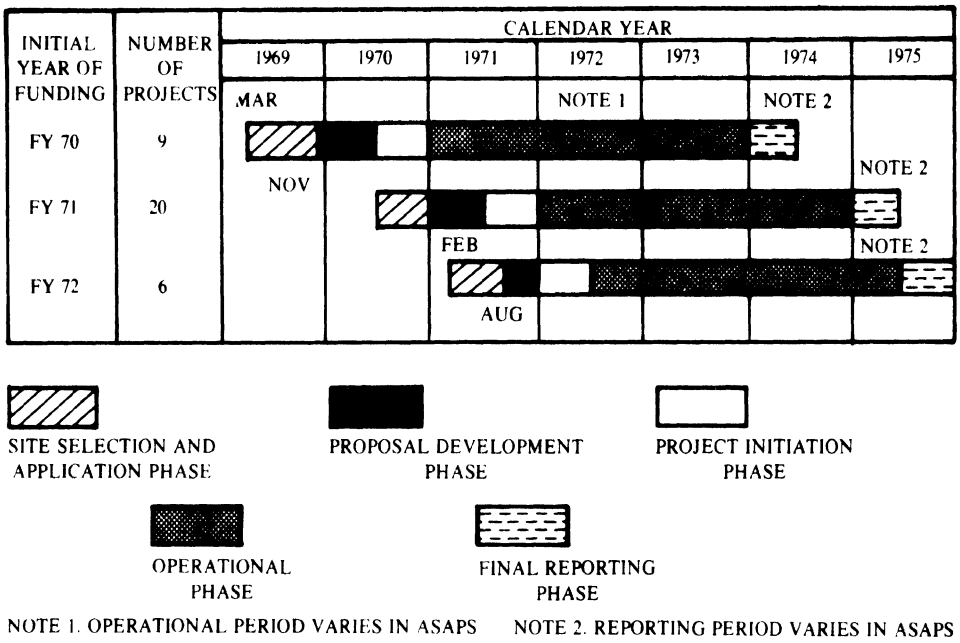
The first group of nine ASAPs began operation in 1971 (see Figure 4-3). Twenty-six additional ASAPs initiated operations in 1972. The locations were widely distributed around the U.S. and included one site in Puerto Rico (see Figure 4-4).

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 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.

There is little documentation in the available literature on how the systems approach was actually implemented in ASAP. The Handbook for Directors of Alcohol Safety Action Projects (McKnight, Adams, and Personeus 1971) provided a one-page descrip-

Figure 4-3. Operational phasing of the Alcohol Safety Action Projects

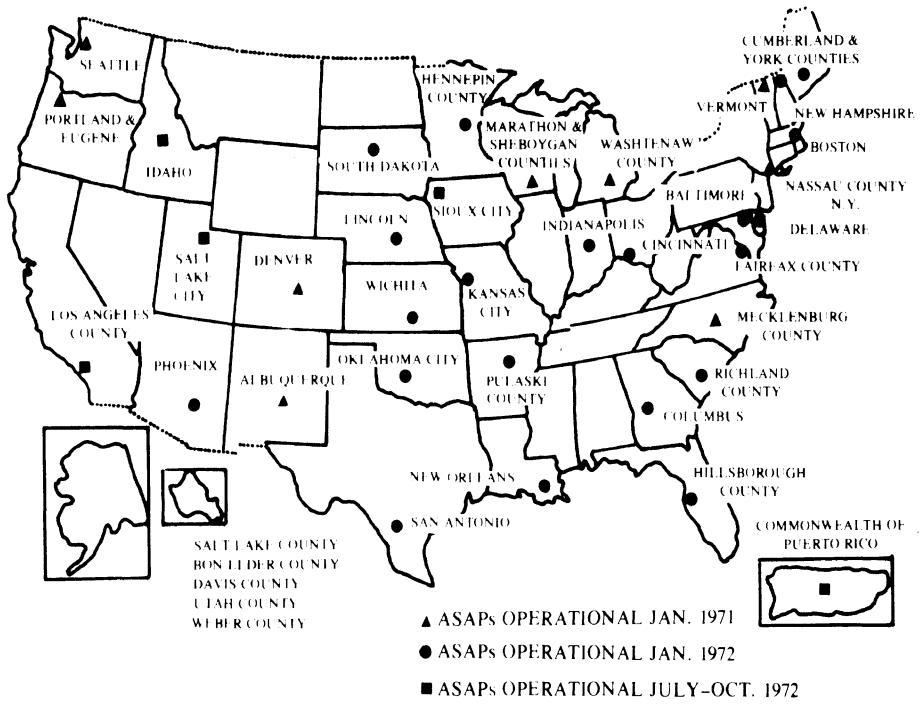


Source: U.S. Department of Transportation 1974a, p. 2

tion 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 Indiana University 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-driving control system. Two of the major tools of the aerospace systems approach (system management and system effectiveness evaluation) were, however, given much emphasis.

Evaluation was specially emphasized in ASAP, and detailed evaluation requirements were placed on the individual sites (Promisel, Blomberg, and Oates 1971; U.S. Department of Transportation 1973). The evaluation philosophy was based on a "chain of action" approach. 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 dollars and effort was related to the problem and to existing safety-program efforts. The output of ASAP in terms of countermeasure activity 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.

Figure 4-4. Locations of Alcohol Safety Action Projects



Source: U.S. Department of Transportation 1974a, p. 1

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 the project (and the Office of Alcohol Countermeasures) personnel to think in terms of the purposes of their countermeasures and to relate project activities to those purposes.

The Evaluation of ASAP

The first results of ASAP's systems approach were published in the *Alcohol Safety Action Projects. Evaluation of Operations—1972* (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.

After an ASAP investment predicted to be about $6.40 per licensed driver over the three and a half 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" by the courts—that is, 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 indicated a statistically significant reduction in such crashes for sites with two years of operating 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. It was estimated in the analysis 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 three and one-half years (U.S. Department of Transportation 1974a).

An obvious deficiency in the first ASAP evaluation of operations (and one that was pointed out by the NHTSA report) was the lack of control groups to compare with the ASAP sites. 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." 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 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 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 evaluation report (U.S. Department of Transportation 1975a) used additional data to analyze the impact of the twenty-one later ASAPs after two years of operation. This 1974 report found some evidence of reduced numbers in alcohol-related fatal crashes which could be attributed to ASAP. The report 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, 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, Levy, and Voas (1976) also stated that Zador's analysis was not sensitive enough to detect reductions in alcohol-related crashes of less than 20%. In a recent article Zador (1977) repudiated

NHTSA's criticisms and held to his original conclusions about ASAP's ineffectiveness as a large-scale social program.

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 casefinders and classifiers of drinking drivers so that the drivers would receive the most appropriate treatment. As such, it 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 impairment by alcohol.

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 problem 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.

The lack of adequate evaluation makes it virtually impossible to say unequivocally whether any of these approaches have actually worked in reducing crash losses caused by alcohol-impaired drivers.

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. 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. 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. ASAP has provided some indication that problem-drinking drivers can be successfully identified and processed, but does 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 approaches have often been shown to be effective in conveying information, but there is little evidence that they alone have changed either attitudes or behavior. When used in combination with other approaches there are fairly strong indications that public information and education campaigns have been a major factor in the reduction of alcohol-related crashes attributed to those 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. Other technological approaches (e.g., the "sober pill") could 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.

It may well be that the ASAP methodology, the systems approach may have a greater long-term impact on the alcohol-crash problem than the ASAP's 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 had previously existed. ASAP's failure, thus far, to provide convincing evidence that it has had a significant impact on highway safety may be due more to the present primitive state 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-drinking 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 drinking-drivers should be treated rather than punished and that a combined health/legal approach, employing space-age systems management techniques, could result in the 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 obstacles to overcome in improving society's response to the alcohol-crash problem. At the research level, we must undertake new efforts to learn how to design deterrent programs to prevent drinking-driving and treatment programs to cure it. The specific requirements for prevention and treatment must be stated in useful terms. At the same time, we should explore new approaches to provide both new direction and new blood. Pending generation of this knowledge, there is no apparent justification for implementating new, large-scale operational programs. This does not, of course, 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.

Chapter 5

FUTURE DIRECTIONS OF THE ALCOHOL-CRASH PROBLEM

The preceding sections of this report have summarized the state of knowledge about the alcohol-crash problem in the mid-1970s and have reviewed some past efforts to deal with that problem. In this section, some speculations are made about alcohol and highway safety in the mid-1980s, specifically, the magnitude of the problem expected over the next ten years and the changes in the nature of the problem likely to occur. 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.

THE ALCOHOL-CRASH PROBLEM IN THE 1980s

Various techniques are available for projecting historical data into the future in order to estimate the future value of a variable (Kahn and Wiener 1967). If we knew the fraction of fatal crashes involving drunk drivers at various points of time over the past twenty years, we could simply extrapolate to estimate the fraction of fatal crashes involving drunk drivers 10 years hence. Unfortunately, we do not have such direct historial data about alcohol and highway safety, and we must therefore resort to projecting indirect variables thought to pertain to alcohol-related crashes. Examples of these indirect variables are those describing drinking patterns and age distributions of drivers. Obviously, since the relationships between the direct variables of the alcohol and highway safety problem and the indirect variables have not ever been precisely defined, we cannot estimate precisely the direct variables at some future time by projecting indirect variables. In this section of the report, several indirect variables which research suggests are related to direct variables of interest are briefly considered to see how they might change over the next ten years. This will give a rough idea of the effects such changes will have on the alcohol-crash problem.

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 Re-

sources Council 1976; U.S. Department of Transportation 1975b; 1976a) of the highway transportation system of the 1980s project fairly large increases—on the order of 50%—in the number and severity of highway crashes during 1975–1985. Two major factors contributing to these increases have been stated as:

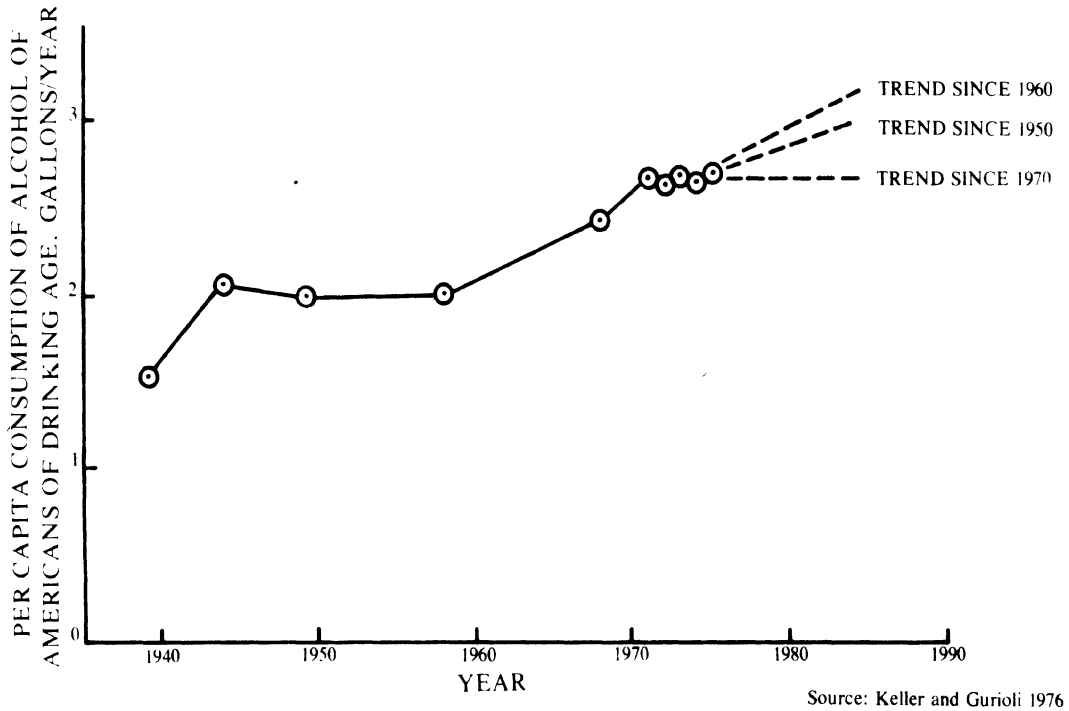
- more licensed drivers' driving about the same number of miles per year per driver, resulting in a larger number of vehicle miles travelled, and
- a large number of small cars in the vehicle fleet, increasing the severity of the injuries to occupants of smaller cars colliding with larger cars.

The studies agree that even larger increases in the number of crashes could be expected if speed distributions were to return to the levels existing before the imposition of the 55 mph speed limit.

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 fifteen years and could reasonably be expected to continue its rise well into the next decade (Figure 5-1).

Figure 5-1. Projections to 1985 of alternative trends in per capita consumption of alcohol

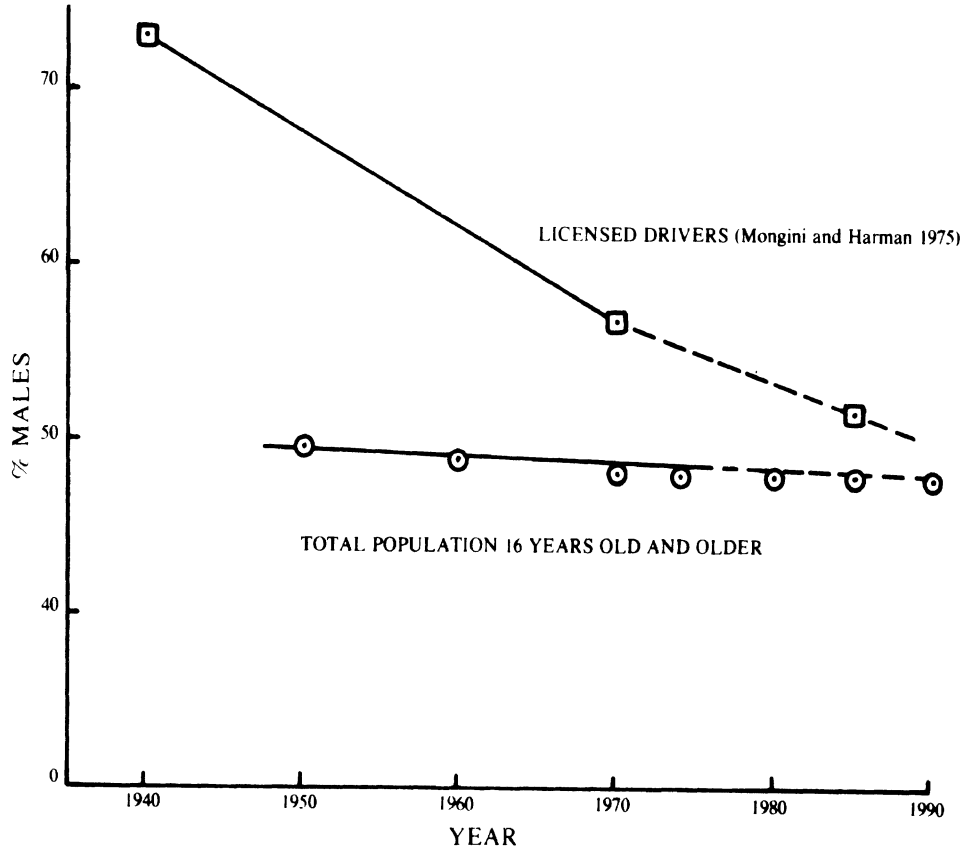


Source: Keller and Gurioli 1976

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), assuming that any increase in per capita consumption of alcohol would be directly translated into a corresponding increase in crash losses, estimated a 5% increase in fatalities due to increased consumption during 1972–1985.

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 1975–1985 (see Figure 5-2). 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

Figure 5-2. Projections of percent males of the population of licensed drivers and of the total population, aged 16 years and older



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. The reader may recall that data from the Grand Rapids study suggest that females have a higher crash risk after drinking than males.)

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 relatively minor (Table 5-1), any resulting increase would probably be not more than a few percent.

TABLE 5-1

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 1975b, U.S. Department of Transportation 1975b

Available data show that time of day and day of week are driving variables with the strongest relationships to drinking-driving patterns. 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 weekend nature of drinking-driving should change in the near 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, those not requiring driver actions to make them effective (air bags, to name one), 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 effect of improving vehicle and highway design on the alcohol-crash problem, and there is no obvious way of making meaningful quantitative estimates from the available data.

Figure 5-3 summarizes expected changes in factors relevant to the alcohol-crash problem during the 1975–1985 time period. Possible decreases in the relative magnitude of the alcohol-crash problem due to a larger percentage of female drivers in the driving population are likely to be counterbalanced by increases due to a larger percentage of drivers in the 20-to-65-year-old age groups. A similar compensating effect seems likely with respect to "safety features" and the projected trend toward a more heterogeneous mixture of large and small cars. The remaining effect, a tendency toward increased per capita consumption of alcohol, could result in a slight increase in the magnitude of the alcohol-crash problem relative to crashes in general.

Thus, the net effect of the factors considered should be to maintain the alcohol-crash problem at about its present level relative to the total crash problem in 1985. At the same time, the total magnitude of the alcohol-crash problem will probably increase because of a larger number of crashes in general. The crashes that do occur are likely to be more severe because of the mixture of large and small cars in the vehicle fleet.

Of course, the development of more effective alcohol safety programs and countermeasures could drastically change the estimates developed here. Changes in the operating environment of the highway transportation system could have an even larger effect on alcohol-related crashes. Such changes could include:

- large decrease in availability of fuel,
- widespread use of passive restraints in cars,
- large changes in the economic climate (e.g., depression, runaway inflation),
- technical breakthroughs in automobile or highway design,

Figure 5-3. Eight changes expected to affect alcohol-related crashes 1975–1985

	Expected Changes
1.	Larger percentage of female drivers
2.	Smaller percentage of drivers under 20 years of age
3.	Smaller percentage of drivers over 65 years of age
4.	Larger percentage of drivers in 20 to 65 year old age group
5.	Increased per capita consumption of alcohol
6.	A heterogeneous mixture of large and small cars with a predominance of small cars
7.	Slight increase in "safety features" in both vehicles and highways
8.	More vehicle miles traveled

- prohibition or large-scale restrictions on alcohol use,
- widespread heavy useage of drugs other than alcohol, and
- increased useage of other forms of transportation (e.g., mass transit).

FUTURE RESPONSES TO THE ALCOHOL-CRASH PROBLEM

Earlier in these pages certain past responses to the alcohol-crash problem were analyzed with respect to their targets: that is, the population groups at which they were aimed; the nature of the various actions they took to control their targets; and their method of evaluating the programs employing these actions to control. The following sections discuss possible ways of improving our response to the alcohol-crash problem relative to these elements in the future.

Targets

Only a small portion of the spectrum of possible targets of drinking-driver control actions has been addressed in the past. With respect to population groups, only broad categories of drinking drivers (e.g., social-drinking-drivers, problem-drinking drivers) have been the targets of past alcohol-safety programs. Also, intermediate populations who might favorably influence the proclivity of the ultimate target groups to drink and then drive have seldom been the target of such programs.

The sequence of events leading to death, serious injury, or property damage due to an alcohol-related crash is, in general, quite lengthy and could be interdicted at many points by effective action. Yet past programs have concentrated only on a small segment of the pre-crash phase by attempting to influence an individual's decision to drink excessively or his decision to drive after drinking.

Similarly, three general categories of factors influence the frequency and severity of crashes: human factors, vehicular factors, and highway environmental factors. Of the three, human factors have received nearly all of the attention of past programs, which have primarily attempted to convince people not to drive after drinking. Little or no attention has been given to interactions among driver, vehicle, and highway relative to alcohol-related crashes. Moreover, there has been a general lack of specificity even in identifying the human factors as targets of corrective action.

Thus, considerable opportunity exists for attacking the alcohol-crash problem along a wider front and for identifying more specific targets for pinpointed actions. For example, past studies have identified a number of characteristics of the drinking-driving population which would permit a more detailed definition of target groups of drivers. Such characteristics as age, sex, drinking patterns and driving patterns could possibly be used to define high-risk groups and to differentiate groups for the most appropriate action. Further, it is possible that some of these groups could best be reached indirectly through other groups such as parents, clergymen, peers (e.g., co-workers, fellow students), and others.

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 crash losses. Such a model could take 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.). It could also 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. 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 interaction 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.

Programs

Reassessment and reformulation of the targets of alcohol-safety programs as suggested in the preceding sections 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 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, but there are fundamental questions about how this can be accomplished in operational alcohol-safety programs:

- 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?

In view of the relative insensitivity of alcohol-related crash losses to past levels of legal-approach activity, it appears that rather substantial revisions are needed to hypothesize about legal deterrence. For example, it may be necessary to increase apprehension rates by a factor of 10 or more to deter drunk drivers. Finding practical ways to achieve these large changes without violating fundamental human rights or imposing a police presence obnoxious to 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 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 development of treatment modes that work should be the highest priority for improving the overall effectiveness of the health approach. 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 approach has been used to improve the knowledge, attitudes, and behavior pertaining to drinking and driving. It has been most often used to support measures in the legal approach, particularly to increase the public's perception of the risk of being apprehended for drunk driving. Important unanswered questions about the public information and education approach are why it worked in the British application and under what conditions would it work as well or better in other settings. Specifically, we need to know and understand the key ingredients for using public information and education as an effective instrument for modifying drinking-driving behavior. When we know this, then perhaps we will be able to apply it in ways not dependent on the legal system, such as to educate 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. Many questions will need to be resolved before the full potential of the technological approach can 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.

realized. In the meantime, technological solutions 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 so that many of the present constraints on its use can be removed—for example, cost, reliability, maintainability, legality, and ability to discriminate the alcohol-impaired drivers from other drivers.

Among the approaches that have been tried to date, only the systems approach clearly offers much hope of conquering a problem as multifaceted 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 for system management only, as was the case in the ASAP program. It should be applied to give new form to the drinking-driver control system (Joscelyn and Jones 1972). At the same time, it must be realized that the success of the systems approach is ultimately limited by the current state of knowledge in the many disciplines that relate to the alcohol-crash problem.

Approaches other than the five noted—and individual countermeasures as well—have been suggested and, in some cases, 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 driving while intoxicated, 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 proceding section. Further research and, where indicated, testing of new concepts should be supported. At the same time, it would be remembered that these concepts will remain hypotheses until they have been validated and refined. Premature adoption of unproven approaches will nearly always be counterproductive and should be avoided in dealing with the alcohol-crash problem of the future.

Evaluation

The evaluation of measures taken to reduce alcohol-related crashes is a key ingredient to future progress in alcohol safety. Without it, misconceptions will be perpetuated and mistakes will be repeated; with it, successful techniques can be identified, improved, and used by others. Though evaluation is essential to improving programmatic responses to the alcohol-crash problem, no one knows precisely how it should be conducted. In the near future, the careful application of time-series analysis techniques seems the most practicable. 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 sometime defy common sense, should be avoided. Research and testing of innovative approaches (including decision-theory approaches) should be strongly supported.

SUMMARY AND CONCLUSIONS

The 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 in-

crease substantially over the next decade. Losses from alcohol-related crashes as a fraction of losses from all crashes, however, will remain about the same.

Several 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.

Second, the approaches used by alcohol-safety programs in the past 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 define adequately the parameters of deterrence: 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 application of that technology in the various social systems that interact with drinking drivers. Similarly, 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 clear-cut objectives (e.g., rapid air transport). Particularly, the systems approach should be applied to the design as well as management of alcohol safety programs.

Finally, no progress or improvement can be sustained and passed on 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.

Chapter 6

CONCLUSIONS AND RECOMMENDATIONS

This section summarizes the major conclusions and recommendations resulting from this 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 what has been done so far in response to the problem. It proposes measures to develop more effective responses to the alcohol-crash problem in the future. The section closes with some insights by the authors on the implications of the study's findings for operational agencies.

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:

  The risk of being involved in a serious crash is much greater at BACs over .10% w/v than it is with no alcohol.

  Much basic behavior related to driving is impaired in most individuals at BACs of .10% w/v, or more.

- Driver and driving characteristics associated with a higher than average involvement—that is, those occuring with greater relative frequency—in alcohol-related serious crashes are:

  male sex,

  age of 20 to 60 years,

heavy drinking and severe drinking problems,
preference for beer over other alcoholic beverages,
nighttime driving habits,
weekend driving habits, and
history of prior arrests for drunk driving.

- The characteristics of drivers with a higher than average risk of crashing after drinking a given amount are:

  female sex,
  youth (under 20 years old),
  old age (over 60 years old), and
  light drinking habits.

- The knowledge of driver characteristics and driving habits is useful for identifying high-risk groups, but it 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. To identify and define the problem more clearly, both epidemiologic and experimental studies are indicated. The most critical needs for epidemiologic research 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 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 of alcohol-related crashes and the interactions of alcohol with other factors to cause crashes.

The needs for experimental research are of equally high priority:

- 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 the effect of alcohol on actual driving performance.

RESPONSES TO THE ALCOHOL-CRASH PROBLEM

The programs intended to control alcohol-crash losses have followed five main approaches: legal, health, public information and education, technological, and systems. The most important things to be said about these are:

- The targets of the programs 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 pertaining to fundamental hypotheses upon which most alcohol-safety programs have been based in the past is totally inadequate for designing and operating effective programs. Specifically, it is not known:

  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.
  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 hardly unique to the field of alcohol safety. Efforts to apply the legal and health approaches to control other forms of individual and societal risk, such as crime and drug dependence are also hampered by similar informational deficiencies.

With regard to future responses to the alcohol-crash problem, it seems clear 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 operations 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.

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 stemming 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 be systematic in its approach. We believe also 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 re-

sources 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 deterrence, focusing on individuals identified as drinking drivers, usually through law enforcement action. Detection and sanction of drinking drivers by the legal system with sanctions broad enough to deal effectively with individual cases. (In particular, individuals who clearly have severe drinking problems should be referred to the health care system—the "health/legal" approach.)

  General deterrence, designed to reduce the incidence of drinking-driving and with broad targets. For example, public information and education efforts to inform about the risk of a crash while 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*—Implementing 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 form 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 current lack of 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 the measurement of alcohol involvement in the general driving population as well as in the accident population.

The elements identified above we believe to be necessary for programs intended to reduce the risk of alcohol-related crashes. The present state of the knowedge does not allow us to state with certainty that a program encompassing all these elements will be effective in reducing crash losses. Based on what is now known, 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.

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