Epidemiologic Perspectives on Drunk Driving

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What is the one element found in approximately half the U.S. highway fatalities? This question has been raised over the last few decades and the answer is still the same: Alcohol. This answer generates another question: If a single, identifiable element is involved in such a large portion of a serious public health and public safety problem, should it not receive top priority for investigation, intervention, and prevention?

Alcohol produces both pleasure and pain, euphoria and depression. Alcohol also produces many jobs and billions of dollars in tax revenues to the States and to the Nation. Each year, alcohol also produces unintentional death to thousands and injury to millions. When mixed with driving, alcohol is the basis for a major public health and public safety problem. In our automotive society, the car is used for almost all facets of social activity. Therefore, since alcohol is involved in many aspects of social behavior, driving after drinking is a relatively frequent occurrence. Fortunately, the vast majority of such driving-after-drinking instances do not result in crashes. One very important task for researchers is to identify variables that differentiate between those driving-after-drinking instances that do result in a crash and those that do not.

How do we learn about the contribution of alcohol to unintentional injury and death on the highways? In attempting to do so, we still find a large gap between description and explanation that, at this time, can be bridged only provisionally through inference. Two widely separated research approaches have been used to date as a basis for inferring the contribution of alcohol to highway crashes: epidemiologic and experimental.

The epidemiology of alcohol and highway safety can be traced from the first review of the problem presented in 1933 (Miles 1934). Over the years, high blood alcohol concentration (BAC) has been thoroughly implicated in serious and fatal injury highway crashes by post hoc epidemiologic studies. Most evidence for relating this alcohol contribution to highway crashes has been obtained by examination of the distribution of BAC both among drivers involved in actual crashes (fatal and nonfatal) and—on the basis of case-control roadside surveys—among drivers using the highways, but not involved in crashes at the time. A number of such case-control studies have demonstrated that alcohol is overrepresented among deceased drivers relative to drivers in the population-at-risk using the highways at corresponding times and places (e.g., Borkenstein et al. 1964, 1974; Perrine et al. 1971; for reviews see NRC 1987; NHTSA 1985; Perrine 1975a, b).

The second approach consists of controlled administration of alcohol in experiments conducted on isolated variables that are assumed to be relevant for actual driving. Alcohol impairment of real-world driving performance is then typically inferred from the mosaic of these bits of behavior examined separately in the laboratory, in driving simulators, and in instrumented cars driven on closed courses (NRC 1987).

Both research approaches to the study of drunk driving are necessary and have been productive (NRC 1987; Perrine 1976). However, this chapter is limited to epidemiologic aspects; it is organized as follows:

A discussion of the scope of the drunk-driving problem from an epidemiologic perspective

A brief outline of the major components involved in studying the problem by means of the available data sources

A review of the most relevant literature, focusing on alcohol involvement in fatal as well as nonfatal highway crashes and in noncrash drivers; crash risk and alcohol; and characteristics of drunk drivers

An examination of current issues and problems

Recommendations

Scope of the Problem

The primary problem clearly consists of those motor vehicle crashes that result in fatal injuries. It is now generally well established that alcohol is involved in approximately half of all such fatal crashes. For example, the total number of highway fatalities in 1986 was 46,056, of which some 24,000 (52 percent) involved alcohol. More specifically, BACs exceeded the typical legal limit (0.10) in 41 percent of all fatal crashes.

An estimated 4.8 percent of deaths in the United States during 1980 were directly or indirectly attributable to alcohol (NIAAA 1987). Of these, motor vehicle crashes were the largest single cause of death. Approximately 26,000 deaths in 1980 were attributed to alcohol in motor vehicle crashes; these deaths constituted about 27 percent of the total number of deaths (approximately 98,000) attributable to alcohol (NIAAA 1987, p.6). The number of alcohol-involved motor vehicle deaths is about two times that of the second largest single cause of alcohol-involved death, namely, homicide (approximately 12,000 or 12 percent) (NIAAA 1987, p.6).

The scope of the alcohol and traffic safety problem has recently been reviewed briefly both from a public health perspective (NIAAA 1982, 1985, 1987) and from a public safety perspective (NHTSA 1985, 1987b; NRC 1987). In this chapter, the problem is examined further to provide a more integrated synthesis of the literature from both these perspectives.

Major Components of the Study

Aside from epidemiologic methodology considerations, the major components involved in the present perspective on drunk driving consist of the data sources. The two primary sources of data for this area are official records and surveys of various types.

The official records consist primarily of the following:

The citation report for driving under the influence of alcohol (DUI)

The accident report, if alcohol is involved

The prosecutor record

Court records

Department of Motor Vehicle records

Treatment/service provider records

Probation department records

Of special importance are those reports of accidents in which a fatality resulted, since these data are collected at the State level and then forwarded to the Fatal Accident Reporting System (FARS) of the National Highway Traffic Safety Administration (NHTSA). As an example of using such data, analyses of DUI processing from the point of the arrest citation through the other official records, including the postconviction countermeasures, have been prepared for the State of California (Perrine 1984; Helander 1986; Peck 1987).

The other major source of data for epidemiologic studies consists of surveys. The main varieties are:

roadside surveys,

telephone surveys (in recent years, the random-digit-dialing telephone survey),

household surveys, and

special location surveys (bars, jails, etc.).

Of these various types, only the roadside surveys can obtain direct measurements of the major criterion variable — namely, BAC — from drivers actually using the roads at the time. All the other survey methods depend on self-reported information from the respondents, including data concerning driving after drinking. Thus, only the direct measurement of BAC at roadside can be used to provide criterion measures for estimating alcohol crash risk and for evaluating the impact of countermeasure programs on the motoring public.

Review of the Most Relevant Literature

Alcohol Involvement in Fatal Highway Crashes

In 1986, 46,056 people were killed in traffic crashes (NHTSA 1988), which are the leading cause of death for Americans age 6-34 (Richardson 1985). Traffic fatalities in 1986 resulted in 1,425,517 years of potential life lost before age 65, an amount greater than deaths from cancer, heart disease, and all other causes. Traffic crashes cost society approximately $74 billion annually in terms of damage, insurance costs, injury treatments, lost work, and so forth. (NHTSA 1987c). Since 1900, over 2,600,000 Americans have died in traffic crashes; that is 1,500,000 more than the total number of Americans killed in all the wars in U.S. history.

It is well known that alcohol is a leading factor in traffic crashes. It was involved in over half of the traffic fatalities in 1986, resulting in close to 24,000 deaths (NHTSA 1988). Each year, nearly 560,000 additional people suffer injuries in alcohol-related crashes— an average of one person injured every minute of the day. About 43,000 of these injuries are serious (NHTSA 1988).

During the 1982-86 period, approximately 119,000 people lost their lives in alcohol-related traffic crashes—an average of one alcohol-related fatality every 22 minutes over the past 5 years. About two out of five Americans will be involved in an alcohol-related crash in their lifetime (NHTSA 1987a). Approximately 1,800,000 drivers were arrested in 1986 for DUI—an arrest rate of about 1 out of every 90 licensed drivers in the United States (Greenfield 1988).

The problem is especially devastating for young people. In 1986, more than 40 percent of all teenage deaths resulted from motor vehicle crashes. Over half of these were alcohol related, making alcohol-related traffic crashes the leading cause of death for teenagers. For traffic crash victims age 20-24, close to 70 percent of the 8,000 who died in 1986 were in alcohol-related crashes (NHTSA 1988). The probability that a given death is due to a traffic fatality is 55 times as great for a 20-year-old male as for a 65-year-old male; the corresponding ratio for females is 43 (Evans 1987).

The average BAC of drinking drivers involved in fatal crashes was 0.15 in 1986 (NHTSA 1985). The legal intoxication limit in most States is 0.10. In a recent survey of drivers jailed for drunk driving offenses, over a quarter of the drivers had consumed at least 20 beers or 13 mixed drinks within 3-4 hours before they were arrested (Greenfield 1988). Research has shown that a driver with a BAC of 0.15 has a 26-times greater probability of being involved in a crash than a sober driver (NHTSA 1985).

FARS indicated that 41 percent of the traffic fatalities in 1986 involved either a driver or a pedestrian with a BAC of 0.10 or greater. This percentage translated to 18,890 fatalities. An additional 11 percent (5,100 fatalities) involved a driver or pedestrian with some alcohol (BAC = 0.01–0.09). Only 48 percent of the fatalities involved all drivers and pedestrians with zero alcohol.

Alcohol involvement did vary by time of day, day of week, and type of crash (table 1). Seventy-seven percent of the fatal crashes that occurred between 8 p.m. and 4 a.m. on any night of the week involved alcohol. Alcohol was also much more prevalent in single-vehicle crashes than multiple-vehicle crashes. Almost half the collisions resulting

Table 1. Alcohol involvement in fatal crashes: 1986

Crashes	N	BAC		
		0.00 (percent)	0.01–0.09 (percent)	0.10 and higher (percent)
Fatal	41,062	48	11	41
Daytime (4 a.m. - 8 p.m.)	23,828	67	9	25
Nighttime (8 p.m. - 4 a.m.)	16,900	23	14	63
Weekday	22,700	59	9	32
Weekend (8 a.m. Fri - 4 a.m. Mon)	16,277	35	12	53
Single vehicle	17,114	38	11	51
Multivehicle	16,244	58	11 ·	31
Nonoccupant (pedestrian/bicyclist)	7,704	51	9	40

Table 2. Drivers and nonoccupants (pedestrians/bicyclists) involved in fatal crashes: 1986

	N	BAC		
		0.00 (percent)	0.01–0.09 (percent)	0.10 and higher (percent)
All drivers	60,297	66	8	26
Driver fatalities	26,613	52	9	39
Surviving drivers	33,684	77	8	15
Nonoccupant fatalities	7,770	64	7	29
Male drivers	46,622	63	9	28
Female drivers	12,734	79	6	15

in a nonoccupant (pedestrian or pedalcyclist) death involved alcohol, mostly on the part of the pedestrian.

When examining data for all drivers involved in fatal crashes, keep in mind that in multiple-vehicle crashes, at least two drivers are involved in one crash. In 1986, 60,297 drivers were involved in the 41,067 fatal crashes. Twenty-six percent of these drivers were legally intoxicated (BAC greater than or equal to 0.10) at the time of their crashes (table 2). Of the 26,613 drivers who were killed in their crashes, 39 percent were legally intoxicated compared with only 15 percent of the drivers who survived fatal crashes. Male drivers were almost twice as likely to have over 0.10 BAC at the time of their crashes as female drivers (28 percent versus 15 percent).

Alcohol involvement did vary substantially by driver age in 1986 (table 3). While 21 percent of teenage drivers were legally intoxicated at the time of the crash, an additional 13 percent had also been drinking. Drivers 20-24 years old had the highest alcohol involvement rate: 47 percent. In contrast, only 7 percent of drivers age 65 and older were legally intoxicated at the time of their crash.

Examining certain combinations revealed that while almost two-thirds of the fatal

Table 3. Alcohol involvement by driver age, 1986

Driver's age	Driver's BAC			N*
	0.00 (percent)	0.01–.09 (percent)	0.10 and higher (percent)	
16-19	66	13	21	7,854
20-24	53	12	35	11,427
25-34	59	8	33	16,163
35-54	72	6	22	14,305
55-64	81	5	14	4,017
65 and older	89	4	7	4,881
All ages	66	8	26	60,297

*N = Number of drivers in age group where age was known.

Table 4. Drivers involved in fatal crashes, 1986

	N	BAC		
		0.00 (percent)	0.01–.09 (percent)	0.10 and higher (percent)
Male/weekend/night	10,573	38	14	49
Female/weekday/day	6,503	90	3	7
Driver age groups				
15-20	10,467	64	13	23
21-44	34,518	60	9	31
45 and older	13,968	82	5	13

crashes involving a male driver on a weekend night were alcohol related, only 10 percent of the crashes involving a female driver in a weekday crash in the daytime involved alcohol (table 4).

Alcohol involvement was also found to vary considerably by the type of vehicle driven (indicating the type of driver, in most cases) (table 5). Drivers of motorcycles involved in fatal crashes had by far the highest alcohol involvement rate: 54 percent. Only 3 percent of heavy-truck drivers involved in fatal crashes had BACs over 0.10. Drivers of older vehicles were more often legally intoxicated than drivers of newer vehicles (34 percent versus 22 percent).

Intoxicated drivers in fatal crashes also tended not to use safety belts. Of the fatally injured drivers who were at zero alcohol, 20 percent were wearing safety belts compared with only 7 percent of the fatally injured drunk drivers. Thirty-six percent of the zero-alcohol surviving drivers were reported as using belts, in contrast to only 15 percent of the intoxicated surviving drivers.

Contrary to some popular misconceptions, the victims of alcohol-related fatal crashes are most often the drinking driver or drinking pedestrian. Two-thirds (66 percent) of the 23,990 victims of alcohol-related crashes in 1986 were the drinking driver or drinking pedestrian (table 6). An additional 20 percent of the victims were passengers in the

Table 5. Drivers involved in fatal crashes, 1986

Drivers of:	N	BAC		
		0.00 (percent)	0.01–0.09 (percent)	0.10 and higher (percent)
Motorcycles	4,542	46	13	41
Passenger cars	35,920	65	9	26
Light trucks and vans	11,724	63	8	29
Medium trucks	653	92	3	5
Heavy trucks	4,355	95	2	3
Older vehicles (older than 1976)	13,168	59	9	34
Newer vehicles (1984-87)	15,579	70	8	22

Table 6. Alcohol-involved fatal crash victims, 1986

	N	Percent
Drinking drivers killed	13,190	55
Drinking pedestrians and pedalcyclists killed	2,640	11
Passengers in drinking driver's vehicle killed	4,800	20
Sober drivers killed in crash with drinking driver's vehicle	1,680	7
Passengers in sober driver's vehicle killed in crash with drinking driver	960	4
Sober pedestrians/pedalcyclists killed by drinking driver	720	3
Total	23,990	100

drinking driver's vehicle. Additional analyses revealed that in fatal crashes where BACs were known for drivers and their passengers, 36 percent of the time the driver was legally intoxicated but the passenger was not.

Table 7 shows the basic trend with regard to the alcohol problem in fatal crashes over the past 5 years. The percentage of drivers in fatal crashes who were intoxicated (BAC = 0.10 or greater) at the time of the crash decreased from 30 percent in 1982 to 26 percent in 1986—a 13-percent reduction, which is substantial. The reduction was especially great for teenage drivers (table 8). While 29 percent of the teenage drivers in 1982 were legally intoxicated, this amount dropped to 21 percent in 1986, a 28-percent reduction. While this teenage driver trend is encouraging, one must still keep in mind that teenage driver involvement in fatal crashes per mile driven is substantially higher than other driver age groups (Fell 1987).

The nature of this 5-year alcohol reduction trend was examined in the following manner. Specific decreases of certain types of drivers and certain types of crashes were compared with the overall reduction. If these specific reductions were substantially greater than the overall reduction, then that would indicate that these drivers or conditions were affected most. Figure 1 summarizes the key findings concerning the nature of the reduction.

The largest reductions noted were for teenage drivers (28 percent), followed by teenage pedestrians killed in collisions (26 percent). Also affected were drivers of vans (23 percent reduction), female drivers (21 percent), and drivers who survived the fatal

Table 7. BACs for all drivers involved in fatal crashes, 1982-86

(in percents)

BAC	1982	1983	1984	1985	1986	1982-86 change
0.00	61	62	64	66	66	
0.01-0.09	9	9	9	8	8	
0.10 and higher	30	29	27	26	26	-14
N	56,029	54,656	57,512	57,883	60,297	

Table 8. BACS for teenage (16-19) drivers involved in fatal crashes

(in percents)

BAC	1982	1983	1984	1985	1986	1982-86 change
0.00	58	61	63	67	66	
0.01–0.09	13	13	13	11	13	
0.10% and higher	29	27	24	22	21	–28
N	7,467	7,050	7,366	7,151	7,854	

crashes (17 percent). The absolute reduction was also larger in weekday crashes (17 percent) and in multivehicle crashes (16 percent).

Drivers age 25-34 had only a slight reduction during this 5-year period (6 percent). Motorcycle drivers, with the highest percentage of alcohol involvement to begin with, experienced no change in the percentage of drivers legally intoxicated during this period. Pedestrians age 20-64 also had no reduction in the percentage legally intoxicated between 1982 and 1986. Late night crashes and single-vehicle crashes showed only modest reductions in the percentage of drivers who were at 0.10 BAC or higher (6 percent and 9 percent, respectively).

The average BAC of drinking drivers in fatal crashes in States where most of the drivers were tested showed a modest decrease from 0.165 in 1980 to 0.153 in 1986.

Alcohol consumption per capita decreased in the United States between 1982 and 1986. But if that decrease was a prime factor in the decreased alcohol involvement of drivers in fatal crashes, then a similar reduction should have occurred in intoxicated adult pedestrians in fatal crashes, which was not the case.
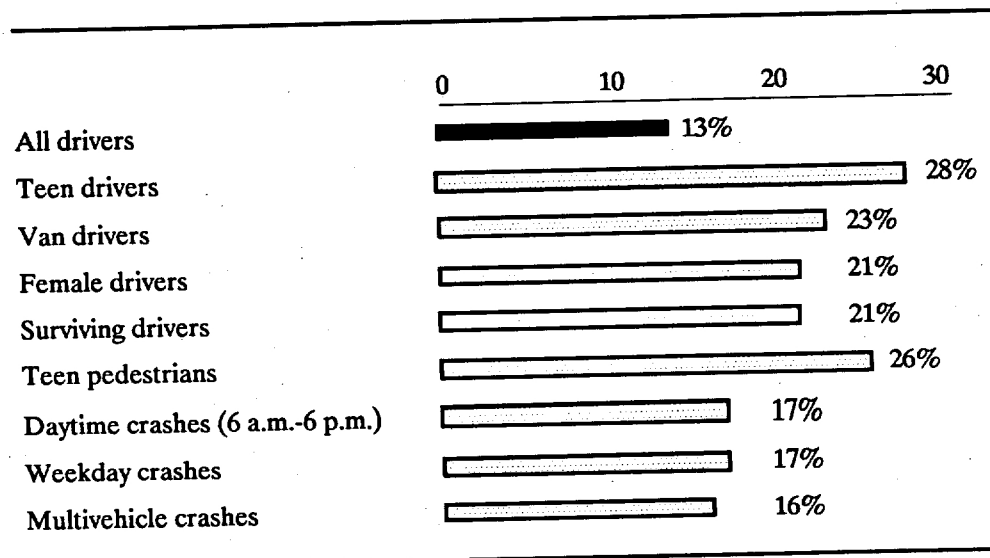
Figure 1. Nature of alcohol reduction in fatal crashes, 1982-86
Decrease in percentage drunk (BAC = 0.10 or higher)

Table 9. Nature of alcohol reduction among fatally injured drivers with known BACs in 15 good reporting States*

(percents)

BAC of fatally injured drivers	1980	1981	1982	1983	1984	1985	1986	1980-86 change
00	39	40	41	43	46	49	48	+23
.01-.09	11	11	11	10	11	10	12	+9
.10-.19	27	26	25	25	23	22	22	-19
.20+	24	23	23	21	20	19	18	-25

*Test and report BACs on 85 percent of fatal drivers.

The nature of the reduction of alcohol in fatal crashes does seem to point to main effects in responsible social drinkers, i.e., substantial reductions in daytime crashes, by female drivers, drivers of vans, and teenagers. However, there is some evidence that the percentage of drivers with very high BACs is also decreasing, at least in the 15 "good-reporting" States in FARS. Table 9 shows that, in 1980, almost a quarter (24 percent) of the fatally injured drivers in these States had BACs of 0.20 or greater. That portion in 1986 was 18 percent, which was a 25-percent reduction—greater than the reduction for the drivers at BACs between 0.10 and 0.19. Most researchers would agree that drivers at 0.20 BAC or greater are most likely problem drinkers or alcoholics. Yet the percentage of drivers at these levels has decreased significantly since 1980 (in that 15-State sample). Are these problem drinkers finding alternatives to driving? Are they confining their drinking to their homes? Have many of them stopped drinking? More research is necessary to answer these important questions.

Alcohol in Noncrash Drivers

Accurate determination of alcohol actually present in drivers while they are using the highways can be estimated only by obtaining measurements from samples of these drivers at roadside. (Thus, self-reported drinking-and-driving data from telephone or household surveys are not considered here.) Measurement of alcohol in noncrash drivers is generally obtained at roadside for four major purposes:

1. To estimate the contribution of alcohol to crash risk

2. To provide data for describing a particular problem by identifying and specifying relevant parameters

3. To provide data for evaluating the results of any changes in circumstances surrounding the particular problem, whether they result from unplanned natural events or from controlled countermeasures

4. To foster general deterrence of drunk driving and to enforce DUI laws

Research designed to accomplish the first purpose involves case-control studies. Activities designed for the fourth purpose are currently referred to as either enforcement checkpoints or sobriety checkpoints. Studies designed for the second or third purpose have a broader range of objectives. Useful epidemiologic data can be obtained from activities designed for any of these four purposes, but the most fundamental question is addressed in investigations of alcohol and crash risk by means of case-control studies.

Case-Control Roadside Surveys and Alcohol Crash Risk

That alcohol is found in approximately 50 percent of fatally injured drivers tested does not necessarily prove that alcohol actually contributed to the occurrence of these crashes. To begin building a case for or against the actual contribution of alcohol, it is first necessary to determine the extent to which fatally injured drivers with alcohol are representative of drivers with similar exposure, but not involved in the crashes. Thus, it is necessary to compare the distribution of BACs obtained from control or comparison drivers randomly selected while passing the same place as the crashes and at equivalent times. By comparing these two sets of data, it is then possible to determine the similarities and differences between the two sets of drivers in terms of the percentages of each with no alcohol, with detectable alcohol, with medium BACs, with high BACs, and so forth.

For example, a number of studies have indicated that between 40 and 50 percent of fatally injured drivers examined had BACs of 0.10 or higher. If we had been able to examine the other motorists who were actually driving at the same times and places that these fatal crashes occurred, and if we had found that about 45 percent of these noncrash-involved drivers also had BACs of 0.10 or higher, then we would have no basis for concluding anything at all about the contribution of alcohol to highway crashes. That is, the percentages of high-BAC drivers in the fatally injured sample would have been the same as the percentage of high-BAC drivers in the comparison sample from the population-at-risk—namely, about 45 percent. Therefore, in this hypothetical instance, high-BAC drivers would have been neither under- nor overrepresented in terms of the percentage of the population-at-risk made up of high-BAC drivers, namely, about 45 percent.

Conversely, if we had found a significant difference between the percentage of high-BAC fatally injured drivers and the percentage of high-BAC control drivers from the same population-at-risk, then we would be able to make some strong inferences about the relative contribution of alcohol to these fatal crashes. This line of reasoning provides the logical basis for attempting to obtain these BAC data from the population-at-risk using the case-control design with roadside research surveys.

The first such study was conducted in Evanston, Illinois, 50 years ago by Holcomb (1938), and several more studies have been conducted in the United States and abroad since that time. These case-control studies have been analyzed from a variety of perspectives and summarized in a number of publications (Hurst 1973, 1985; NHTSA 1985; Perrine 1975a, b; Reed 1981; Zylman 1971). However, the material that follows in this subsection is taken primarily from the most recent review (NRC 1987). In all these reviews, a consistent pattern is revealed by the case-control studies: crash risk increases sharply as BAC rises.

The relative probability of being involved in a crash is defined as the ratio of the BACs of comparison drivers to those of drivers involved in crashes. This probability remains roughly equivalent for crash-involved drivers compared with noncrash drivers up to about 0.08 BAC (figure 2). (However, these relative risk curves understate the risk of involvement at low BACs.) Although the rate of increased risk varies across studies (in part because some studies examine all crashes and some examine only fatal crashes), the risk increases after about 0.08 BAC in all cases and increases dramatically after 0.10 BAC in most studies.

The curves depicted in figure 2 are based on groups of drivers of different ages who have varying experience with alcohol and with driving. Because of the heterogeneity of control groups and the lack of perfect comparability, the effect of alcohol at low BACs is masked by other variables. For example, the major shortcoming of the Grand Rapids study (among the most cited case-control studies) is the lack of comparability between the drivers involved in crashes and the control drivers regarding the frequency of consuming alcohol. This lack of comparability is the source of the apparent improvement in crash risk at low BACs in the Grand Rapids data (the much debated "Grand Rapids
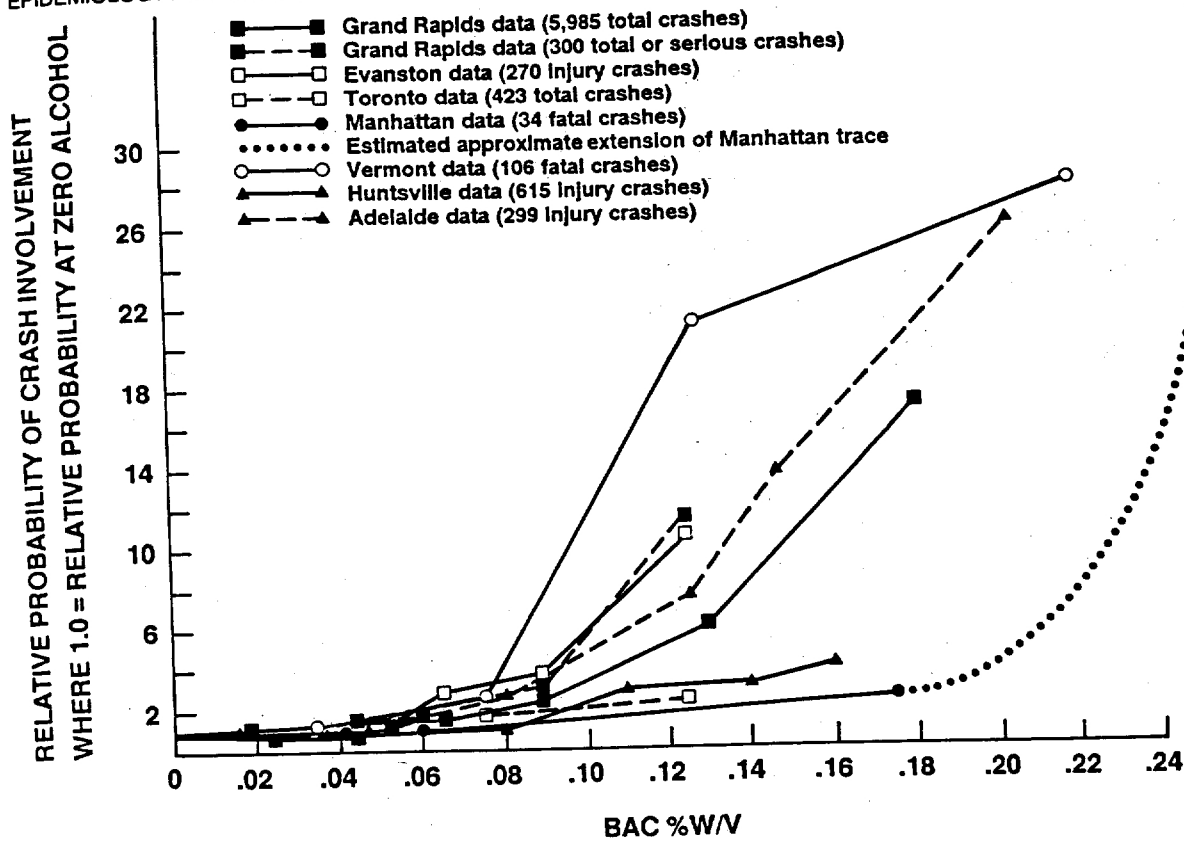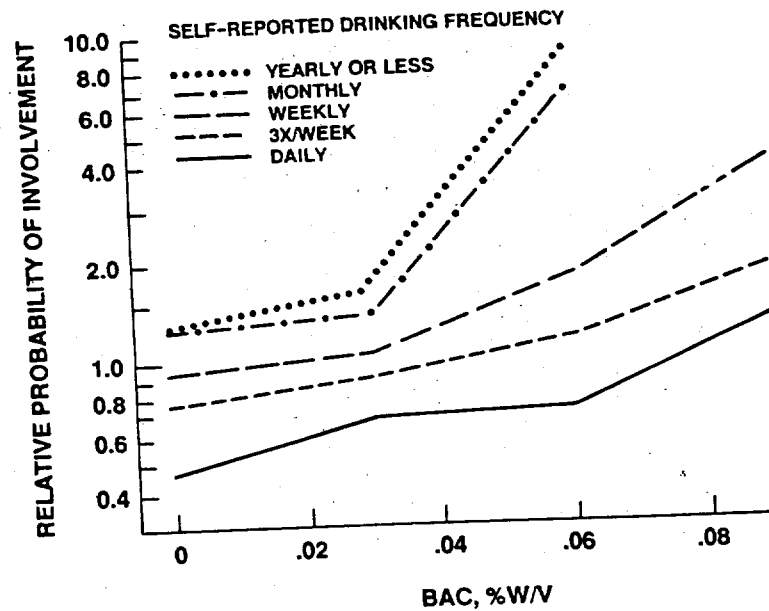
Figure 2. Relative probability of crash involvement as a function of BAC. (Hurst 1985.) Reprinted with permission.

dip") and the understatement of the risk of crash involvement at low BACs. Hurst (1973) noted that the control group had a higher percentage of drivers who were regular consumers of alcohol. Their apparently greater tolerance for alcohol had made them safer drivers at low BACs than the drivers involved in crashes at low BACs, presumably because the latter had less experience as drinkers. Hurst recalculated the relative risk of crash involvement in the Grand Rapids data based on the drivers' self-reported frequency of alcohol consumption (figure 3). He drew three conclusions from the results. First, drivers with frequent experience as drinkers are less likely to be involved in crashes than light and medium drinkers at comparable BACs. Second, regardless of the tolerance for alcohol, the risk of crash involvement increases with BAC. Third, the curves greatly underestimate the risk for the average driver at any BAC; they only demonstrate the relative hazard to drivers who regularly drink and drive. The curvilinear relationship between relative risk of crash involvement and BAC is therefore caused in part by the comparison of drivers with varying degrees of experience as drinkers and experience driving under the influence of alcohol. When experience with alcohol is controlled for, the risk of crash involvement increases with BAC without evidence of a threshold effect.

As noted by Perrine (1975b) in his review of the literature, the relative risk of involvement is not the same as evidence of causality. Given the many interacting factors that may contribute to a crash (and the lack of data on many of them), the role of any single factor is difficult to isolate. Three of the case-control studies deserve special attention because they also estimate the effect of alcohol on the probability of being responsible for a crash.

The methodology for estimating crash responsibility was first developed by McCarroll and Haddon (1962) in their case-control study of fatal crashes in Manhattan. They

Figure 3. Relative probability of crash involvement by self-reported drinking frequency (Hurst 1973). Reprinted with permission from the *Journal of Safety Research*, a joint publication with the National Safety Council and Pergamon Press, Ltd.

categorized the crashes into five classes, the first three of which were assigned responsibility:

1. Only one vehicle involved

2. Two vehicles involved but only one moving

3. More than one vehicle involved and in motion, with responsibility assigned based on circumstances of the crash (cases in which there was any doubt were excluded from this category).

The Manhattan study is based on a sample of 43 drivers fatally injured in crashes that occurred between June 1950 and June 1960. For the 26 drivers in the assigned responsibility classes, 19 (65 percent) had positive BACs, of which 14 (46 percent) had BACs greater than 0.10 . Of these 14 drivers, 12 had BACs of 0.25 or greater. Of 156 drivers randomly selected as controls at or near the sites of the crashes, 39 (25 percent) had positive BACs, of which only 8 (5 percent) were at or above 0.10 .

The Grand Rapids investigation involved by far the largest sample of all the case-control studies (5,985 crashes of all types) (Borkenstein et al. 1964, 1974). By comparison, the 423 cases in the Toronto study constituted the next largest sample (Lucas et al. 1955; Hurst 1985). Using McCarroll and Haddon's method for assigning responsibility, Borkenstein, Crowther, Shumate, Zill, and Zylman estimated that 3,305 of the involved drivers were responsible for the crash that occurred. They used the innocent drivers as controls.

The Vermont study was the third to estimate crash responsibility, based on 106 cases (all fatal crashes) (Perrine et al. 1971). These crashes resulted in 113 fatalities, and 97 of the drivers were assigned responsibility, again relying on the method developed by McCarroll and Haddon. Of the drivers judged responsible, 60 percent had positive BACs and 46 percent had BACs at or above 0.10. Perrine, Waller, and Harris (1971) also calculated a crash-responsible curve, but in contrast to the Grand Rapids study, the drivers stopped at roadblocks were used as controls.
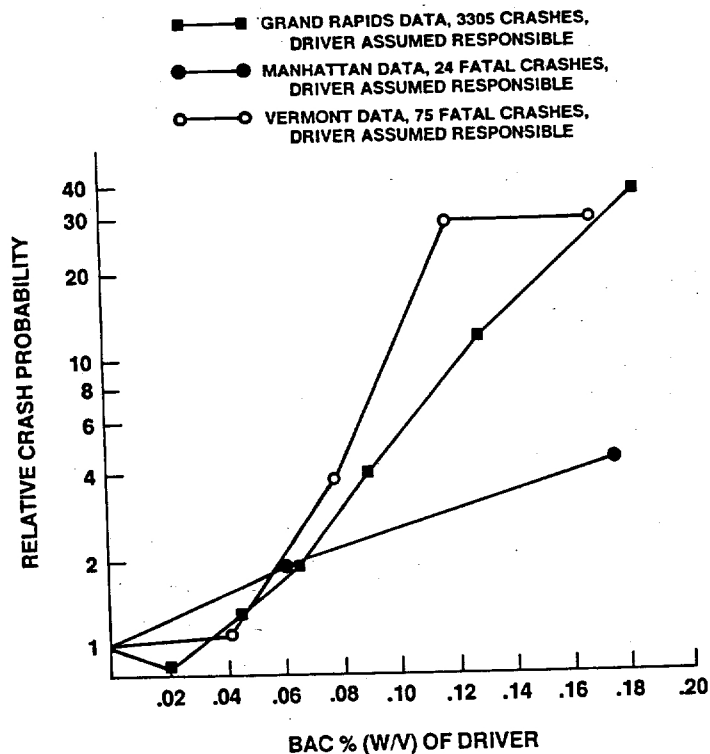
Figure 4. Relative crash responsibility for drivers assumed responsible and those not assumed responsible as a function of BAC, where 1.0 = relative probability at zero alcohol. (Hurst 1973.) Reprinted with permission from the *Journal of Safety Research*, a joint publication with the National Safety Council and Pergamon Press, Ltd.

Hurst (1973) replotted the curves from these three studies on a logarithmic scale to facilitate comparison (figure 4). Although risk of crash responsibility increases as BAC increases in all three studies, several disadvantages with the underlying data should be noted.

The trend in the Manhattan data is based on a very small number of crashes: 25 responsible drivers with positive BACs. In addition, the trend at the higher BACs is greatly understated. For the fatal crashes in which the driver had a BAC of 0.25 or higher (about half those in the driver-responsible category), no driver in the control group had an equivalent BAC. "Hence, the relative hazard calculated from the case/control ratio would be infinite within the range, were it possible to graph it" (Hurst 1973).

One of the shortcomings of the relative risk curve estimated in the Grand Rapids study is the inclusion of drivers involved in single-vehicle crashes in the group of responsible drivers. Although the responsibility of the driver is not in question, because of the nature of the crash, a control driver is not available. The published data do not provide sufficient detail to allow the curve to be completely recalculated without the single-vehicle crashes to determine the effect of including these crashes, but the available data suggest that the curve would shift to the right. It would still accelerate after 0.04 BAC and at an exponential rate, but the curve would not rise as quickly as shown in figure 4.

One problem with the Vermont data is the small number of crashes in the sample. In the comparison of crash risk as BAC rises, one or two drivers are responsible in some of the BAC ranges. Chance occurrence could distort the results when so few drivers are the basis of the calculations.

Despite the weaknesses in the case-control studies, some important conclusions can be drawn. In several of the case-control studies done in the United States and abroad, a consistent increase in risk of crash involvement has been shown. When experience with drinking is controlled for, this risk increases with BAC without any evidence of a threshold effect (or dip). The three studies that attempted to estimate crash responsibility showed that the risk of causing a crash increases even more rapidly than the risk of crash involvement as BAC increases (NRC 1987).

Another important aspect of the alcohol contribution to crash risk is reported by Voas (NHTSA 1985). To emphasize the significance of the difference in BAC between drivers assumed to be responsible versus those assumed not to be responsible for crashes, Hurst (1974) also presented an additional calculation on the data from the Grand Rapids study. His results for the drivers assumed to be responsible are represented by the center plot in figure 4. However, the probability of being innocently involved in a crash remains essentially level and does not increase with increasing BAC; the plot is basically flat and would lie between the relative crash probability of 1 and 2 in figure 4. The same result was found in the Huntsville/San Diego study by Farris, Malone, and Lilliefors (1977). These results provide further evidence for the causal role of alcohol in crashes.

Other Roadside Research

The success and utility of the case-control procedures for investigating alcohol crash risk stimulated interest in using the roadside survey technique for evaluating alcohol safety programs by measuring the change in the number of high-BAC drivers actually on the roads. Standardized procedures for conducting roadside surveys were developed (Perrine 1971) and applied successfully in 28 of the 35 Alcohol Safety Action Projects (ASAPs) funded by the Department of Transportation between 1970 and 1975 (Voas 1972; Carr et al. 1974). In these programs, the roadside surveys were used to evaluate project effectiveness (Levy et al. 1978) by serving as a means to collect data used as the primary criterion or dependent variable (BAC). Roadside surveys were conducted before and after program implementation to measure the change in average driver BAC (if any) resulting from project activities (Lehman et al. 1975). When used for program evaluation, sampling was conducted during periods when a high percentage of drinking drivers was on the road (i.e., Friday and Saturday nights) rather than at times and places at which accidents had occurred. By a return to the same sites, changes over time can be measured.

Roadside surveys provide a more direct method of evaluating alcohol safety counter-measure programs than does the use of accident data, because highway crashes result from a large number of factors (weather, roadway construction, economic conditions, etc.) that are unrelated to the evaluation of enforcement activities. The BAC values of drivers serve as an intermediate measure between action programs and the ultimate criterion of accident prevention. While a reduction in the average BAC of drivers on the road does not guarantee a reduction in crashes, the relationship between driver BAC and risk of crash involvement is close enough to make this measure a credible criterion for program effectiveness.

During the ASAP period (1970 through 1974), some 77 roadside breath-testing surveys of nighttime drivers were conducted. In addition, a national roadside breath-testing survey was conducted in 1973, and a computer archive of these 78 roadside surveys is stored at the University of Michigan Highway Safety Research Institute (Lehman et al. 1975). The file contains breath-testing results, demographic data, and so forth, for some 78,000 randomly selected drivers, as well as 2,700 passengers. Analysis

of these aggregated data show the following percentages of drivers with BACs at or exceeding 0.10: 1 percent of weekday-early drivers, 3 percent of weekend-early drivers, and 6 percent of weekend-late and weekday-late drivers. Significant reductions in the percentages of drivers above the legal limit (0.10 BAC) were demonstrated for those jurisdictions that used this evaluation method (Levy et al. 1978).

Based on the utility of this roadside BAC measure in the ASAP program, it was applied again in a 4-year study of a special DUI enforcement effort in Stockton, California (Voas and Hause 1987). In this study, survey procedures were modified to permit low cost and low profile surveys that were conducted every weekend for 3 ½ years (Hause et al. 1982). Drivers with a BAC of 0.10 or greater on Friday and Saturday nights decreased from 88 per thousand before the Stockton project to 50 per thousand during the third year.

The roadside survey technique also permits (through an application of Bayes' Theorem) estimation of the probability that a driver at a given BAC will be arrested by the police. This procedure was first applied by Beitel, Sharp, and Glauz (1975) to the ASAP survey data in Kansas City. Hause, Voas, and Chavez (1982) used the same procedure in Stockton. These studies provided roughly similar results indicating that the chances of being arrested at a BAC of 0.15 is roughly 1 in 100, while the chance of arrest at 0.10 BAC is half that amount, about 1 in 200. Since both these studies involved intensive enforcement programs, they provide a reasonable indication of the maximum arrest rate that can be achieved with traditional patrol methods.

The ASAP experience with roadside research surveys and with the success of the manual for conducting and evaluating them (Perrine 1971) provided the basis for subsequent international activity. An invitational international workshop was conducted in Paris in an attempt to coordinate the methodology for roadside research surveys to be implemented in other countries in order to maximize the comparability of the obtained data. The workshop resulted in a useful manual (Carr et al. 1974) and complemented parallel activities being conducted under the auspices of the Organization of Economic and Cooperative Development. As a result of these activities, use of roadside surveys for international comparisons of countermeasure programs was stimulated in Canada, the Netherlands, Norway, Sweden, and Finland. The resulting data permitted an international comparison of driver BACs (Voas 1982), which indicated that approximately 12 percent of drivers on weekend nights were at or above 0.05 BAC in Canada, the Netherlands, and the United States, whereas less than 2 percent of drivers were at this level in Scandinavian countries.

Although use of roadside research surveys has diminished in the United States since the end of the ASAP activities in the mid-1970s, the technique continues to be used effectively in other nations, for example, Canada, Australia, Denmark, and Norway. Nevertheless, a few studies of the population-at-risk in the United States either have been conducted recently or are currently being conducted. In the spring of 1986, U.S. National Roadside Breathtesting Survey II (Wolfe 1986) was conducted in a representative sample of 32 localities, 18 of which had participated in the 1973 U.S. National Roadside Breathtesting Survey I (Wolfe 1974). Statistically significant reductions were found in the percentage of medium and high BAC drivers sampled at high-risk times (Friday and Saturday nights from 10 p.m. to 3 a.m.). Drivers at or above the illegal BAC of 0.10 decreased from 5.0 percent in 1973 to 3.1 percent in 1986; drivers at or above a BAC of 0.05 decreased from 13.5 percent in 1973 to 8.3 percent in 1986. It should be noted that the breathtest completion rates were 86 percent in 1973 and 92 percent in 1986.

In Vermont, a large-scale roadside research study involving a projected 42,000 nocturnal drivers sampled at high-risk times (Friday and Saturday nights from 10 p.m. to 3 a.m.) is currently being conducted. It is funded by the National Institute on Alcohol Abuse and Alcoholism (NIAAA, Grant AA07876). This 5-year field study is primarily

designed to determine the prevalence of drivers with high alcohol tolerance, and to determine their salient and differentiating characteristics. Since the high alcohol tolerant driver is apparently rare, a large number of motorists (42,000) driving at high-risk times must be stopped and screened for BAC to identify a sufficient number of such people (40 to 60) to be able to conduct a meaningful study. In the process of conducting this field study, a large number of people will be breathtested using both the new passive alcohol sensor and the more traditional hand-held evidentiary devices. Approximately 4,000 of these motorists, sampled across the full distribution of BACs, will participate in extensive personal interviews concerning self-reported background data; drinking, driving, drinking-and-driving, drugs-and-driving information and attitudes; and selected personality characteristics. Data will also be gathered on these motorists' driver records, performance on the most valid field sobriety tests (gaze nystagmus, walk-and-turn, and standing steadiness), and ratings on clinical signs of intoxication. With a test completion rate of 96 percent, the results from the first 650 drivers indicate that 3.7 percent had a BAC of 0.10 or higher, whereas 10.2 percent had a BAC of 0.05 or higher. Although the sample size is still relatively small, these 1988 data show a decrease in distribution of BAC when compared with data obtained in a 1974 Vermont study (Perrine 1976) of 1,663 drivers at high-risk nocturnal times (Thursday, Friday, and Saturday nights between 10:30 p.m. and 3 a.m.): 4.6 percent had a BAC of 0.10 or higher and 14.7 percent had a BAC of 0.05 or higher. Thus, these roadside studies of the high-risk population would seem to show that some progress is being made in the war on drunk driving, if motorists with BACs in excess of the legal standard (0.10) are taken as the criterion.

Enforcement Checkpoints

Police officers conduct sobriety checkpoints at which they stop motorists at random and test them for breath alcohol. Such activities are conducted primarily for enforcement purposes, although they also serve as general deterrence. Although useful data for epidemiologic purposes are available from these enforcement checkpoints, few systematic studies have been conducted to analyze such data. If they were analyzed carefully and properly, these data could provide a valuable source of relatively low-cost information concerning the population-at-risk. In a recent Charlottesville, Virginia study, Voas, Rhodenizer, and Lynn (1985) evaluated the effectiveness of such sobriety checkpoints, especially in comparison with the drivers arrested for DUI by traditional roving patrols. In addition, this study found evidence of police biases in those arrested, whereby both young drivers and women were underrepresented among arrested drivers, while minority and very high BAC drivers were overrepresented. Thus, such studies clearly demonstrate that researchers can avail themselves of enforcement checkpoints as an opportunity to collect valuable data for epidemiologic purposes.

Characteristics of Drunk Drivers

During the past 20 years, numerous statistical and clinical studies have been published on various aspects of the drinking driving problem. However, surprisingly little rigorous research has been published on characteristics of convicted DUI offenders, particularly when contrasted with the vast literature on problem drinkers/alcoholics, and on characteristics of drivers involved in fatal accidents. As suggested by Zylman (1974) and by Moskowitz, Walker, and Gomberg (1979), the population arrested and convicted of DUI offenses is not typical of impaired drivers in general or of drivers involved in alcohol-related accidents. The mean BAC of convicted DUI offenders in California during 1984 was 0.18—a concentration far in excess of the State's 0.10 limit per se, and well beyond the level at which impairment occurs. In one of the few formal statistical studies of differences between alcohol-involved fatal accident drivers and convicted DUI offenders, Fridlund and Hagen (1977) used discriminant function analysis in comparing 146 DUI offenders in Los Angeles County with a sample of 191 alcohol fatalities. The DUI conviction group had significantly more prior DUIs, more prior reckless-driving

convictions, and more prior moving traffic convictions. The differences on the incidence of DUIs and reckless convictions was large, with the DUI group having about three times as many entries during the prior 3-year period.

Moskowitz, Walker, and Gomberg (1979) conducted a detailed review of the literature on DUI offender characteristics. This subsection relies heavily on their monograph for the pre-1979 literature, but concentrates on recent studies and studies not included in the 1979 review for its primary source references. However, a few pre-1979 studies of special importance are reviewed here as primary references even though they are also included in Moskowitz et al. (1979).

Moskowitz, Walker, and Gomberg organized their review by type of offender characteristic (prior driver record, age, etc.), and reached the following conclusions with respect to each domain:

- Marital status: DUI convictees are much more likely to be divorced, separated, or widowed than are non-DUI control populations. Some studies have reported five- to sixfold differences in rates compared with control populations.

- Employment history: Convicted DUI offenders are more likely to be unemployed, with rate differentials ranging from two- to fourfold higher across various studies.

- Occupation: Convicted DUI offenders are more likely to have lower status occupations. DUI offenders in blue collar jobs averaged 65 percent across studies compared with 51 percent for control samples.

- Income: Convicted DUI offenders tend to have lower incomes — about 18 percent lower than controls across the reviewed studies.

- BAC: The mean BACs for the offenders averaged from 0.18 to 0.28. (Statewide California figures have consistently averaged 0.18.)

- Drinking behavior: DUI offenders drink more often and consume more alcohol per sitting than do non-DUI populations. Beer is the preferred beverage of DUI offenders. The findings of the Southern California study by Pollack (1969) are typical. Pollack reported that 18 percent of DUI drivers drank every day compared with 11.5 percent for a control sample. In terms of drinks per sitting, 35.2 percent of the DUI sample typically consumed five or more drinks compared with 5.7 percent of the control sample.

- Reason for drinking: Convicted DUIs (and alcoholics) are more likely to drink to release tension and to cope with stress.

- Problems caused by drinking: Convicted DUIs are much more likely than controls to exhibit poor health, family disorganization, financial problems, and poor job performance.

- Prior alcohol treatment history: Convicted DUIs are more likely than controls to have previously entered some form of alcohol treatment program. The median across 20 studies was 6.0 percent, with a maximum of 42.5 percent. (This characteristic is highly dependent on the institution and delivery systems of a particular region, and would be expected to vary across jurisdictions and over time.)

- Problem drinking status: Studies using the Michigan Alcoholism Screening Test (MAST) indicate that 54-74 percent of convicted DUIs fall in the problem-drinking and alcoholic range. Studies using the Mortimer-Filkins test produce slightly lower prevalence figures.

- Driving after drinking: Convicted DUIs are much more likely than controls to drive after drinking. Pollack (1969), for example, reported that 49 percent of DUI offenders admitted to driving at least once a week after two drinks compared with 12 percent of a control sample.

- Total prior arrests: Convicted DUI offenders are more likely to have prior arrests for both alcohol and nonalcohol offenses.

- Driving history: Convicted DUI offenders have substantially more driving record entries of all types than do controls (more DUIs, more alcohol and total accidents, more moving traffic violations, and more license actions). The rate increases across studies and variables range from 100 percent to 500 percent. The driving record histories of convicted DUIs are also substantially worse those of medically diagnosed alcoholics.

- Personality traits: Convicted DUIs have a significantly higher prevalence of personality trait disorders. They are more likely than controls to exhibit neuroticism, depression, paranoid ideation, low self-esteem, and to have a lower sense of personal responsibility and control and greater feelings of aggression/hostility.

- Stress: Convicted DUI offenders are more likely to report experiencing stress from family, financial, and job problems.

- Education: Convicted DUI offenders are more likely to be high school dropouts and have fewer years of education.

- Age: Convicted DUI offenders tend to be slightly older than non-DUI controls, with the highest disproportionate concentration in age interval 30-45.

- Race: Most convicted DUI offenders are white, but minority groups (hispanics and blacks) are overrepresented compared with their representation in the population.

- Sex (not covered by Moskowitz): The great majority of convicted DUI offenders are male. The range for females is from 5 to 20 percent, depending on the characteristics of the specific DUI population (first versus repeat offenders), region, and so forth. A large statewide sampling in California indicates that 13 percent of those convicted for a DUI offense in 1982 were female (Tashima and Peck 1986). Among first and second offenders, females accounted for 17 percent and 10 percent, respectively.

Drinking Status

It is clear from the above summary that persons convicted of drunk driving offenses deviate greatly from the general driving population on a wide variety of characteristics. That DUI offenders contain a disproportionate number of problem drinkers would be expected, of course, since the offense of drunk driving is, per se, a problem associated with the consumption of alcohol.

The number of drinks required to produce manifestly detectable impairment in driving and the BACs typically attained by DUI offenders implies a level of alcohol consumption that is statistically deviant. Given the very low probability that any given incident of impaired driving will result in detection (arrest or accident), the percentage of DUI offenders who were simply unlucky, in the sense of getting caught in a rare instance of impaired driving, would be relatively small. One would therefore expect most DUI offenders to be heavy consumers of alcohol.

Most of the empirical literature, and most authorities in the area, agree with this conclusion, although controversy has developed over the percentage of DUI offenders who are alcoholics in the clinical disease context. This controversy stems more from semantic and epistemological complexities than from disagreements over data, and is not pursued here.

Lest the impression be created that opinion and data are unanimous on the drinking status of DUI offenders, the results of a recent California study of first offenders will be summarized in detail. This study was carried out by the Pacific Institute for Research

and Evaluation (PIRE); it was commissioned by the State of California pursuant to Assembly Bill 3405 (Stewart et al. 1987).

The major objective of the PIRE study was to develop a model curriculum and rehabilitation program for use by courts in sentencing first-offender DUI cases. However, this review will only consider that component of the study pertaining to offender characteristics (natural variation component).

Detailed biographical, drinking habit, and arrest-incident information was collected by questionnaire on 5,052 respondents from 26 first-offender treatment programs throughout California. The authors reported the following statistics from an analysis of the questionnaire responses:

- Median number of drinks on day of arrest: 6
- Median BAC upon arrest: 0.16
- Median number of days in past year with four or more drinks: 60
- Median number of days in past year with eight or more drinks: 4
- Percentage who did not feel intoxicated upon arrest: 35 percent
- Median number of previous days in past year driven while impaired: 1
- Percentage with prior DUI arrests: 20 percent

The authors categorized the drinking pattern responses into two typologies for comparison with a statewide general population survey. The more complex of the typologies was a 7-point continuum: abstainers, infrequent drinkers, light monthly, light weekly, moderate weekly, and frequent heavy. Using a probit analysis to adjust for population differences, the authors found no significant differences between the drinking frequency of the two groups after abstainers were removed from the general population sample.

The difference was significant, however, in the frequency of heavy drinking (five or more drinks at least once a week), with substantially more of the DUI offenders falling into that category. Nevertheless, fewer than 30 percent of the first offenders were placed in this category. In commenting on these findings, the authors concluded:

> While defining a "typical pattern of drinking for all subjects is difficult, the median frequencies of use conditional upon the level of use at arrest is revealing: 40 percent of the subjects reported having had 8 or more drinks on the day of their arrest. The median frequency of use at this level among these subjects was 14 occasions over the previous year and only one occasion in the preceding 30 days. A pattern of use including drinking 8 or more drinks at least weekly over the previous year was reported by only 20 percent of these subjects. Thus, for the majority of subjects, drinking at the level of use at which they were arrested is relatively infrequent (pp. 27-28)

> . . . first offenders are not unlike the general population of drinkers in California in terms of the typical frequency of use. However, it appears that the incidence of heavier drinking is greater among first offenders (p. 32)

The authors also included a measure of alcohol dependency in their study. Subjects completed a 25-item Alcohol Dependency Scale (Skinner and Allen 1982), and the scores were compared with those of clinically diagnosed alcoholics. Ninty-two percent of the subjects produced scores "indicating a low level of alcohol dependency." The authors went on to conclude "the dramatic differences in these distributions suggest that dependency symptoms among first offenders are quite low, as compared to alcohol treatment groups."

The results and conclusions of the PIRE study are at odds with prevailing opinion and most prior studies in this area. If the findings are accepted at face value, the great

majority of first offenders fall within the bounds of social drinking. Even the percentage characterized as heavy does not seem extreme.

There are several possible explanations. First, the PIRE study was limited to first offenders, and it is known that the percentage of problem drinkers among first offenders is lower than among repeat offenders.

Second, problem drinkers and DUI offenders are known to understate their drinking, sometimes dramatically. Stewart, Epstein, Greenewald, Laurence, and Roth (1987) acknowledge this possibility and recommend caution in interpreting the study findings. Although previous studies are also subject to reporting biases, many have included clinician interviews, psychometric instruments employing lie scales, and a variety of public agency data. No evidence is presented in the PIRE study to indicate that procedural controls were used to minimize the tendency of people to "fake good" or employ various forms of self-denial.

Third, the first-offender survey only involved offenders who were sentenced to an alcohol program and who agreed to cooperate by completing the questionnaire. In California, 23 percent of first offenders are not assigned to programs. Approximately 15 percent of the sample did not return a questionnaire.

There are also inconsistencies in some of the values derived from the self-report. For example, it would have taken more than a median of six drinks to produce a median BAC 0.16. The fact that 35 percent of the subjects did not feel intoxicated when arrested and that only 14 percent acknowledged being definitely intoxicated is cause for further suspicion.

Finally, it is difficult to accept the median estimate of only one incident of driving while impaired in the previous 12 months. The suggestion is that many of the subjects were not being candid in their responses.

The PIRE report also contains a description of first offender biographical and socioeconomic characteristics. The statistics of interest are summarized below:

- Male: 81 percent
- Single: 46 percent
- Divorced, widowed, or separated: 21 percent
- White: 68 percent
- Hispanic: 22 percent
- Black: 3 percent
- High school dropouts: 22 percent
- Median age: 30
- Unemployed or employed part-time: 30 percent
- Median income: $16,500

These demographic characteristics are reasonably consistent with the portrayal from the Moskowitz review, particularly when allowance is made for differences in time and region. The percentages for ethnic minorities are somewhat lower than would be expected based on California ethnicity composition and prior evidence showing that some minorities (e.g., Hispanics) are overrepresented in DUI populations. It is important to recognize that the PIRE sample is limited to offenders entering first-offender programs and, within this subset, to those who returned the questionnaire. These factors could alter the representativeness of the sample.

Prior Driving Record

It is also clear that DUI offenders have statistically deviant driver records before their

DUI arrest. Although one would expect overinvolvement in previous alcohol-related accidents and convictions, the extent of DUI offender overinvolvement in nonalcohol related incidents is not widely recognized.

Statewide, data from Tashima and Peck (1986) indicate the following pretreatment 30-month rates for representative statewide samples of 29,097 first and 7,797 repeat DUI offenders:

	Mean non-DUI accidents	Mean total accidents	Mean non-DUI related convictions
First offenders	.17	.36	1.3
Second offenders	.18	.45	1.4

The above rates are more than twice the rates expected for a similarly stratified (age and sex) population of non-DUI drivers.

The Tashima and Peck (1986) study and numerous previous California studies indicate that nonsuspended DUI offenders also accumulate worse non-DUI driving records (total accidents, total moving violations, etc.), *following* conviction for a first or repeat DUI offense (Sadler and Perrine 1984; Hagen et al. 1978; Hagen 1977; Arstein-Kerslake and Peck 1985).

The most detailed analysis was performed by Arstein-Kerslake and Peck, who compared the subsequent 4-year driving records of first and repeat DUI offenders from Sacramento County with a general population group that was similarly age-sex stratified. The first and repeat offenders were grouped into quartiles based on their actual and predicted DUI recidivism. Except for the first quartiles (i.e., lowest 25 percent in terms of recidivism expectancy), all quartiles had substantially worse accident and traffic conviction records. The differences were also highly significant when summed across quartiles.

The above relationship between DUI offenses and driving behavior in general has been addressed by a number of other investigators (Maisto et al. 1979; Raymond 1971; Denberg 1974). Donelson, Beirness, and Mayhew (1985) consider the issue from the impaired problem-driver paradigm addressed in Simpson's (1977) paper. This heuristic paradigm views the convicted DUI population as containing drivers whose drinking is subordinate to a larger problem of high-risk negligent driving. The alcohol impairment can combine, additively or synergistically, with negligent driving to increase risk, but the underlying problem-driving behavior exists independent of alcohol.

Although Donelson, Beirness, and Mayhew stress the hypothetical nature of this paradigm, the premise that impaired drivers who drive aggressively and unlawfully are more likely to be apprehended is in no way hypothetical. It has also been established that DUI offenders with a prior history of moving violations represent substantially greater accident risks than DUI offenders with clean records (Sadler and Perrine 1984; McConnell and Hagen 1980; Peck and Kuan 1983).

The linkage between problem driving and DUI offenses is the very essence of a recent study by Donovan, Umlauf, and Salzberg (in press). These investigators followed the driving records of 254 non-DUI-involved problem drivers over a 3-year period subsequent to initial identification. Approximately 11 percent of the sample had a DUI conviction during that period—a rate five times greater than that of the general male driving population in Washington State. The study was replicated on a sample of 38,695 driver record files. The authors found that drivers with four or more moving violations were greatly overinvolved in subsequent DUI offenses, with 16.9 percent receiving an initial DUI conviction during a 3-year followup period. The DUI rate was particularly pronounced for males under age 30.

DUI Recidivism

How do first offenders compare to repeat offenders on the various characteristics described above? This question is, of course, related to the question of recidivism correlates and is best addressed by longitudinal recidivism studies.

The actual rate of recidivism cannot be determined in any general sense because it is inextricably tied to the length of the followup period, the length of record retention in a given State, the DUI arrest rate of a particular region or State, regional plea reduction practices, and the effectiveness of DUI countermeasures. In California, approximately 35 percent of all DUI convictions each year involve drivers with prior DUIs within the preceding 5 years.

Recidivism prediction was directly addressed by Ellingstad (1974) as part of the evaluation of the South Dakota ASAP. Discriminant analyses, performed separately for problem and nonproblem drinkers, assessed the predictability of a dichotomous DUI recidivism measure using 14 variables related to prior conviction history, demographic characteristics, drinking pattern, and Mortimer-Filkins score. The problem-drinker group yielded the highest level of prediction. For the 1,744 problem-drinker clients, of whom only 12.6 percent were actual recidivists, prediction of subsequent 2-year DUI recidivism was significant at the 0.001 level. However, only 4.4 percent of the variance in recidivism was accounted for by the discriminant function (multiple $R = 0.209$). Of the 14 variables used for the recidivism analysis, only 6 had a significant univariate relationship with recidivism: prior DUI convictions, reckless convictions, total convictions, marital status, drinking pattern, and Mortimer-Filkins score. All relationships were in the expected direction—that is, less favorable values were associated with increased recidivism.

The level of recidivism prediction reported by Ellingstad (1974) was greater than that reported by Burch (1974) in her analysis of the Los Angeles ASAP. A multiple regression analysis was conducted for approximately 1,000 clients with the objective of predicting subsequent 7-month DUI recidivism using treatment, age, accident, and conviction measures as predictor variables. The actual 7-month recidivism rate in the sample was approximately 10 percent. The analysis indicated that 2.4 percent of the variance in recidivism could be accounted for by the seven predictor variables ($R = 0.155$, $p < 0.01$). The relatively low level of prediction reported by Burch results at least in part from the brief 7-month period during which recidivism data were collected.

As part of the evaluation of the El Cajon Drinking Driver Countermeasure Program, Wendling and Kolodij (1977) collected data on driving history, criminal arrest record, probation officers' evaluation of problem-drinking severity, and Mortimer-Filkins diagnostic scores from 1,740 DUI offenders. These measures served as predictors of the yearly rate of recidivism (DUI and reckless-driving convictions). The duration of data collection subsequent to treatment ranged from 0 to 72 months. Stepwise multiple regressions were performed for each half of the sample, and then each equation was applied to the other half of the sample in order to provide a measure of cross-validation. Although Wendling and Kolodij report impressive Rs in the range of 0.40, the high levels of classification error upon cross-validation indicate that the construct multiple Rs were inflated.

Development of a prediction model to identify likely recidivists among a sample of Los Angeles DUI offenders was one of the main objectives of Pollack, Didenko, McEachern, and Berger (1972). Three models were developed and evaluated: multiple regression, discriminant function, and empirical bayes. The authors reported a high degree of classification accuracy for drivers with extremely high predicted recidivism expectancies. However, since these drivers represented only a small part of the total recidivist population, it could not be concluded that recidivism can be accurately predicted. On the contrary, the data indicated that the classification error would be substantial for drunk drivers with nonextreme recidivism expectancies. Although no

multiple R or overall classification accuracy was cited, the authors reported that the best prediction would achieve an 11-percent increase in predictive accuracy over what would be expected by chance prediction. Increased recidivism was associated with lower education, younger age, and a higher incidence of traffic accidents, traffic violations, and nontraffic arrests.

McGuire (1975) assessed the predictability of accidents and alcohol-related convictions for DUI 2,255 offenders who had participated in the Orange County Alcohol Traffic Safety project. Convicted DUI offenders were assigned to one of a number of alternative countermeasure programs. Driver record recidivism data were collected for 15 months after treatment assignment. McGuire performed stepwise regression analyses of driver record, psychosocial, and psychometric variables to identify covariates significantly related to accidents and alcohol-related convictions. The significant predictors of subsequent accidents were sex, age, court-martial (if in service), number of accidents in last 3 years, and number of traffic tickets in last 3 years, yielding a multiple R of 0.20. Surprisingly, subsequent alcohol-related convictions were slightly less predictable than subsequent accidents (R = 0.14). The significant predictors of alcohol-related convictions were marital status, number of full-time jobs in last 5 years, frequency of smoking, number of tattoos, and number of traffic tickets in last 3 years. No cross-validation analysis was performed.

Arstein-Kerslake and Peck (1985) used multiple regression and discriminant function techniques to predict the 4-year DUI rate, subsequent to treatment, of large samples of first- and second-time DUI offenders selected from Sacramento County. The best multiple R was 0.27, which shrank to 0.21 on cross-validation. The regression equations and correlation coefficients indicated that recidivists were more likely to:

- Be younger
- Be single or divorced
- Have more prior DUI offenses
- Have more nonalcohol moving traffic violations
- Be male
- Have blue collar occupations
- Have more nonmoving traffic violations
- Be ethnic minorities
- Have previous alcohol treatment or disulfiram use
- Have exhibited negative attitude ratings during the intake interview
- Have received intake recommendations for more intensive alcohol treatment
- Have higher BAC levels

Most of the above recidivism correlates are intuitively plauible and onsistent with the prior literature. Simply put, DUI offeders are more likely to recidivate if their drinking probem is more severe and their driving record reflects numeous non-DUI- and DUI-related violations.

Arstein-Kerslake and Peck (1985) also developed regression models for predicting program compliance — that is, successfully completing the rehabilitation program. Program compliance proved much more predictable than DUI recidivism. In addition, persons with a high likelihood of being noncompliant tended to have extremely high subsequent accident rates.

Multivariate and Taxonomic Studies of DUI Offender Characteristics

One limitation of simple univariate studies is that they fail to consider the inter-

relationship among the set of variables being evaluated to characterize a given sample of DUI offenders. Although regression and discriminant function procedures partial out intercorrelations in producing linear composites that maximally differentiate between groups (e.g., offenders versus nonoffenders), these techniques are focused on the sole objective of discrimination with respect to a single statistical criterion. As a result, they do not provide a portrait of the offender population in terms of the complete array of measurements and the more general dimensions underlying those measures.

In recent years, a number of investigators have attempted to develop multivariate typologies of DUI offenders through factor and cluster analysis procedures (Arstein-Kerslake and Peck 1985; Wells-Parker et al. 1985). These efforts to construct empirically anchored multivariate typologies were preceded by a number of attempts to produce rational typologies through less formalized statistical or clinical methods. A brief summary of this literature follows.

Intuitive and univariate typologies. The concept of distinguishing drinkers on a continuum of severity (social, problem, alcoholic; light, modest, heavy; primary versus secondary alcoholism) has a long history. (Some research on DUI typologies has been referred to above in connection with the literature on univariate characteristics of DUI offenders.)

Cahalan, Cisin, and Crossley (1969) and Jellinek (1960) provide detailed examples of analytic systems, based on a complex of medical, sociopsychological, and drinking-style parameters. Many of the ASAPs developed clinical and statistical taxonomies for classifying convicted drunk drivers. These efforts have been reviewed by Epperson, Harano, and Peck (1975), Ellingstad (1974), and Nichols (1974). Although it is difficult to formulate a coherent generalization about the success of these efforts because of the diversity and limitations of the validation methods, the various systems had some utility in elucidating characteristics of convicted DUI offenders and in differentiating offenders from drivers in general. The following characteristics were often used to create problem-drinking continuums, and each has been found to differentiate convicted DUI offenders from non-DUI populations:

- Scores on psychometric and personality tests, such as the Minnesota Multiphasic Personality Inventory (MMPI)

- Scores on tests specifically designed to detect problem drinkers and alcoholism, such as the Mortimer-Filkins and MAST

- Quantity-frequency index scores

- Blood alcohol levels at time of arrest or accident involvement

- Prior record of DUI offenses and alcohol-involved accidents

- Prior arrests for public drunkenness and alcohol-associated misdemeanors

- Other criminal offenses

Many of these variables were discussed above in connection with the univariate studies.

Nichols and Reis (1974) concluded that number of prior DUI offenses and BAC were among the two most useful indicators for classifying DUI offenders into a problem no-problem dichotomy, and they used this dichotomous system to classify DUI offenders across many of the ASAP sites. A description of the complete classification criteria is presented in table 10.

After 24 months of followup from the point of treatment classification, Nichols and Reiss reported that 15 percent of the problem-drinker group had been rearrested compared to 8 percent of the nonproblem group.

Epperson, Harano, and Peck (1975) regressed the BAC values for a sample of 1,366

Table 10. Department of Transportation problem drinker classification criterion

1. Diagnosis as an alcoholic by a competent medical or treatment authority.

OR

2. Self admission of alcoholism or problem drinking.

OR

3. Two or more of the following:
   a. A BAC of 0.15 or more at time of arrest
   b. A record of one or more prior alcohol-related arrests
   c. A record of previous alcohol-related contacts with medical, social, or community agencies
   d. Reports of marital, employment, or social problems related to alcohol
   e. Diagnosis of problem drinker on the basis of approved structured written diagnostic interview instruments (e.g., MAST, Mortimer-Filkins, National Council on Alcoholism (NCA), Johns Hopkins diagnostic tests)

DUI arrestees against a pool of several driver record measures obtained on each subject. Higher BAC values were found to be associated with significantly higher ($p < 0.05$) rates of prior alcohol-related accidents and DUI convictions. The authors concluded that a combined criteria of prior offense frequency and BAC should be included in any problem drinker driver taxonomy. In another component of the same study, they reported that two psychometric tests, the Risk Addiction Profile and Mortimer-Filkins, produced significant discrimination between a group of DUI arrestees with BACs in excess of 0.20 and a group of non-alcohol-involved negligent drivers.

A number of authors have commented on the criterion problem in validating problem-drinker taxonomies — a problem that emanates from the difficulties in defining what constitutes problem drinking and alcoholism (Epperson et al. 1975). As a result, different classification schemes and diagnostic procedures can diverge greatly in their respective problem-drinker incidence rates. Table 11 from Filkins, Mortimer, Post, and Chapman (1973) provides an apt illustration of the problem.

These data, based on a sample of 709 DUI offenders from three ASAP sites, nevertheless provide some indication of the percentage of the convicted DUI population whose drinking patterns deviate from social use levels.

Vingiles (1983) reached similar conclusions in her extensive review of the literature on DUI drinking status classification. The DUI offenders classified as problem drinkers ranged from 2 percent to 89 percent across the various studies. Vingilis estimated that 30-50 percent of DUI offenders would most likely be alcoholic.

Sutker, Brantley, and Allain (1980) evaluated the MMPI profiles of 500 DUI offenders, all of whom were found to share mild antisocial tendencies. Four profile patterns were identified and were found to differ significantly on levels of self-reported drinking. Profile groups also differed significantly in race, age, and education. The authors reported a strong association between elevated levels of self-reported drinking and patterns in which indices of depression and social deviance were also elevated. Comparing profile patterns of DUI offenders with those of alcoholics and psychiatric patients revealed only a modest overlap among the groups.

Fine, Scoles, and Mulligan (1975) used clinical rationale to develop a three-group classification typology for 1,500 DUI first offenders. The three groups were differentiated primarily by quantity, frequency, and circumstances of alcohol consumption.

Table 11. Percentages of drivers classified into three drinker categories by various classification methods

Scale	Social drinkers	Excessive drinkers	Problem drinkers
MF questionnaire	.62	.26	.12
MF interview	.71	.06	.22
Total MF	.64	.19	.17
CRIT[1]	.17	.29	.53
Presentence investigation	.52	.30	.18
Psychometrist	.46	.21	.33

* Combined criterion consisting of driver record and medical and social agency records.

Struckman (1975) grouped DUI offenders into four categories: social drinker, problem drinker, serious problem drinker, and chronic alcoholic. This drinker-type diagnosis was based on information from a number of sources, including driving record, criminal arrest record, Mortimer-Filkins test, and interviews. The reliability of this classification strategy was quite good, but no significant recidivism differences were found for control group subjects classified into drinker types.

Homel (1980) developed a typology based on biographic, demographic, driver record, and criminal record data. Homel hypothesized the existence of six operationally anchored groups of convicted DUI offenders: never-convicted-again drivers, minor motoring offenders, serious motoring offenders, dedicated drinking drivers, criminal offenders, and drive-disqualified offenders. The description of group differences based on measures such as marital status, age, occupational status, income, BAC, driver record entries, and response to penalties provided a logical characterization of subtypes within the DUI offender population. No attempt was made to substantiate the hypothesized typology statistically, either by comparison of mean differences for cases classified using this typology, or by cross-validation on an independent sample of DUI offenders.

Formal multivariate taxonomies. Only a small number of DUI-offender studies employing formal methods of factor and cluster analysis have been reported in the literature, and they are of relatively recent origin. Among the earliest was a study by Steer, Fine, and Scoles (1979). These authors applied a hierarchical cluster analysis technique to three indices of drinking status (BAC and quantity-frequency indices) and psychoneuroticism scores collected from 1,500 first and repeat DUI offenders. The analysis produced a number of types, but the resultant hierarchical structure was complex and difficult to interpret. The authors therefore resorted to a simpler procedure of forming 16 clusters from a binary mean split of the four measures ($2^4 = 16$). The seven most predominant subtypes, containing 87.6 percent of the cases, were found to differ significantly on several relevant external variables: ethnicity, number of prior DUIs, prior treatment for alcoholism, prior drug use, and father's alcohol use.

Scoles, Fine, and Steer (1984) classified 124 non-DUI high-risk drivers using the Sixteen Personality Factor Questionnaire (16PF). Through Modal Profile Analysis, 91.1 percent of the drivers were assigned to one of seven types, named on the basis of the largest high score trait: intelligent, shrewd impulsive, shrewd controlled, warmhearted resourceful, warmhearted adventurous, assertive, and resourceful. The authors concluded that the 124 high-risk drivers were easily able to distort their responses on the 16PF in a socially desirable fashion, and that the utility of the 16PF for assessing personality disturbance within the high-risk driver population must be questioned.

Donovan and Marlatt (1982) identified five subtypes through hierarchical cluster analysis of 17 driving-attitudinal, personality, and hostility measures from 172 DUI offenders. These five subtypes were externally validated through comparison on demographic, drinking, and driving-risk variables. Subtypes 2 and 5 were less deviant than the other three subtypes. Subtype 2, in addition to being the largest group, also presented the highest overall level of emotional adjustment. Subtype 2 members had the lowest levels of driving-related aggression, depression, sensation seeking, and overt and covert hostility. Subtype 5 members had slightly higher scores on these dimensions, but the remaining three subtypes expressed much more deviant levels of these risk-enhancing characteristics. Subtypes 1 and 4 were found to have particularly high levels of risk-enhancing traits (e.g., high levels of driving-related aggression and hostility, and low levels of assertiveness, perceived control, and emotional adjustment). The remaining subtype (subtype 3) was characterized by high levels of depression and resentment and low levels of assertiveness and emotional adjustment.

Donovan, Queisser, Umlauf, and Salzberg (1984) continued investigating these personality subtypes through analysis of subsequent 3-year driving records. Subtype membership was not a significant predictor of DUI recidivism or accidents. However, significant differences were found for other violation types.

Wells-Parker, Cosby, and Landrum (1985) used an inverse factor-analytic procedure (Q-mode factor analysis) to develop a typology of 353 DUI offenders who were referred to a probation and rehabilitation program in Mississippi. The variables used in the clustering consisted of 45 measures representing different types of traffic- and criminal-offense information available from driver and criminal record files.

The cluster analysis resulted in five subgroups that the authors characterized as follows: low (overall) offense group, mixed (offense) group, traffic (moving violations) group, public drunkenness group, and license offense (equipment and licensing violations) group. The classification accuracy of the cluster groups was verified through a multiple-discriminant-function procedure. Incorrectly classified individuals were moved to the group indicated by the discriminant function. There was an overall agreement of 84.4 percent between the two classification procedures.

The authors cross-tabulated the typology against several external measures and found statistically significant relationships on the majority of the comparisons. In most instances, the relationships were intuitively plausible. Of particular interest were relationships with BAC, Mortimer-Filkins scores, drinking status, and subsequent 24-month accident and DUI recidivism rates. The public drunkenness and license groups had the highest percentage of offenders with Mortimer-Filkins scores in the problem drinker range (24 percent versus 5 percent for all groups combined). The public drunkenness group also had the highest BAC levels, and by far the highest rate of subsequent accidents. The license group and public drunkenness groups had the highest DUI recidivism rates. The low offense, mixed, and traffic groups had comparatively lower proportions of problem drinkers, and lower rates of recidivism. The low offense and mixed groups also had the lowest accident rates, in contrast to the traffic group, which had the second highest accident rate of the five types. These three groups were substantially younger than the other two, and the traffic group was youngest of the five (mean = 33.1 versus 42.8 for groups 4 and 5 combined).

The authors compared the characteristics of their typologies with those of Steer, Fine, and Scoles (1979) and Donovan and Marlatt (1982). Although the resulting typologies reflect a number of dissimilarities, all three exhibited types that varied in terms of problem-drinker status (severity), age, and the extent to which the driving record reflects a general disregard for traffic laws (elevated moving violation and accident rates).

Sacramento DUI Offender Typology Study. Probably the largest multivariate typol-

ogy study of DUI offenders was that of Arstein-Kerslake and Peck (1985). The primary objectives of this study were to:

1. develop and cross-validate DUI offender typologies based on psychometric and nonpsychometric variables and

2. assess the extent to which DUI recidivism and DUI treatment-program compliance can be predicted from traffic safety, criminal record, demographic, and psychometric variables.

These analyses were performed on data from 7,316 DUI offenders initially collected during the operation of the California Driving Under the Influence (CDUI) project in Sacramento, California, from September 1977 through January 1981 (Reis 1982a,b). The Reis analyses focused on the question of the relative effectiveness of various randomly assigned countermeasures and did not address the data from classification or prediction perspectives.

Two sets of variables were used as scores in constructing first-offender, repeat-offender, and total sample typologies: the psychometric domain and the descriptive (nonpsychometric) domain.

The psychometric variables were:

Conforming compliance/acting-out aggressiveness

Extroversion/introversion

Sanguine, self-confident/anxious, depressed

Moralistic, conservative/nontraditional, unconstrained

Paranoid-suspicious/naive trust

Residential stability

Alcohol consumption/quantity-frequency

Alcohol problems

Physical health problems

Treatment receptiveness

Financial status, employment situation

Familial interaction, living situation

Social interaction and involvement

The descriptive variables were:

Age

Average BAC at arrest

Intake diagnosis — a clinical rating of drinking problem severities

Client attitude at intake

Average monthly income

Educational level

Marital status

Number of marriages

Number of dependants

Occupational socioeconomic status

Intake test score — standardized or modified Mortimer-Filkins test

Traffic conviction record — moving and nonmoving

Traffic accident record

Alcohol-related accidents and convictions

Criminal record entries

The psychometric variables are scales on the Life Activity Inventory (LAI) and were selected because their factorial structure and psychometric properties have been well-established (Reis 1982a, b). Both the psychometric and descriptive variables were standardized before performing the cluster analysis.

It should be noted that the descriptive domain variables were available for the entire sample, whereas the measures in the psychometric LAI domain were only obtained on the subsample of 2,889 assigned to followup interview conditions in the Reis study.

A K-means cluster program identified nine clusters from analysis of the psychometric variable domain. These DUI offender types were characterized on the basis of their average scores on both psychometric and nonpsychometric variables. Descriptions of the nine clusters follow.

- Negligent Operator (cluster 1): Members express behaviors commonly associated with negligent operators (youthfulness, acting-out aggressiveness, etc.). Levels of social interaction are high, and levels of residential stability and financial status are low. This group had the highest rate of alcohol-related and total accidents and the second highest rate of moving traffic violations. They also had the highest rate of drug arrests and the lowest rate of program compliance.

- Pre-DUI Alcoholic I (cluster 2): This has a strong, alcohol-related component, but not as extreme as cluster 3. This group had high level of mistrust, higher than average conservatism and depression, and high levels of aggressiveness. It also had a very high percentage of minorities (55 percent) and the highest rate of moving, nonmoving, and reckless driving convictions. The group was predominantly composed of first offenders (63 percent).

- DUI-Alcoholic (cluster 3): A number of measures indicate an extreme alcohol problem and a high traffic-safety risk. This group had the highest levels of anxiety-depression, and aggressiveness, and the highest quantity frequency index. It also had high levels of health problems.

- Pre-DUI Alcoholic II (cluster 4): This cluster is descriptively similar to cluster 2, although these two cluster groups do differ with respect to psychometric measures. Cluster 4 expressed high levels of introversion and isolation and high levels of lack of constraint.

- "Mid-Life Crisis" Problem Drinker (cluster 5): Members report high levels of stress in interpersonal relationships, high levels of physical health problems, high unemployment, and high average age. A relatively large number perceived alcohol as a problem in their lives despite having the lowest Q-F index.

- Deceptive Problem Drinker (cluster 6): Levels of socially desirable attributes were surprisingly high, and levels of improbable response were very high as measured by the "lie" scale.

- White-Collar Controlled Problem Drinker (cluster 7): A relatively high percentage of persons employed in white collar occupations appear to be controlling their drinking and pose a relatively low traffic safety risk. This cluster exhibited high levels of conforming-compliance, self-confidence, and trust, and a comparatively low Q-F index.

- Blue Collar Controlled Problem Drinker (cluster 8): Members possess attributes similar to cluster 7, except for their generally lower level of socioeconomic status.

- Social-Normative Problem Drinker (cluster 9): Age distribution is similar to clusters 2 and 4, but cluster 9 members express much higher levels of

socioeconomic status and socially desirable attributes. It may well be that these persons tend to consume excessive amounts of alcohol in settings in which such behavior may not be considered deviant (i.e., socially normative).

Statistically significant differences in subsequent 4-year accident rate, traffic conviction rate, and DUI recidivism were found among the nine psychometric clusters.

A separate K-means cluster analysis was performed on nonpsychometric variables (driver record, criminal record, and intake interview). Descriptions of the 10 clusters follow:

- Cluster 1: Lowest average age (22.0 years); lowest average BAC at arrest; one-fourth without high school diploma; high percentage of males (92 percent); relatively low percentage of persons married or cohabitating; highest number of moving and nonmoving violations; 67 percent first offenders.

- Cluster 2: Average age 24.0 years; relatively high levels of educational attainment and white collar employment; lowest average income; average levels of acting-out aggressiveness; exclusively unmarried; 82 percent male; 74 percent first offenders.

- Cluster 3: Average age 24.2 years; one-fourth without high school diploma; 91 percent male; highest average score on accident composite measure and drug-alcohol composite measure; high levels of alcohol problems and treatment receptivity; 58 percent multiple offenders.

- Cluster 4: Average age 30.4 years; highest percentage of females (32 percent); no never-marrieds; 78 percent either separated, divorced, or widowed; highest percentage of first offenders (78 percent).

- Cluster 5: Average age 33.2 years; smallest descriptive cluster; above-average incidence of accident and convictions; high percentage of minorities (36 percent); very high levels of hostility and suspicion as judged by diagnostic counselor; 56 percent first offenders.

- Cluster 6: Average age 34.6 years; above average income; high percentage of blue-collar workers; highest number of dependents; highest percentage currently married (84 percent); highest percentage of minority members (37 percent); 61 percent first offenders.

- Cluster 7: Average age 35.1 years; above-average incidence of accident and convictions; very high levels of criminal record entries; contains all persons who refused the BAC test associated with entry arrest (approximately 50 percent of cluster 7 members); highest proportion unemployed (42 percent); largest descriptive cluster; 59 percent multiple offenders.

- Cluster 8: Average age 35.7 years; very high score on alcohol problem severity on psychometric inventory administered at intake (refers to standardized score on Mortimer-Filkins or CDUI scale—both tests were used at different times during the operation of the CDUI project); high levels of acting-out aggressiveness and depression; high levels of perceived alcohol problems and physical health problems; high levels of treatment receptivity; lowest level of satisfaction in marriage or marriagelike relationship; highest percentage of multiple offenders (71 percent).

- Cluster 9: Average age 38.6 years; highest occupational status (83 percent white-collar—professional/technical, management/administration, sales); high levels of educational attainment (41 percent 4 or more years of college); high levels of marital stability and familial and social interaction; low levels of acting-out aggressiveness; 62 percent first offenders.

- Cluster 10: Average age 53.0 years; no members under 30 years old; 95 percent of members over 40 years old; relatively high unemployment (39 percent);

relatively low average income; lowest levels of educational attainment (49 percent with fewer than 12 years education); high percentage of females (24 percent) and minorities (30 percent); 50 percent married more than once; 46 percent currently divorced or widowed; lowest levels of acting-out aggressiveness; high levels of introversion and physical health problems; low levels of familial and social interaction; 64 percent multiple offenders.

Comparisons of the descriptive clusters on subsequent 4-year driver record indicated statistically significant differences in fatal accident rates, accidents involving alcohol, moving traffic convictions, and DUI recidivism. Clusters 1, 3, 5, and 7 tended to have the poorest records, whereas cluster 9 consistently had the lowest number of driver record entries.

Both the psychometric and descriptive (nonpsychometric) solutions were cross-validated using a 25-percent subsample not used during the information of the cluster solution. In addition, the cluster solutions were submitted to discriminant function analysis. In each case, differences among clusters based on relevant clustering variables were substantial, resulting in 89.9 percent correct classification for members of the psychometric cross-validation subsample and 67.6 percent correct classification for members of the descriptive cross-validation subsample. For the psychometric cluster solution, 86.8 percent of the variance in cluster membership was explained by five discriminant functions. For the descriptive cluster solution, five functions accounted for 80.2 percent of the variance in cluster membership.

Since Arstein-Kerslake and Peck performed separate cluster analyses within each domain, the resultant typologies did not constitute a single integrated system. They were able, however, to investigate the structural relationship between the two by cross tabulating the two systems. The end product of this analysis was a contingency table showing how membership in the psychometric domain clusters were distributed across each category of the descriptive variable typology. The results are summarized in table 12.

Although the relationship between the two typologies was significant, the association was quite low (Cramer's $v = 0.22$, $p < 0.001$). Thus, the two systems are much more independent than they are overlapping.

It would be possible to view table 12 as a two-dimensional taxonomic system if one of the dimensions can be viewed as subordinate to the other. For example, if one considers the psychometric typology to have logical precedence over the descriptive taxonomy, then one could view the groups of the former as types and those of the latter as subtypes. To illustrate from table 12, consider the DUI alcoholic type (type 3). We find that 64 percent of this group "maps" into descriptive subtypes 7 and 8. Hence, these combinations could be numerically coded as 3.7 and 3.8. Both subtypes 7 and 8 clearly reflect serious alcohol problems and the psychosocial manifestation of alcoholism. Therefore, they corroborate the psychometric taxonomy (DUI alcoholic) but provide some additional differentiation. Subtype 7 manifests more antisocial traits (criminal record), resistance to authority (implied consent chemical test refusal), bad driving record (accidents, moving violations, prior DUIs), and high unemployment. Subtype 8 appears to have the most acute alcohol problem but the members appear more receptive to treatment and to be aware of their problems.

Arstein-Kerslake and Peck point out that the clusters vary greatly in terms of their similarity/dissimilarity and that many of the clusters would not be fixed in time. Intuitively, one would expect flux with persons changing clusters as they age and experience deterioration or improvement in their drinking status and its relation to driving. For example, it is known that some young people pass through a period of excessive drinking and use of alcohol in conjunction with driving. Such people might not be labeled social drinkers, even though many will eventually leave the drinking-driver population and never progress to alcoholism. A longitudinal repeated-measures factorial study would be required to validate the hypothesized transitions empirically .

Table 12. Cross tabulations of correspondence between psychometric cluster membership and descriptive cluster membership

Count Row percent Column percent	Psychometric clusters									Row total
	1	2	3	4	5	6	7	8	9	
1	37	25	10	27	3	21	9	6	39	177
	20.9	14.1	5.6	15.3	1.7	11.9	5.1	3.4	22.0	1.1
	10.6	13.7	3.2	7.2	1.4	5.4	2.6	2.4	8.5	
2	86	29	21	74	16	54	8	3	115	406
	21.2	7.1	5.2	18.2	3.9	13.3	2.0	0.7	28.3	14.1
	24.7	15.8	6.7	19.7	7.3	13.8	2.3	1.2	25.2	
3	48	9	26	47	14	13	14	8	39	218
	22.0	4.1	11.9	21.6	6.4	6.0	6.4	3.7	17.9	7.5
	13.8	4.9	8.3	12.5	6.4	3.3	4.0	3.2	8.5	
4	39	25	16	41	19	57	20	11	76	304
	12.8	8.2	5.3	13.5	6.3	18.8	6.6	3.6	25.0	10.5
	11.2	13.7	5.1	10.9	8.6	14.5	5.7	4.4	16.6	
5	9	7	5	13	8	9	13	7	13	84
	10.7	8.3	6.0	15.5	9.5	10.7	15.5	8.3	15.5	2.9
	2.6	3.8	1.6	3.5	3.6	2.3	3.7	2.8	2.8	
6	9	9	15	12	8	39	85	63	9	249
	3.6	3.6	6.0	4.8	3.2	15.7	34.1	25.3	3.6	8.6
	2.6	4.9	4.8	3.2	3.6	9.9	24.4	25.3	2.0	
7	96	45	111	94	77	95	71	65	81	735
	13.1	6.1	15.1	12.8	10.5	12.9	9.7	8.8	11.0	25.5
	27.6	24.6	35.2	25.1	35.0	24.2	20.3	26.1	17.7	
8	16	18	89	19	28	5	20	36	23	254
	6.3	7.1	35.0	7.5	11.0	2.0	7.9	14.2	9.1	8.8
	4.6	9.8	28.3	5.1	12.7	1.8	5.7	14.5	5.0	
9	2	3	15	14	4	42	100	29	49	259
	1.2	1.2	5.8	5.4	1.5	16.2	38.6	11.2	18.9	9.0
	0.9	1.6	4.8	3.7	1.8	10.7	28.7	11.6	10.7	
10	5	13	7	34	43	57	9	21	13	202
	2.5	6.4	3.5	16.8	21.3	28.2	4.5	10.4	6.4	7.0
	1.4	7.1	2.2	9.1	19.5	14.5	2.6	8.4	2.8	
Column total	348	183	315	375	220	392	349	249	457	2,888
	12.0	6.3	10.9	13.0	7.6	13.6	12.1	8.6	15.8	100.0

Chi-square = 1162.3 with 72 df. significance = 0.0000
Eta (descriptive cluster dependent) = 0.35
Cramer's lambda = 0.22

It is instructive to note that Arstein-Kerslake and Peck failed to uncover any group labeled social drinkers. The following quotation illustrates their reasoning.

> "Hapless social drinker" does not constitute a sizeable enough portion of the DUI offender population to be identified as a separate subtype. In an intuitive sense, there are three dimensions which seem to characterize the differences between the nine psychometric clusters: (1) consumption of alcohol (moderate to excessive), (2) problem drinker predisposition (transient to chronic), and (3) negligent operator characteristics (none too many). Different weightings on these dimensions for each cluster contribute to the differential accident/conviction levels among clusters. Even those clusters with low accident/conviction levels (e.g., very low negligent operator characteristics) have high enough levels on other dimensions (e.g., problem drinker predisposition) to preclude their being classified as "social drinkers."

The above conclusion requires clarification and tempering. Each cluster is really an aggregation of people into averages, and some of the clusters imply relatively moderate levels of alcohol consumption. Individual variation may be substantial within groups and latent subtypes that were too small in number to emerge as a distinct type. Obviously some of those among convicted DUI offenders could be characterized as social drinkers. However, as Stewart., Epstein, Gruenewald, Laurence, and Roth (1987) point out, the very term "social drinker" is imprecise and of dubious scientific value. It can be more meaningful to talk about the amount, frequency, and pattern of alcohol consumption, and about points on this continuum where problems are likely to occur.

Discussions and Conclusions

The preceding review of the literature on DUI offender characteristics indicates that convicted offenders differ from the general driving population on a wide range of variables. Although they share some of the same characteristics as problem (negligent) drivers, alcohol-involved accident drivers, and alcoholics, the overlaps are not large with any of the three in an absolute statistical sense. The convicted DUI offender represents a combination of the traits of all three, plus a substantial amount of unique DUI-offender characteristics.

The research on multivariate typologies and other taxonomic systems indicates that the DUI-offender population contains some distinct subgroups, or types, and there is some consistency across studies in the structure of the taxonomies and the subgroups resulting from them. These classification systems may be useful in providing insight concerning etiology of problem drinking (driving) and in suggesting potentially effective modes of treatment.

The concept of the impaired problem driver has merit and is consistent with some of the typologies described above. To a limited extent, DUI recidivism can be predicted, and the characteristics of recidivists clearly indicate a profile of persons with progressively increasing drinking problems and negligent-driving problems. Nevertheless, the results of Arstein-Kerslake and Peck (1985) suggest that the majority of first offenders are statistically indistinguishable from repeat offenders and represent equally high accident risks. This finding suggests that most first offenders are problem-drinker drivers who have simply not yet had their second DUI offense.

Current Issues and Problems

The major problems and questions in this area are identified and briefly discussed in this section. Extensive discussion of these topics is unnecessary since they follow immediately from the literature review presented above. In addition to the major headings

used in the literature review, a subsection focused on the data management aspects of the problem is included below.

Alcohol Involvement in Crashes

The most fundamental problem in establishing alcohol involvement in highway crashes stems from the incomplete testing and reporting of BAC data. Enormous progress has been made during the past decade in obtaining BAC data from fatal crashes through FARS, by means of which the States are expected to report all relevant information to NHTSA. Although a few States report BAC data for all fatal crashes within their borders and approximately one-third of the States report the BAC in at least 85 percent of their fatal crashes, most States fall far short of acceptable reporting standards for this crucial bit of information from each fatal crash. Overall, BAC data are now reported to FARS for 74 percent of fatally injured drivers, but for only 45 percent of the surviving drivers involved in fatal crashes. Thus, the shortfall of data for this latter category of driver represents another major problem.

Far fewer BAC data are available for surviving drivers injured in highway crashes, primarily because American hospitals generally will not release such information. Consequently, estimates of the legally impaired drivers injured in highway crashes range from 20 percent to 40 percent, with the best estimate being around 25 percent. This question is currently being addressed in Ontario, Canada, in a research project funded by NIAAA (principal investigator: Evelyn Vingilis).

Data on BAC are especially scarce for crashes with property damage only, i.e., those collisions involving reportable damage to property but none to humans. Although these crashes are of less importance for epidemiologic research than the two previous categories involving human injury, it would nevertheless be useful to obtain BAC data across the full continuum of reportable crashes for the sake of fully explicating the relation of alcohol amount to the relative seriousness of the crash.

Alcohol and Noncrash Drivers

The traffic safety community is experiencing a shortfall of up-to-date information concerning the population-at-risk, i.e., drivers who are not involved in crashes. Although BAC data are the most important, it is also necessary to obtain additional information concerning age, gender, purpose of trip, perceived risk of being stopped at an enforcement checkpoint, perceived risk of being arrested for drunk driving, and so forth. Such data are crucial for evaluating the progress and current status of both public health and public safety programs. As noted above, NIAAA is currently supporting a research project focused on alcohol tolerance among drinking drivers that is obtaining substantial information about the nocturnal population at risk (principal investigator: M.W. Perrine). Data from this 5-year roadside survey of 42,000 drivers will be reported as obtained over the course of the next 4 years of field activity.

Characteristics of Drunk Drivers

The present state of research knowledge already permits differentiation within the category of drunk driver. Indeed, recent research provides for an increasing number of differentiations not only among drunk drivers, but also among drinking drivers, as described by Perrine (1987). However, further increases, refinements, and validations of such differentiations among drinking drivers are necessary in order to address the major problems in this area more effectively. The specific shorter term goals for such efforts should be:

- early identification of potential DUI offenders through increased differentiation among drinking drivers,

- more accurately targeted sanctions for convicted DUI offenders,

- more accurately individualized referrals of DUI offenders from the courts to selected treatment programs available in the locality,

- more individually customized counseling and treatment programs for DUI offenders,

- increased success rates in terms of alcohol treatment program compliance and completion, and

- lower recidivism rates.

Although these goals are focused initially on specific deterrence and the convicted DUI offender, the broad longer term goals involve aspects of both general deterrence and public education (Perrine 1987).

The NIAAA is currently supporting a research program designed to address the above goals through grants concerned with the probabilities of drunk driving among the U.S. public and among convicted DUIs (AA06774 and AA06926, principal investigator: M.W. Perrine). This research program is based upon 15 concurrent, interrelated projects that focus on five different but interdependent segments of the American drinking and driving public: the general driving population, the nocturnal driving population, the convicted DUI first-offender population, the convicted DUI multiple-offender population, and those arrested for DUI, but not convicted. The basic rationale for this approach derives from analyzing the known characteristics of those in these interrelated populations to determine the similarities among those who "get into trouble with alcohol," as well as the differences between those who do and those who do not (Perrine 1987). The results of this ongoing research program should enable developing much more specific — and thus much more effective — means for prevention and intervention in this major public health problem area.

Data Sources and Management

Much epidemiologic research on drunk driving (as in many other areas) depends on data collected by third parties and available in the form of official records. Thus, the adequacy, utility, and validity of such research are seriously constrained by the accuracy and completeness of the data themselves, as well as by the data collecting and data reporting. The systems for DUI processing (from the point of arrest through the monitoring of adherence to the imposed sanctions) vary greatly from State to State, but apparently all such systems are prone to loopholes and failures. Indeed, it is necessary to analyze the individual State DUI processing systems carefully, not only to understand their functioning, but especially to identify points for dropouts and other failures. Only by so doing can the accuracy and completeness of the resulting DUI data be assessed.

An extensive evaluation of the drunk-driving countermeasure system in the State of California has recently been completed, funded by the NHTSA. The first of the eight-volume series is concerned with an analysis of DUI processing from arrest through postconviction countermeasures (Perrine 1984). The objectives of the project were to develop process flow charts and a description for the whole DUI system, as well as to identify sources of system inefficiency or modes of circumvention of specific provisions of the laws and the system. The interorganizational task force formed to accomplish these objectives represented all major constituencies in the DUI countermeasure system: law enforcement agencies; prosecutors; municipal, superior, and juvenile courts; program/service providers; State and county alcohol-program administrators; probation officers; and the Department of Motor Vehicles (DMV).

A subsequent study was conducted to identify deficiencies in the California DUI countermeasure system and to evaluate empirically the frequency with which DUI offenders avoid timely processing or circumvent system countermeasures owing to these

deficiencies (Helander 1986). To accomplish these objectives, a sample of DUI offenders was tracked all the way through the system in order to describe and analyze the flow of the system.

A total of 3,959 DUI offenders arrested by 44 law enforcement agencies in seven sample counties was tracked through the DUI system from the point of arrest through postconviction countermeasures. A separate sample of 701 convicted DUI offenders referred to alcohol education/treatment programs in the seven sample counties was identified from program provider records and tracked through DMV, court, and program records. The principal results were:

- Probability of conviction for a DUI offender varied widely, depending on the county and court in which the offense was adjudicated. The use of sanctions also varied widely by county and court.

- Most alcohol education/treatment program dropouts were not reported to the DMV by the courts, and a substantial percentage of DUI offenders avoided license suspension as a result.

- Nine percent of drivers arrested for DUI were under license suspension or revocation at the time of arrest. Only 20 percent of these drivers were convicted for the offense of driving while license was suspended or revoked.

- A surprisingly large percentage of DUI offenders was unlicensed or had more than one driver record, that is, they had multiple licenses under different names or errors in the files (e.g., wrong name or date of birth) created additional records that were not charged to the driver.[1]

Based on the study findings, Helander (1986) concluded that:

- The probability of punishment for DUI offenses must be increased in order to produce any large-scale impact on the problem of drinking and driving.

- The citation and conviction rates of those who drive while suspended or revoked must be improved if license suspension is to remain an effective and credible traffic safety countermeasure.

- If the DUI countermeasure system is to function as a true system, goals and objectives must be developed along with a management information system to assess the achievement of those goals and objectives.

- Improvement is needed in the accuracy of records in the DUI countermeasure system.

The final volume in this series evaluating the California drunk driving countermeasure system consists of an overview of study findings and policy recommendations prepared by Peck (1987). Among many other important findings, Peck emphasized the need to improve the management information system and monitor its quality control through periodic process evaluations. For example, it is necessary to monitor:

- time lags in the processing system;

- characteristics of the plea bargaining process, as well the plea bargaining rate;

- the rate of dismissal of prior DUI convictions;

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1   In California, all traffic convictions for moving traffic violations and for major violations, such as drunk driving, are reported to the DVM and placed on the driver's driving record file. The driving record also includes fatal and injury accidents and property damage accidents involving more than $50 to a vehicle. The driver record entries are retained from 3 to 10 years, depending on the nature of the offense. Other States have similar file systems, although the specific provisions and retention periods will vary from State to State.

- the rate of compliance with imposed sanctions;
- the rate of completing the sanctions (especially the treatment/education programs);
- the incidence of jury trials; and
- the incidence of implied consent refusals to submit to a breathtest.

Some of the more serious shortfalls identified in the data system are (Peck 1987):

- accurate reporting of the BAC at the time of arrest;
- accurate determination of the offense status (whether a first, second, third, or more DUI offense);
- determining whether a jail sentence was imposed, but more important, determining whether it was actually served to completion;
- determining whether community services were actually performed
- determining positively through affirmative evidence that the alcohol treatment program had actually been completed by the DUI offender.

Research Questions

In 1987, as part of a continuing effort by NIAAA to assess research opportunities and needs in the field, a series of meetings focused on issues in alcohol research on safety and trauma. A series of papers provided solicited advice on extramural research priorities (these papers are published in a special issue of *Contemporary Drug Problems*, Spring 1988). In addressing the research issues, needs, and opportunities in the area of alcohol, trauma, and traffic safety, Perrine (1988) formulated a number of specific questions that should be addressed through epidemiologic and field studies. These questions are also appropriate to consider in the present context.

- How frequently does driving actually occur after drinking among the U.S. motoring public?
- How firm is the linkage between social drinking activities and subsequent driving activities?
- Why are some drivers involved in crashes after drinking, whereas others are not — even at the same BACs?
- To what extent do fatally injured drivers with high BACs differ from other high BAC drivers who crash but are not fatally injured, or are not injured at all, or who are not even involved in a crash?
- To what extent is alcohol involved in crashes, and to what extent is alcohol responsible for crashes?

A number of research questions and issues were also formulated concerning idiosyncratic characteristics of drinking drivers (Perrine 1988), namely;

- What characteristics can be identified to distinguish among the various groups/types of individuals across the spectrum of drinking drivers?
- To what extent is it possible to differentiate drinking drivers who avoid detection, accidents, and conviction of DUI from drinking drivers who are arrested and convicted of DUI?
- To what extent is it possible to identify future DUI offenders in advance, that is, before the fact? At what point or stage of development is such identification possible?
- To what extent is it possible to identify potential DUI reoffenders or recidivists in advance, for example, after the first DUI offense but before the second? At what point or stage of development is such identification possible?

- To what extent do such advance indicators of DUI consist of stable, persistent characteristics, as opposed to more temporary and transitional aspects? In other words, to what extent does a person have a "predisposition"-to become a DUI offender?

- To what extent do factors other than alcohol contribute to high-risk drinking and driving and ultimately to alcohol-involved crashes?

- Is a drinking driver a potential DUI offender when actually alcohol-impaired, or simply when the BAC is 0.10 or higher?

These questions may prove valuable in designing new research projects to investigate further the role of alcohol and traffic safety.

Recommendations

A number of recommendations emerge clearly from the foregoing literature review and examination of current issues and problems. The most important of these recommendations are listed below without further comment.

- Develop policies and procedures to ensure that uniform and consistent alcohol data are obtained for all highway crashes.

- Develop policies and procedures to ensure that accurate alcohol data are obtained for commercial motor-vehicle operators using the highways.

- Determine feasibility of gathering accurate data on drivers under 0.10 BAC at enforcement checkpoints.

- Develop more effective roadside survey policies and techniques to collect increasingly valid data on drunk driving (e.g., incidence and prevalence, changes in distribution of alcohol concentration).

- Develop a central monitoring, record keeping, and reporting capability for drunk driving data.

- Develop and test a valid, cost-effective surrogate for roadside surveys in order to evaluate countermeasure programs and to monitor public awareness and perception of risk.

- Determine more accurately the characteristics of drunk drivers to facilitate early identification and counseling, to encourage more accurately targeted sanctions for convicted DUI offenders, to encourage more customized counseling and treatment programs for DUI offenders, and thereby, it is hoped, to obtain increased success rates in terms of alcohol treatment compliance and completion, as well as lower recidivism rates.

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