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ABSTRACT

This paper reviews the research literature on the relationship of drugs, alcohol, and driving among young people, university students, and a group of young criminals. The data show that young people use drugs more than adults do, and that they drive under the influence of drugs or alcohol, especially at night, more often than adults do, and consequently young people are more vulnerable to accidents due to drug use than are adults. The writer then considers possible countermeasures against drinking and driving such as limitations on drinking by young people, the amount of permissable liquor consumption, and limitations on driving such as forcing speed limits during certain periods of the day. The writer concludes that few countermeasures have demonstrated their effectiveness; nevertheless, he argues that it is essential that more effort be placed on the development of effective countermeasure programs and that those programs in existence be more effectively evaluated. (Author/SE)

alcohol, drugs and young drivers

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National Highway Traffic Safety Administration

ALCOHOL, DRUGS AND YOUNG DRIVERS*

by

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PREFACE

This report was written as part of an Organization for Economic Cooperation and Development (OECD) Research Study on Accidents Involving Young Drivers. OECD Research Group S-8 was established in 1972 to review the literature on young driver research, report on any new research in the young driver area, formulate a position paper on the young driver problem, and make recommendations for countermeasures and research to the OECD countries.

The author of this report, as United States Representative to a Cooperating OECD Research Group on Alcohol and Drugs in Relation to Highway Safety, prepared a chapter of the position paper dealing with alcohol and drugs as related to the young driver problem. Other OECD representatives from other countries were responsible for other significant areas of the young driver problem. The individual chapters have been completed by the Research Group and the position paper is structured as follows:

RESEARCH ON ACCIDENTS INVOLVING YOUNG DRIVERS

Chapter 1: The Young Driver Problem
Chapter 2: Exposure and Experience
Chapter 3: Driver Training
Chapter 4: Personality, Attitudes and Other Personal Characteristics
Chapter 5: Alcohol and Drugs
Chapter 6: Type and Condition of Vehicle
Chapter 7: Accident Data Collection, Analysis and Findings
Chapter 8: Conclusions and Recommendations

The entire position paper has been published by OECD.

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Introduction

Driving an automobile is a highly complex, psychomotor, and perceptual task which is, therefore, subject to impairment by any factor which significantly alters the physiological or psychological state of the organism. Whether such disruption occurs depends upon the extent of the psychological and/or physiological change produced by the drug and the extent to which the individual attempts to compensate in his driving for that effect.

Youth is a period at which physical skills tend to reach their peak. However, emotional reactivity is greater than in the adult and the ability to compensate for psychological and emotional changes is more limited because of the lack of experience. Because of the relative lack of driving experience and emotional lability, the use of psychotropic drugs would be expected to have a particularly significant impact upon young drivers. This would appear to be all the more probable because in most cultures the young are experimenting more actively with drugs. Because these expectancies are so logical, it is important that they be recognized by the scientist approaching this problem so that he can avoid becoming a victim of preconceived assumptions and ensure that all hypotheses are tested carefully before being accepted.

I. Classification of Drugs Including Alcohol

Classification of the agents to be considered under the heading of drugs is open to considerable controversy. A review of the studies of drugs and driving indicates that individual investigators vary widely in the substances with which they have concerned themselves. Pharmacologically a drug can be considered any chemical substance which causes a change in function or structure of a living organism. Such a definition, however, would include all foodstuffs and is too broad to be useful in the present context. A more useful definition for the present purposes is the one proposed by Neal (40),* "Any substance administered to a person by a physician, or by the patient himself in hopes of achieving a better physiological state." If we add to this the words "and psychological state" we are closer to the definition commonly accepted by the public.

Such a definition still encompasses many thousands of substances. A list of the major drugs of concern, sometimes classified as "psychotropic" drugs is provided in Figure 1. The agents listed are the primary substances which are capable of producing a drug dependence. This dependence may be either physiological or psychological. Indeed, in many cases it is difficult to determine which type of drug dependence may be operating in a particular situation. To the public, alcohol

* Numbers in parentheses refer to references in the bibliography on page 51.

Narcotics	Sedative Hypnotics	Volatile Intoxicants	Stimulants	Hallucinogens	Miscellaneous
Opiates	Barbiturates	Anesthetics	Sympathomimetic amines	Tryptamine group	Nicotine
morphine	pentobarbital (Nembutal®)	ether	amphetamine (Benzedrine®)	lysergic acid diethylamide (LSD 25)	
heroin	secobarbital (Seconal®)	nitrous oxide	dextroamphetamine (Dexedrine®)	harmine (Caapi)	
hydromorphone (Dilaudid®)	amobarbital (Amytal®)		methamphetamine (Methedrine®)	dimethyltryptamine (DMT)	
oxymorphone (Numorphan®)	butabarbital (Butisol®)	Solvents	phenmetrazine (Preludin®)	psilocin	
codeine		paint thinner		psilocybin	
dihydrocodeine		gasoline			
hydrocodone (Dicodid®, Hycodan®)		other petroleum distillates			
oxycodone (Percodan®)	Nonbarbiturates	toluene	Cocaine	Phenylethylamines	
	glutethimide (Doriden®)	acetone and other ketones	Caffeine	mescaline (peyote)	
Synthetic narcotic analgesics	ethinamate (Valmid®)	aliphatic acetates			
meperidine (Demerol®)	ethchlorvynol (Placidyl®)	carbon tetrachloride		Anticholinergics	
anileridine (Leritine®, Apodol®)	methyprylon (Noludar®)	other chlorinated and fluorinated hydrocarbons		atropine	
piminodine (Alvodine®)	chloral hydrate	airplane glue, etc		scopolamine	
alphaprodine (Nisentil®)	paraldehyde				
methadone (Dolophine®)	meprobamate (Miltown®)			Miscellaneous	
dextropropoxyphene (Darvon®)	chlordiazepoxide (Librium®)			cannabis tetrahydrocannabinol (marihuana, hashish, charas, bhang, kif)	
levorphanol (Levo Dromoran®)	Alcohol				
phenazocine (Prinadol®)					

Figure 1. Representative Agents Capable of Producing Drug Dependence

is quite distinct from substances they would classify under the term "drugs." However, it exemplifies all the characteristics of the other substances shown in Figure 1 in terms of its psychological effects and its ability to produce drug dependence.

Being the most widely used and, therefore, the most widely studied drug, much of our knowledge and many of our hypotheses about the effects of drugs on driving behavior are derived from studies of alcohol.

II. Patterns of Alcohol and Drug Consumption by Young Drivers

A recent comprehensive study has been conducted of drug use in the United States by the National Commission on Marihuana and Drug Abuse (39). This report, entitled "Drug Use in America: Problem in Perspective," was issued in March 1973 and contains survey data on the major types of drugs used by various segments of the U.S. society. Figures 2 and 3 summarize the relative level of drug use for young Americans. The first figure provides the percentage of high school students who have ever used drugs. The second figure provides the same data for college students.

The high school years in the United States normally span the late teen period from age 15 to 18. For most young people driving begins between ages 16 and 18. This corresponds to the second year or the third year in high school. The driver education courses which prepare these young drivers are normally provided in the second year of high school. The college period embraces the ages 19-22.

As can be seen from these two figures, alcohol and tobacco are by far the most widely used drugs. However, the use of marihuana has been growing rapidly over the last five years to the point where currently half of the college students have at least tried marihuana once. Prescription and proprietary drugs and particularly illicit drugs are used by a much smaller proportion of young people in America. Of these stimulants the amphetamines appear to be the most frequently consumed, as might be expected since they are probably used frequently for maintaining alertness during late night study efforts, as well as for emotional stimulation.

Drug	Mean Percentage					
	1967	1968	1969	1970	1971	1972
Tobacco	50	34	61	49	45	66
Alcohol	62	47	39	65	72	74
Marihuana	15	23	23	23	25	40
Inhalants	4	5	11	8	7	9
Hallucinogens	6	9	6	7	8	14
Stimulants	4	10	14	12	11	19
Depressants	3	4	13	12	10	16
Opiates	04	17	33	33	4	52

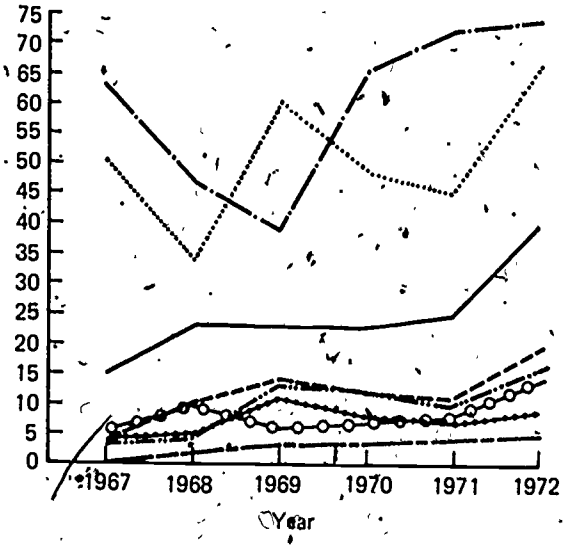


Figure 2. Mean Percentage of Senior High School Students Who Have Used Drugs (Ever Used) by Type and Year of Survey (39, p. 82)

Alcohol

The use of alcohol begins early in American culture and grows rapidly through the early teens

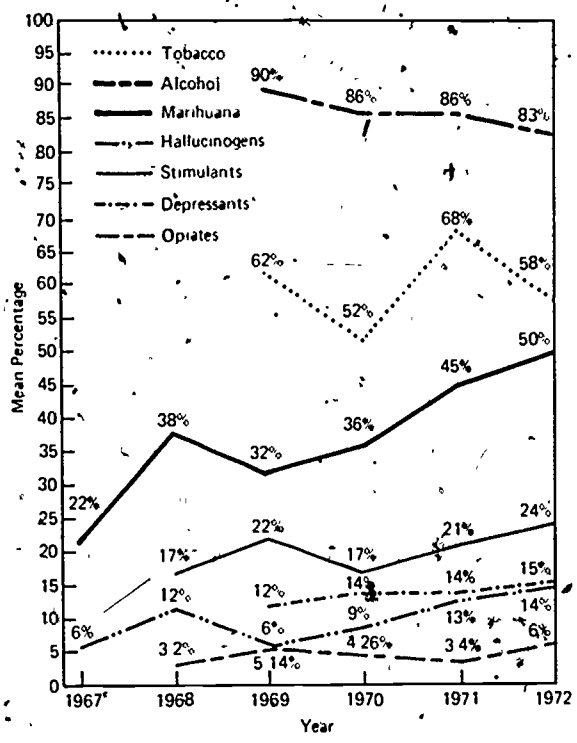


Figure 3. Mean Percentage of College Students Who Have Used Drugs (Ever Used) by Type and Year of Survey (39, p. 83)

as shown by Figure 4 (39). Some 16 percent of 12 to 13 year olds admit to using alcohol. This proportion grows to 35 percent by age 16 to 17, which is also the period when driving is normally initiated. By the period 18 to 21 it has grown to 65 percent. By age 21 the proportion of young people who are drinking has reached approximately its maximum level. It remains at that level through the mid-forties and drops off slowly in the fifties.

Tobacco

Tobacco demonstrates a growth pattern through the early teenage years quite similar to the use of alcohol, Figure 5 (39). By the late teens and early twenties, the proportion using tobacco is as large as for any age group and it drops off beyond that point. There is considerable correlation between the use of tobacco and the use of alcohol. These two drugs, which have traditionally been widely used in American culture, tend to be used by the same groups.

Psychoactive Drugs

The use of psychoactive drugs by young Americans is shown in Figure 6 (39). The use of both ethicals (prescribed drugs) and proprietaries (over-the-counter) drugs increases rapidly through the teenage years. It peaks in the young adulthood period between 22 and 25. Included in this survey are sedatives, tranquilizers, and stimulants. It is clear that a relatively large proportion of the young driver population is making use of these psychoactive drugs, at least occasionally. The vast majority of this use is through legal channels. The illicit use of the proprietary and ethical sedatives, tranquilizers, and stimulants is limited to seven percent or less among both youth and adults (39, p63). It should also be noted that, as shown in Figure 8 (39), young people are more likely to use ethical drugs for non-medical reasons such as "to help get along with the family," "to help get ready for some big or important event;" "to help enjoy myself more with other people;" and other reasons indicating a psychological need or dependence.

Age	% of Drinkers
[redacted]	16
	21
16 - 17	35
18 - 21	65
22 - 25	66
26 - 34	62
35 - 49	57
50 +	39

Figure 4. Age and Alcohol Use (39, p. 48)

Age	% of Smokers
12 - 13	4
14 - 15	16
16 - 17	32
18 - 21	42
22 - 25	47
26 - 34	48
35 - 49	44
50 +	25

Figure 5. Age and Incidence of Smoking (39, p. 46)

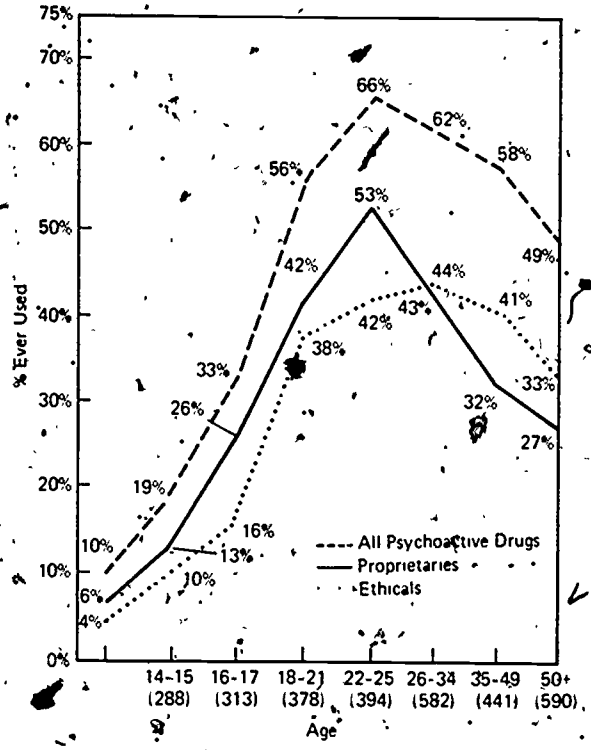


Figure 6. Age Distribution of Those Ever Having Used Psychoactive Drugs (39, p. 49)

Marihuana

Figure 7 (39) gives the percent of each age group having experience with the use of marihuana. As with the substances previously discussed, the use of this drug grows rapidly through the teenage period. The period of peak use appears to occur somewhat earlier than for alcohol or the psychotropic drugs, falling into the 18 to 21 age group.

Age	% of Marihuana Users
12 - 13	4
14 - 15	10
16 - 17	29
18 - 21	55
22 - 25	40
26 - 34	20
35 - 49	6
50 +	2

Figure 7. Age and Incidence of Use of Marihuana, 1972 Survey (39, p. 65)

Age	Sedatives	Tranquilizers	Stimulants
18 - 21	12	7	14
22 - 25	9	7	9
26 - 34	2	6	5
35 - 49	2	6	3
50 +	2	4	1

Figure 8. Percentage by Age Who Use Ethical Drugs for Non-Medical Reasons (39, p. 59)

Multiple Drug Use

In the use of ethical drugs young people are more likely than their elders to be multiple users as shown in Figure 9 (39). There is also an association between illicit drug use and use of alcohol and tobacco in both youth and adults.

The Commission on Marihuana and Drug Abuse summarizes its discussion of multidrug use by indicating that "Youth and adults who try and use LSD, cocaine, or heroin are most likely to be found in the group of persons who regularly smoke cigarettes, or are regular consumers of alcohol (used within the last week), have some experience with marihuana, and use ethical psychoactive drugs (and alcohol) for self-defined non-medical purposes, such as coping with stress," (39, p70).

Summary

The picture which emerges from these data is that the late teenage and early adult period, which encompasses the first eight or nine years of driving experience for most Americans, is a period when the use of drugs of all types is rapidly increasing. During this time young people are first coming into contact with these drugs

	% Who Are Recent Multiple Drug Users		
Age	Sedatives	Tranquilizers	Stimulants
18 - 25	70	28	46
26 - 34	6	13	18
35 - 49	15	35	30
50 +	9	24	3

Figure 9. Age and Multiple Drug Use (39, p. 62)

and "learning" to use them. They are becoming familiar with the effects of these drugs and they are developing habits related to when, and in what situations they will use them. It is at this time that they begin to use drugs for emotional support in stress situations (if such a dependency is ultimately to emerge).

This is an important period because the young user is learning to control his behavior while under the influence of drugs. For example, the young man who drinks too much, becomes intoxicated, loses his balance, falls down, and is derided by his companions. With experience he learns to control his behavior while drinking so as to appear less intoxicated. This is encouraged by his peers who commend him for being able to "hold his liquor." Unfortunately, the behavioral control which is supported by the peer group may not be the same behaviors which are required to drive safely. Therefore these critical skills may not be learned. Thus, for those young Americans who will become drug users, this learning period is of major significance to future safe use of drugs. This is further complicated since this period of learning to use drugs corresponds to the period of learning to use the automobile.

Drug use in relation to driving by young people differs in four significant ways from that of adult use of drugs. First is the factor of experience. As just discussed, the young are just learning to use drugs. Therefore, they are less able to cope with emergencies which result from drug use or driving or the interaction of both activities. Secondly, the young are more likely to be multiple drug users, which compounds their difficulties in handling any problems which drugs pose for their driving. Thirdly, with the exception of alcohol, teenagers and young adults appear to be heavier drug users than are more mature drivers. Fourth, the young driver is facing a period of emotional milestones; high school graduation, college, marriage, first job. All of these, as Pelz and Schumann (44) point out, cause considerable stress, particularly for young people whose personalities and ability to cope with stress are still maturing.

There may also be environmental factors which further complicate the situation for young drivers. For the most part they live either with parents or in supervised educational facilities, where their drug use is either banned or strictly limited. As a result, the automobile may be important to young drivers as a method of getting to places where drug consumption is possible or even as a locale for drug use which is away from parental supervision.

Use of Drugs by the Driving Population

No direct estimate is available for the frequency of the use of drugs other than alcohol by the driving population. Nichols (43) reviews the available data and provides the information in Figure 10. As Nichols notes there is no way to know what proportion of those drug users, who also drive, drive with any frequency following the ingestion of drugs. It is probable that some types of drug users, such as heroin addicts, drive frequently with the drug in their systems since their addiction pattern requires at least a minimum level in the blood at all times. Some evidence for this has been provided by recent study by Dunlap, Inc. (8), for the United States Department of Transportation in which they found that the majority of former heroin addicts admitted to driving shortly after having taken the drug.

In the United States the level of drinking among the driving population has been determined by both objective breath alcohol tests and by drinking questionnaires. The development of breath tests for alcohol has provided an objective, easily available measure of the blood alcohol concentration (BAC). Breath tests are easy to administer, rapid and permit an objective determination of the amount of alcohol which has been used in contrast to the more subjective questionnaire approach. This technique, when combined with survey procedures for selecting a random sample of

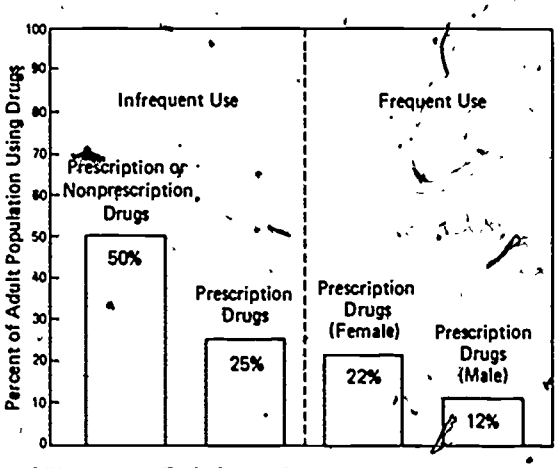


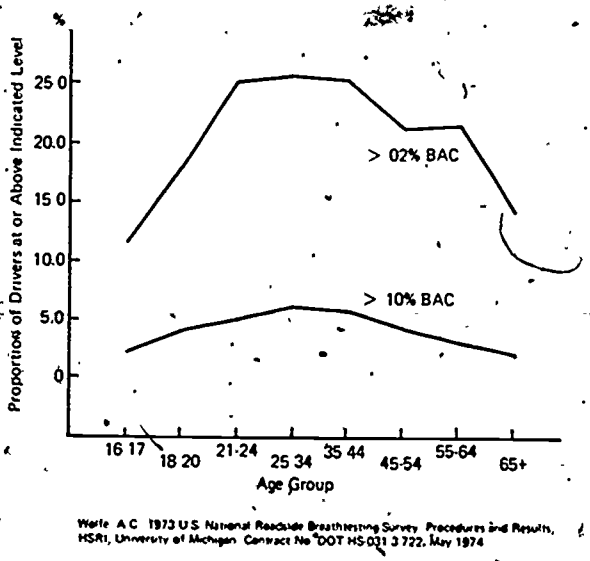
Figure 10. Estimates of Drug Use in Adult or Driving Population (43, p. 45)

Type	BAC = 0	0.01 - 0.04	0.05 - 0.09	⩾0.10	Totals
Very light	83.5% (304)	12.4% (45)	2.5% (9)	1.6% (6)	364
Fairly light	62.9% (117)	23.1% (43)	10.2% (19)	3.8% (7)	186
Moderate	35.9% (69)	27.6% (53)	24.5% (47)	12.0% (23)	192
Fairly heavy	11.1% (1)	33.3% (3)	22.3% (2)	33.3% (3)	9
Heavy	15.4% (2)	7.7% (1)	23.0% (3)	53.9% (7)	13
Nondrinkers	98.2% (166)	1.2% (2)	0.0% (0)	0.6% (1)	169
Totals	659	147	80	47	933

Figure 11. Self-Classification vs. BAC (25)

drivers using the highway, permits the determination of the number of drivers on the road at each BAC level. These objective measures, when combined with questions regarding frequency and quantity of drinking, provide a check on the validity of the self-reports. An example of such data is presented in Figure 11 (25), which presents the results of a survey of 933 drivers using the road on Friday and Saturday nights in Kansas City, Missouri. The drivers were stopped at random, asked a series of questions, one of which required them to classify themselves as very light, fairly light, moderate, fairly heavy, heavy, or nondrinkers. Only 24 of the 933 chose the category of "fairly heavy" or "heavy." The measured blood alcohol concentrations were highly correlated with the self-classification.

Typical blood alcohol concentrations in drivers using the road on Friday and Saturday nights between the hours of 7 p.m. and 3 a.m. are given in Figure 12. These figures are believed to be reasonably representative of most areas in the United States.



Wolfe A C 1973 U S National Roadside Breathtesting Survey Procedures and Results, HSRI, University of Michigan Contract No DOT HS-031 3 722, May 1974

Figure 12. Age and Proportion of Nighttime Drivers Who Have Been Drinking (BAC > .02%) or Who Are at Illegal BACs (BAC > .10%)

III. Studies of Drug Use in Relation to Driving

In comparison to alcohol, relatively few investigations have been conducted on the effects of drugs on driving, particularly when one considers how many different psychoactive substances are commonly in use. This, of course, is not surprising since alcohol is the drug of choice in most western cultures. With increasing drug use, particularly among younger members of industrialized societies, there has been increasing interest in the study of the potential effects of drugs on driving. Three recent reviews of this subject, Kilbrick and Smart (30); Waller (59), and Nichols (43), all come to basically similar conclusions that, while psychoactive drugs have been found to have significant impact upon many different kinds of behavior, there is as yet little evidence that their use by drivers is a major factor in the causation of crashes.

Methodological Problems

Evidence on the potential role of drugs in crash production is derived from five sources. 1) experimental investigations using laboratory equipment, driving simulators or vehicles in closed courses, 2) comparison of driving records of drug users and nonusers, 3) epidemiological studies involving systematic analysis of samples taken from the bodies of fatally injured drivers, and 4) anecdotal reports and case histories. Most of the positive data which have led to the general belief that drugs have an important role in producing crashes have come from the latter source. Such anecdotal reports, however, at best demonstrate that in a given case a particular drug may have played a role. However, since psychotropic drugs have a mind-altering effect, it is difficult to trust the reports of drug users. In some cases they may overestimate the potential impact of the drug and in many cases they may have some need to demonstrate that the drugs they are using do not have a significant effect on their driving.

Controlled experimental studies of driving-related activities have frequently demonstrated impairment as a result of various drug dosage levels. Unfortunately, many difficulties exist extrapolating from these studies to the "real" world. Whatever the impact of a given drug upon the skilled performance that can be measured in controlled situations, the applicability of these findings to real driving conditions is impaired by the role of emotional factors. The real life stress involved in driving can rarely be duplicated in the laboratory. Psychoactive drugs produce mood changes; indeed, they are specifically taken for this purpose. Therefore, their most important impact upon driving would be expected to be in the emotional rather than in the cognitive area. Laboratory situations can rarely explore such emotional factors as "risk taking," and thus can provide only limited information on the potential of a drug to produce crashes in the real world. Moreover, the specific skills required for safe driving are not well understood. Many drug studies may involve skills which are relatively unimportant to safety. For example, a number of investigations have been made of the effects of drugs on vision, but studies of driving records indicate that many drivers perform very well with seriously impaired vision (11). Until there is a better understanding of the human behaviors, skills, and attitudes which underlie the driving activity, extrapolation from laboratory studies will be difficult.

Another significant problem in controlled experimental research on drugs and driving is the selection of an appropriate subject. A number of studies have been done in which drugs were administered to individuals who did not normally use them. It may be possible in this way to study the physiological effects of such drugs on normal

individuals. However, under real life conditions the same individuals would not use the drugs and, therefore, would not be likely to be driving while impaired by them. Moreover, the physiological effect of the drug on the nonhabituated user would be expected to be different from the effect on the habituated user.

Another feature of this problem is that both drug users and heavy alcohol users have differing behavior patterns from those who do not use drugs. Waller (59) in his studies of the driving records of drug users noted that they appeared to have an increased violation frequency while, at the same time, showed little or no increase in accidents. Whether the tendency to break laws was a result of the habituation to drug use or whether the proclivity to commit violations preceded the use of drugs is always a significant issue. There is considerable indication that personality patterns and behavioral patterns of individuals who later become drug users are different. Therefore, experiments performed on nondrug users may provide interesting theoretical information, but may, or may not, be meaningful in terms of the potential for drugs to increase the frequency of highway crashes.

Studies of the driving records of users and nonusers suffer from the difficulty just mentioned, namely, that many of the drug users differ in basic personality from nondrug users and, therefore, any differences in safety records may be related to these personality differences rather than to drug use. Waller (59) concludes that drug users have more violations, but not more accidents than nonusers. However, the results obtained by Crancer and Quiring (19) and by Smart and Schmidt (55) indicate that drug users do have from 1.3 to 2 times as many crashes as nonusers.

Epidemiological studies of drugs in fluid samples from fatally injured drivers found up to 11% of drivers to have some sort of drug in their systems. The proportion using drugs is directly related, of course, to the number of drugs for which tests were conducted. These figures can only be useful if the proportion of drivers using the road and not involved in crashes, who have similar drugs in their systems, can be determined. To date no such data are available, though the National Highway Traffic Safety Administration, DOT, is currently supporting an effort to gather these data through a contract with the Midwest Research Institute (35). Until such data are available it will not be possible to determine whether drug use is over-represented in fatally injured drivers.

Multiple Drug Use

Nichols (43) reviews several studies which include information on blood alcohol concentrations in fatal crash victims who were using drugs. From these studies it appears that, in the United States, about half of the crash victims who are found to have drugs in their systems also have blood alcohol concentrations sufficiently high to impair their driving ability. Thus, a significant portion of any drug involvement in fatal crashes could be explained through this correlation with alcohol. This indication of the role of multiple drug use by fatally injured drivers is significant when viewed against the tendency of the young user to be a multiple drug consumer.

IV. Use of Drugs by Young Drivers

A recent study by Blomberg and Preusser (8) is of particular interest as these investigators attempted to control for the socioeconomic and personality biases of drug users. Their study, which included 1,562 methadone maintenance patients, included an in-depth interview covering the driving history of the participants. Through these interviews they were able to define four periods of drug use: 1) a pre-drug period prior to the abuse of any type of drug except alcohol, 2) a nonheroin period involving the abuse of non-narcotic drugs, such as marihuana, 3) a heroin period while actively addicted to heroin or some other opiate, and 4) a methadone period while enrolled in a methadone maintenance treatment program.

Basic information on the group studied is presented in Figure 13. As can be seen, the average age for the initiation of drug use was 16.23 years. The nonheroin period lasted for approximately three years, while the median length of the heroin period was five and one-half years. Most of the subjects interviewed had been on the methadone program for just over a year when the interviews were conducted. A number of interesting facts emerged from their study. In considering these data, however, it should be kept in mind that all the information presented in Figure 13 are based on interviews with the subjects themselves and, therefore, are subjected to the personal biases of the individuals involved.

From this figure it can be seen that the use of drugs generally began before or contemporaneously with the beginning of driving. It is interesting to note that in the pre-drug and nonheroin period almost twice as many of the subjects of this study were driving as held licenses, suggesting that a major part of controlling drug users who drive involves enforcing license requirements, a problem which is most difficult in most industrialized countries because of the large number of vehicles on the roadways.

Figure 14 presents the type of drugs used in the pre-heroin period by those 1,114 subjects who reported using a drug before using heroin. The use of such drugs among those participating in this study appears to run from approximately age 14 to age 18. The heroin period appears to begin in the teens and runs through age 25 or 26. It must be kept in mind that most of the individuals participating in the methadone program were those who had their use of heroin interrupted as a result of law enforcement action. Individuals whose use of heroin had not been detected would generally not be a part of this study.

Of particular interest was the type and amount of driving done by these individuals during the various phases of drug use. The average annual mileage was approximately equal to the national average for the pre-drug and nonheroin and methadone periods, but surprisingly during the period of heroin use the average mileage was almost 50% higher than normal. Over 90% of the drug users, both for the nonheroin and the heroin phase, reported that they drove immediately after drug use on at least one occasion. In addition, all the drug user groups reported that a high proportion of their accidents had occurred while they were "high on drugs" and that they had also received traffic citations while "high on drugs."

The increased mileage of the heroin users is of particular interest in relationship to the reasons given for driving. As can be seen from Figure 15, during the heroin period the reasons for driving varied significantly from other periods of drug use. About a third of the heroin driving was stated to be for the purpose of procuring drugs. Thus, much of the increased mileage reported during that period appears to be related to the problem

Variable	Period				Comments
	Pre-Drug	Nonheroin	Heroin	Methadone	
Total available experimental subjects	1562	1114*	1562	1562	**448 subjects abused no drugs prior to heroin
Average period length (years)	16 23*	3.13	7 39 5 51 (median)	1 26	*Age of first illicit drug use
Average age at midpoint of period (years)	16 23*	16.79	22 14	26 4	*Age of first illicit drug use
Average yearly mileage, all subjects	5704	8910	18,067	12,089	Averages across all subjects
Average yearly mileage, drivers	11,991	12,725	18,814	12,846	Averages across only those who said they drove
Number who drove	743	780	1500	1470	
Primary purpose for driving	Personal	Personal	To get drugs	Personal*	Work-related driving ranked second except in heroin period when personal ranked second
Percent of drivers who drove several times each day	52%	55%	69%	56%	
Percent of driving done in the daytime	31%	33%	36%	48%	
Percent holding a valid driver's license	26%*	31%	74%*	66%	*Percent of all subjects
Median yearly mileage for unlicensed drivers	5760	5945	9200	6000	
Median yearly mileage for licensed drivers	13,900	14,000	18,300	13,950	
Percent drivers licensed in New York State	85%	90%	91%	94%	
License type held	69% oper. 22% chauf.*	76% oper. 15% chauf.	67% oper. 28% chauf.	59% oper. 36% chauf.	
Most used vehicle type	Pass. car	Pass. car	Pass. car	Pass. car	Second were trucks in all periods
Owner of most used vehicle	Family	Self or family	Self	Self	
Number and percent of drivers who drove immediately after drug use	-	719 (92%)*	1429 (95%)*	-	*973 (65%) did so daily
Percent of all accidents occurring when subjects were "high"	-	34%*	46%*	-	*Interview date
Percent of all tickets received when subjects were high	-	25%*	44%*	-	*Interview data

Figure 13. A Study of the Driving Records of Methadone Users; Summary of Driving Characteristic Data for Experimentals (8)

	Percent	N
Used any drug before heroin	71	1114
Marijuana	67*	1047
Barbiturates	41	633
Amphetamines	36	562
Cocaine.	31	490
Hallucinogens	31	478
Deliriants	16	251
Other and nonspecified	7	108
Did not use any drug before heroin	29	448
Totals	100	1562

*Percents do not total 100 because many subjects used more than one drug.

Figure 14. A Study of the Driving Records of Methadone Users; Use of Other Drugs Prior to Heroin (8)

of maintaining the heroin habit. Apparently, considerable driving was required to find sources of supply.

To make these interview data more meaningful, an attempt was made to check the driving records of the individuals participating in this study and compare them with an appropriate control group. In an effort to avoid the problem presented by the socioeconomic background of the drug user in comparison to the average driver, a special control group was developed by asking the respondents in the study to name a friend or associate of approximately the same age who did not use drugs. In this way the names of 1,059 peers of the methadone patients were obtained. Using the names of the participants themselves and the individuals in the control group named by these respondents, a search was made of the files of the Department of Motor Vehicles. This search yielded driving records for 718 of the methadone subjects and 579 of the peer control group members. The distribution of the number of crashes for each of these groups is shown in Figure 16. As can be seen from this figure there appears to be no significant difference between the drug users and the control group in the number of crashes experienced over the five-year period covered by the Department of Motor Vehicles records.

A possible explanation for this lack of difference is that the drug users would have a much greater tendency not to report accidents. This explanation would seem plausible in light of the data in Figure 17. It provides the answers given to a question in the interview: "Describe the main thing on your mind while driving immediately after using heroin." The largest proportion of the responses related to being able to drive well enough to avoid being stopped by the police. There seemed to be considerable concern about being apprehended by the police, not so much for fear of receiving a traffic citation, as for being caught in possession of narcotics. Thus, if these drivers were in crashes it is to be expected that they would avoid calling a policeman to report the crash if they could do so. To test the possibility that this reluctance to become involved with the police could explain the failure to find a significant difference in crash involvement between the control and experimental groups, the distribution for injury and fatal accidents only was compared. With the control groups, these accidents would be less likely to be under-reported since it is much more difficult to avoid reporting an injury or fatal crash. This test, however, also failed to show any significant difference between the control and the experimental group. Thus, despite the evidence that drug users drive at least as much, and heroin users significantly more than average, the frequency of their crash involvement is no greater than their peers who do not use drugs. Moreover, the crash rates for both the drug users and their peer controls were no greater than that of the average for all drivers of the same ages.

Primary Purpose	Pre-Drug	Period		
		Non-heroin	Heroin	Methadone
To and from work	21%	21%	15%	21%
For work	12%	9%	15%	14%
Personal	62%	63%	32%	56%
To get drugs	N/A	4%	36%	N/A
Other	5%	4%	2%	3%

Figure 15. A Study of the Driving Records of Methadone Users; Primary Purpose for Driving for Each Period (8)

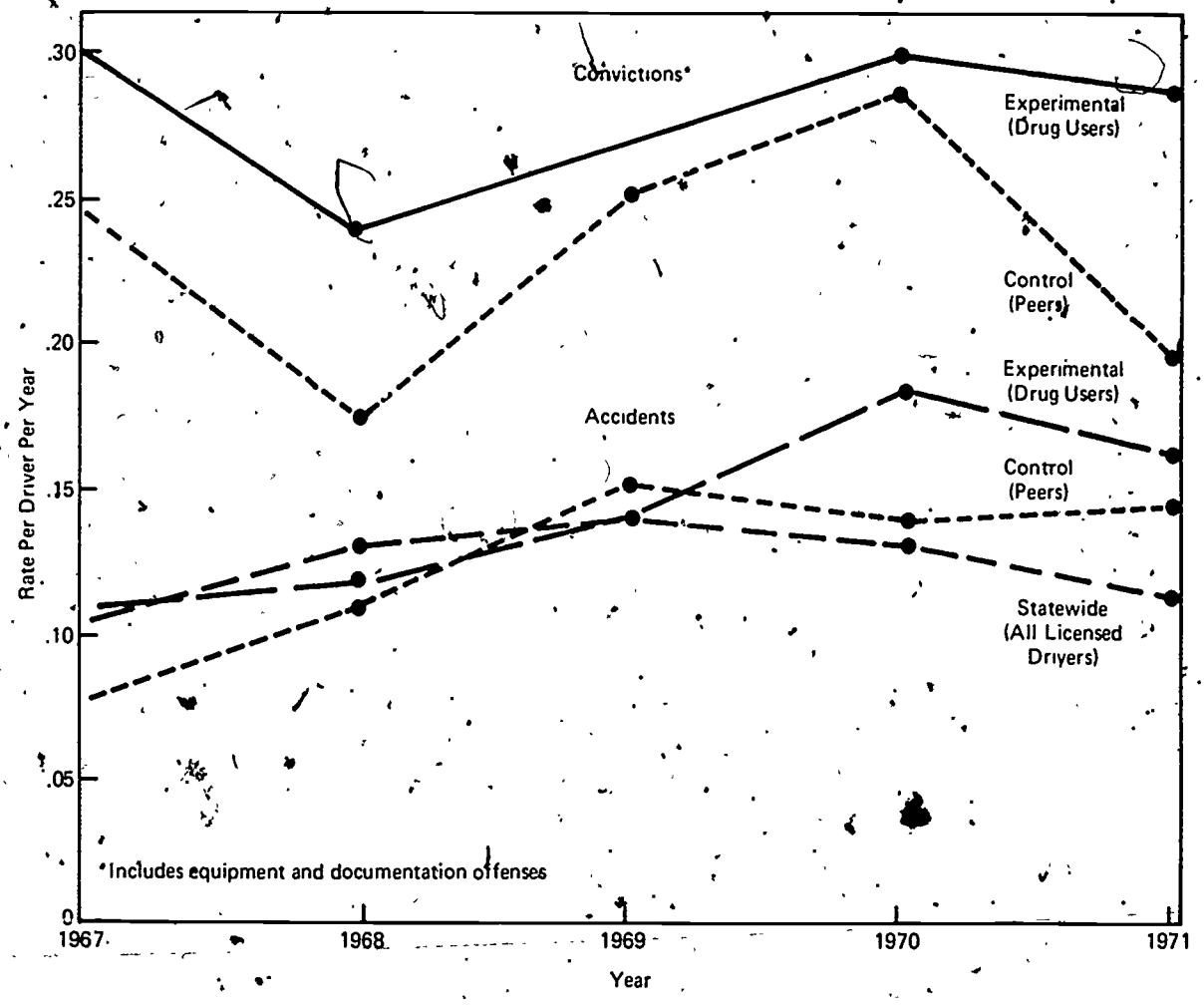


Figure 16. A Study of the Driving Records of Methadone Users; Five-year Accident and Conviction Rates Per Driver (8)

It is difficult to explain this result particularly when, according to those interviewed, they did drive while "high" on drugs. Thus, the lack of crash involvement cannot be explained on the basis of the separation of driving from drug use. One factor that may have been of significance in promoting these normal driving records despite driving under the influence of drugs may have been an increased compensation in their driving. As indicated in Figure 17 the heroin users reported a concern with being arrested. This concern may have resulted in a reduction in risk taking through more conservative driving behavior. This in turn may have held crash involvement to normal levels.

This ability to compensate for the potential impairing effects of the drug on driving may be a significant factor in determining whether a given drug increases the crash experience of the drug user. Alcohol appears to have a tendency to increase belligerence and risk taking in driving (22, 32, 33). This may account for its greater association with crashes. It is possible that other drugs which may be equally impairing to driving skill may have less tendency to result in an increased crash rate because the individuals under the influence of these drugs are able to compensate for their impairment (see discussion of marihuana).

The penalties for traffic offenses in the United States are generally mild. The frequency with which an individual is apprehended and convicted is low relative to the frequency with which infractions are committed. On the other hand, the United States is currently conducting a major enforcement effort to control the abuse of drugs, particularly heroin. The heroin addict faces far more severe penalties if apprehended than the

normal driver. Moreover, imprisonment for the heroin addict may mean loss of access to the drug. Therefore, there is a motive to avoid contact with the police. This enforcement effort may have a serendipitous effect on driving safety. The possibility that such laws are important deterrents to reckless driving while under the influence of drugs warrants further study.

A Study of Drugs and Driving by a Young Criminal Population

Another study of interest by Moser, Bressler, and Williams (37) covered a group of 1,889 young men arrested for a variety of serious crimes. These investigators had available to them results of drug assays on urine samples taken immediately following arrest and detailed questionnaire data concerning drug use. For 977 members of this group, it was also possible to get driving record data. Crash rates as a function of drug data from urinalysis is presented in Figure 18. As can be seen, those arrestees whose urine was free of all drugs had a crash rate substantially higher than prisoners whose urine contained barbiturates, heroin, or methadone. The small amphetamine positive group had a crash rate substantially higher than other drug users or those who were negative. However, this group was too small to permit any great confidence in this result. The relationships between drug use and conviction for hazardous violations were similar to those for crashes. Those arrestees using barbiturates, heroin, or methadone had fewer or no more than an equal number of convictions compared to those with no drugs in their systems. Once again amphetamines were associated with a higher conviction rate. In addition to the objective evidence provided by the urine tests, data on drug use was also provided by the questionnaires. When these questionnaire data were compared to the driving records of the arrestees, conviction rates and crash rates for most drug users were found to be equal to or less than nondrug users in most cases (see Figure 19) (37). Two exceptions to this generalization were psychedelic and hashish users for whom there was a somewhat higher accident rate. Thus, the questionnaire data appear to parallel the chemical data

Main Thing on Mind	Percent
Driving well enough to avoid being stopped by the police	36
Enjoying the high	18
Not caring about anything	11
Fear of accident	7
Fear of getting stopped	7
Not driving well	2
Physical discomfort	1
Other	12
No response	5

Figure 17. A Study of the Driving Records of Methadone Users, Main Thing on Mind of Heroin User While Driving Immediately After Using Heroin (8)

Drug	Drivers		Accidents		Hazardous Convictions		% With Clean Records
	Number Tested	Percent of Tests	N	Rate	N	Rate	
Negative to all	655	48.0	338	.52	160	2.5	17.0
Barbiturates	105	44.0	27	.26	261	2.5	18.1
Heroin	112	35.0	34	.30	214	1.9	19.6
Methadone	25	41.0	7	.28	45	1.8	16.0
Amphetamines	18	48.5	13	.72	54	3.0	16.7

Figure 18. Driving History Summary for Positive and Negative Urine Analysis for a Sample of 2076 Young Criminals (37)

Drug Used	Hazardous Conviction Rate	Accident Rate
Psychedelics	2.7	.63
Amphetamines	2.6	.51
Tranquilizers	2.6	.49
Hashish	2.5	.62
Cocaine	2.5	.41
Barbiturates	2.4	.42
Marihuana	2.4	.44
Morphine	2.3	.45
Heroin	2.1	.41
Special substances	1.7	.41
Methadone	1.6	.16
Nondrug users	2.7	.48

Figure 19. Summary of Conviction and Accident Rates by Drug for the 865 Young Criminals Responding to the Questionnaire (37)

indicating that arrestees using drugs do not have higher crash rates than fellow prisoners who were not using drugs. In evaluating this study, it should be kept in mind that these data provide no control for annual mileage rates. This may account for the very low accident rate for methadone users.

Drugs and Driving in a University Population

In a recent investigation at a major Midwestern university by Berg, et al. (6), blood samples were collected and analyzed for drugs from students treated at the student health service as a result of involvement in a highway accident. Data for this group were compared with drug analyses performed on other students using the health service for nonaccident-related reasons. This study, while covering only a small group of crash involved student drivers, found no difference between the crash involved drivers and a control group of 54 students in the use of psychotropic drugs. The numbers involved in this study are too small to be given much weight. However, this research supports the general picture presented by the other studies which have been reviewed indicating a general failure to find a strong relationship between drug use and highway crashes.

The epidemiological and drug user studies reviewed in this paper and elsewhere (30, 43, 59) are in marked contrast to the laboratory or experimentally controlled driving studies such as those of Keilholz (31), which have indicated a definite impairment as a result of drugs and drugs in combination with alcohol. These contrasting results suggest that to the extent some drugs impair driving skill this effect is overshadowed in real life situations by the many other factors which relate to crash causation. Conclusions regarding the role of drugs in traffic crashes must, however, remain tentative until more comprehensive epidemiological studies have been completed (35, 64).

Marihuana and Driving

Because of its relative popularity, after tobacco and alcohol, marihuana, the drug most widely used by youth in the United States, has attracted considerable interest in terms of its potential for impairing driving performance. Unfortunately, the detection of marihuana in body fluids is currently difficult, if not impossible. Therefore, studies of the use of marihuana by crash victims have, until quite recently, not been undertaken. Currently, a technique is being used by the Midwest Research Institute (64) under contract to the U.S. Department of Transportation, which provides some indication of marihuana use by fatally injured drivers. This technique involves washing the face and hands of the traffic victim with alcohol and then analyzing the washings for THC, the active ingredient in marihuana. This technique does not provide a measure of dosage level, nor does it even provide assurance that the individual himself ingested the marihuana. It does indicate, however, that the individual was in contact with smoke from marihuana. Studies using this procedure are just getting underway. No significant data are yet available.

To this date reliance must be placed upon laboratory experiments and questionnaire studies of marihuana users. Laboratory and driving range studies under the influence of marihuana have recently been summarized by Moskowitz, et al. (38). A number of these studies have used alcohol as a comparison drug. These studies suggest that marihuana produces less significant impairment in driving skill. However, as Moskowitz points out, between alcohol and marihuana, the

effect on driving depends upon the particular behavior chosen for study. Moskowitz concludes that marihuana is a potential threat to drivers because it impairs perceptual functions. Whether this impairment actually increases crashes is dependent upon the extent to which this effect is compensated for by other factors. An answer to this question must await adequate surveys of marihuana in fatally injured drivers in comparison to drivers using the road but not involved in crashes.

One indication that marihuana may be less significant in crash production than alcohol is provided by its apparently smaller impact on risk taking. Several studies have indicated that alcohol increases this risk taking in driving situations (22, 32, 33). Lewis and Sarlanis (32) made a study of responses by drivers to traffic signals on a simulator. In this study, as the driver approached the intersection the traffic signal changed to an amber "caution" light. The driver was required to judge whether to come to a stop or whether he could proceed through the intersection before the red "stop" signal came on. The subjects themselves stated that they believed their driving improved while they were under the influence of alcohol. However, the results demonstrated that they made serious errors in judgment and took more risks.

Similar results were found by Light and Keiper (33) in a car passing situation. This study covered passing behavior of drivers on a simulated two-lane road. The driver was forced to make a decision as to when passing was safe and once the pass was started whether it should be continued when a car approached from the opposite direction. With alcohol the subjects made more decisions to complete their pass in the face of an on-coming car. As a result of taking this increased risk, they were involved in more simulated crashes. This type of risk taking under alcohol was also confirmed in a study by Ellingstad, et al. (22).

Using the same passing test as in the Light and Keiper study, Dott (20) repeated their investigation using marihuana. In this case it was found that the drivers under the influence of marihuana made fewer attempts to pass and when passing were less likely to speed ahead and complete the pass when faced with an on-coming car. A similar result for marihuana and risk taking was found by Ellingstad et al. (22). Thus, it would appear that marihuana and alcohol have opposite effects upon risk taking. Alcohol appears to increase risk taking, along with the general feeling of power and well-being, thereby reducing the probability that the driver will compensate for any impairment of his driving ability produced by alcohol. The marihuana user, on the other hand, appears to be less likely to take risks. He can, therefore, be expected to compensate for any deterioration in his capability due to taking the drug, or, whether or not conscious compensation occurs the drug appears to produce a tendency to drive in a more conservative manner. Thus, the marihuana user may be less likely to become involved in a crash. Until further data become available on the proportion of marihuana users actually involved in crashes, much of this must remain speculation. However, the difference in risk taking attitude appearing in these studies emphasizes once again the significance which attitude and risk taking play in determining whether a given drug will produce an increase in crash potential. Both alcohol and marihuana impair driving skill, but the hazard associated with alcohol appears to be significantly greater because of the type of mood change it produces. The indications that amphetamines are associated with a somewhat increased crash involvement (59) may result from the tendency of users of amphetamines to take increased risks, as much as by any impairment in skill which these drugs produce.

V. Alcohol in Relation to Highway Safety

The role of alcohol in crashes has been summarized in a number of national and international publications; U.S. Secretary of Transportation (50); British Ministry of Transportation (3); The Netherlands Institute for Road Safety (57); American Medical Association (4); OECD Report by Goldberg and Havard (26). In addition a special issue of the Journal of Safety Research (Perrine, Ed. (45)) has been devoted to a review of the alcohol and drug literature in relationship to driving.

The evidence for the relationship between alcohol and crash involvement rests on a number of well-controlled studies which compare the incidence of alcohol in drivers involved in crashes with the incidence of alcohol in drivers using the roads at the same times and places who are not involved in crashes. A series of such studies has been conducted in the United States, Canada, Czechoslovakia and in France, beginning with the study of Holcomb in 1938 and continuing on up through the studies of Perrine et al. in Vermont in 1971 (28, 56). These studies have in common the feature of being "case controlled." That is, for each case, blood alcohol levels are available, not only on the accident victim but also on uninvolved drivers using the road at the same times and places where crashes have occurred. The data for uninvolved drivers are collected through "voluntary roadside surveys" (46, 56) in which drivers are requested to voluntarily provide a breath sample for analysis for alcohol.

These "case control" studies permit the calculation of the relative risk of being on the road at any given blood alcohol concentration. The specific formula for developing relative risk curves has been described by Hurst (28) and involves the comparison of the frequency with which crash-involved drivers demonstrate a given blood alcohol concentration in comparison to the frequency with which noninvolved drivers present that same BAC level. Hurst (28) has calculated crash risk curves for each of the "case control" studies. These are presented in Figure 20. As can be seen, most of these curves are relatively flat from .00% to approximately .06% BAC. From that point on they begin to rise relatively steeply, indicating an increasing risk with increasing BAC levels. These curves describe a rough "dose-response" relationship for the effect of alcohol in producing crashes. Most of these curves take the expected form for dose-response relationships. There is little apparent effect at low dosage levels (below 0.05%) and an accelerating effect from that point on. Such dose response curves provide the best evidence for the role of alcohol in the causation of traffic accidents.

The evidence becomes even stronger if we look at the issue of crash responsibility. Unfortunately, the methods for determination of driver responsibility are generally crude and subjective. In single vehicle crashes where only one driver is involved, that driver is generally assumed to have been "responsible" for the crash. Multiple-vehicle crashes present a more difficult problem. However, it is frequently possible to use the investigating officer's estimate as a rough indication of responsibility. When the relative risk curve is limited to responsible drivers the correlation between crash involvement and BAC is even more striking, as shown in Figure 21. This graph from Hurst (28) presents data from three studies of responsible drivers and one study for which sufficient data on nonresponsible drivers was available to permit drawing a "dose-response" curve. The curves for responsible drivers rise sharply from .10% BAC, whereas the curve for nonresponsible drivers is relatively level and shows little if any effect from alcohol use.

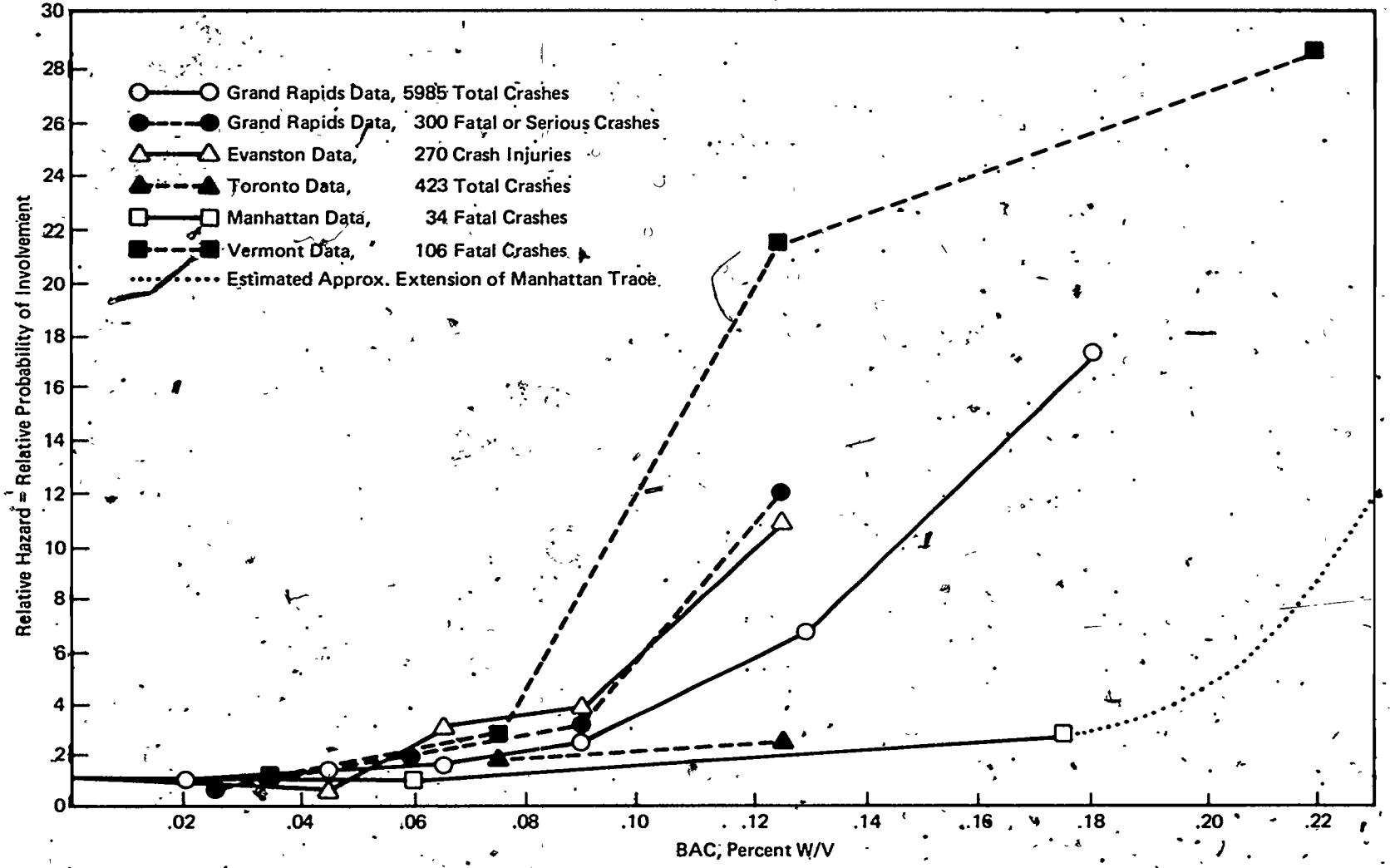


Figure 20. Probability of Crash Involvement as a Function of BAC (28)

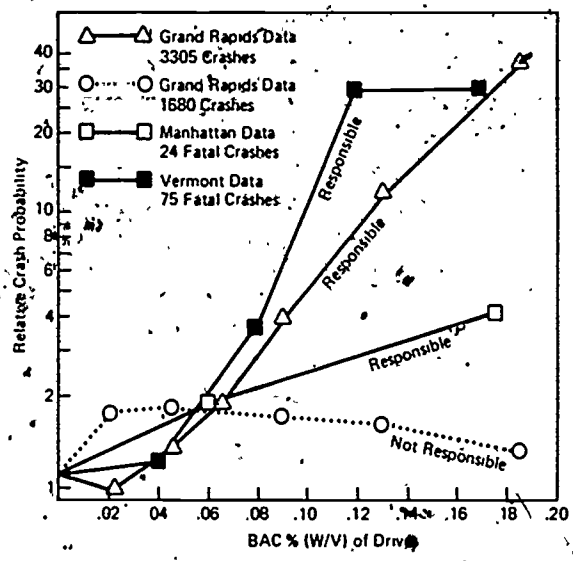


Figure 21. Driver Responsibility and Crash Probability in Relation to BAC (28)

Such dose-response curves provide the best evidence for the role of alcohol in the causation of traffic accidents. Of particular interest to the present report is the issue as to whether these dose-response curves would be different for teenage as compared to older drivers. Separate curves for different age groups have not been calculated but there is some evidence available on the relative exposure to alcohol-related crashes of drivers of various ages. The relative liability of young drivers to crashes, holding alcohol constant, has also been calculated. These data are discussed in the next section.

VI. Are Young Drivers Overinvolved in Alcohol-Related Crashes?

The central question for this paper is whether young drivers are overinvolved in alcohol and drug-related crashes. The question is more subtle than it appears on its face and must be considered in two parts. The first issue is whether young drivers are overly exposed to crashes in which alcohol or drugs play a role and the second issue is, given equal exposure, does a given level of the drug in the body produce a higher impairment of driving in young drivers than in older drivers.

As already noted, use of drugs other than alcohol and tobacco appears to peak in the early twenties. Moreover, maximum use of certain drugs, such as marihuana, may occur in the late teens. Finally, young drivers are more likely to be multiple drug users. Thus, if a given drug has an equal effect upon all persons who take it, but if more young drivers use the drug, then the natural consequence of this increased exposure should be greater involvement in drug-related crashes.

Aside from the amount of drug use itself, exposure is also a function of the extent with which drug use is coupled with driving. At the present time, there is relatively little information on this question. However, considerable information is available on alcohol. Alcohol is primarily used in evening and nighttime periods, with the result that most alcohol-related crashes occur in the late afternoon and evening. This is dramatically illustrated in Figure 22 which compares crashes for which the investigating policemen judged that the driver had been drinking, with those for which the policemen made no notation regarding drinking (23). As can be seen, crashes involving drinking drivers peak after midnight each day of the week. There is some evidence that on weekends the peak occurs slightly later than on week days. Even more striking is the increase in crashes in which the driver has been drinking, on Friday and Saturday evenings. These relationships between hour of

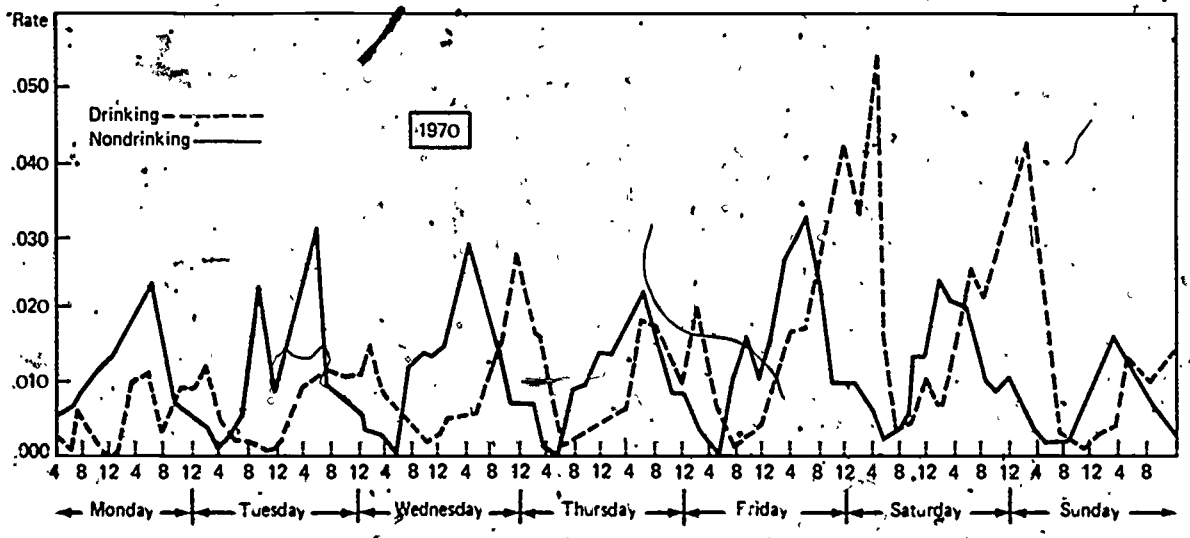


Figure 22. Comparison of Alcohol Involved and Nonalcohol-Involved Crashes Based on the Distribution of Crashes by Two-Hour Periods During the Week for the Years Indicated in Michigan (23)

the day and day of the week in which alcohol-related crashes occur have been confirmed in a number of studies and are fully in accord with expectations from what is known of the drinking habits of Americans.

This time patterning of alcohol-related crashes is significant for the young drivers because surveys of drivers on the road during the peak periods for alcohol-related crashes (Friday and Saturday nights) indicate that young male drivers are more likely to be found on the roads at these times. The data shown in Figure 22 indicate that approximately 50% of all crashes occurring in the 4-hour period between midnight and 4 a.m. are found by the police to be alcohol-related. If, then, young drivers are on the roads at these periods more frequently than their proportion in the licensed driver population, these young drivers are more likely to be involved in alcohol-related crashes. This is true, whether or not they have been drinking themselves, since by chance alone their probability of being involved in an alcohol-related crash between midnight and 4 a.m. is one in two; whereas, if they are driving between 8 a.m. and 12 p.m., their chance would only be one in twenty. Any driver on the road late at night is more likely to be involved in an alcohol-related crash both because he is more likely to have been drinking *and* because he is more likely to be the "innocent" victim of a drinking driver.

Several studies have suggested that young drivers drive more at night than do other age groups. This appears to be supported by the data presented in Figures 23 and 24, which present results of surveys of nighttime drivers conducted at seven different communities within the United States. These surveys were conducted as part of the evaluation program for special community action programs in alcohol and highway saftey being sponsored by the U.S. Department of Transportation (42). As a by-product of such investigations, it is possible to determine the characteristics of the drivers using the road at any given hour of the day or day of the week, provided the sample is properly selected to reflect the time and geographical location of interest.

Since the Alcohol Safety Action Projects for which these surveys are used as an evaluation technique are directed primarily at reducing the number of drivers on the road at high blood alcohol concentrations and thereby reducing the number of drinking-driving crashes, emphasis in these investigations was placed on nighttime and weekend drivers. The minimal requirements placed on each project were to sample drivers on Friday and Saturday nights between 7:00 p.m. and 3.00 a.m. By emphasizing these hours it was expected that the surveys would reflect the largest proportion of drinking drivers. If any changes occurred in the numbers of drinking drivers throughout the life of the projects, they would be most likely to show up at those periods when drinking drivers were most frequent. Because the ultimate criterion of interest was alcohol-related crashes, the projects were instructed to choose the geographical location of their survey based on the locations in which fatal or serious injury crashes had occurred. While these general requirements were placed on the projects, considerable latitude was permitted each site to accommodate to local conditions and requirements. Thus, the surveys summarized in Figure 2 are not all directly comparable. However, every site includes samples taken on Friday and Saturday nights and all are within the time period of 7.00 p.m. to 3:00 a.m.

Some variation does appear from site to site in the proportion of drivers in each age group, but the general uniformity of the findings is striking. While just under nine percent of the drivers licensed in the United States in 1972 were under the age of 20, the minimum frequency with which any of these surveys encountered drivers in this age group on the road in the evening was 11 percent, while three projects found over 20 percent of their drivers to be in this age range. From the data presented, it appears that drivers under 20 are encountered on the roads at night about twice to three times as frequently as would be expected from their numbers in the licensed population. Drivers in the 20-29 age group are also over-represented in the nighttime driving population by from 50 to 75 percent. Drivers in the 30-39 age group appear to be encountered just about as frequently as would be expected from their numbers in the driver license files. The groups above 40 appear to be under-represented, particularly the elderly over 60 who are found from one-third to one-fourth as frequently as would be expected from the number of driving licenses they hold.

Since these results are assembled from widely dispersed geographic communities involving both

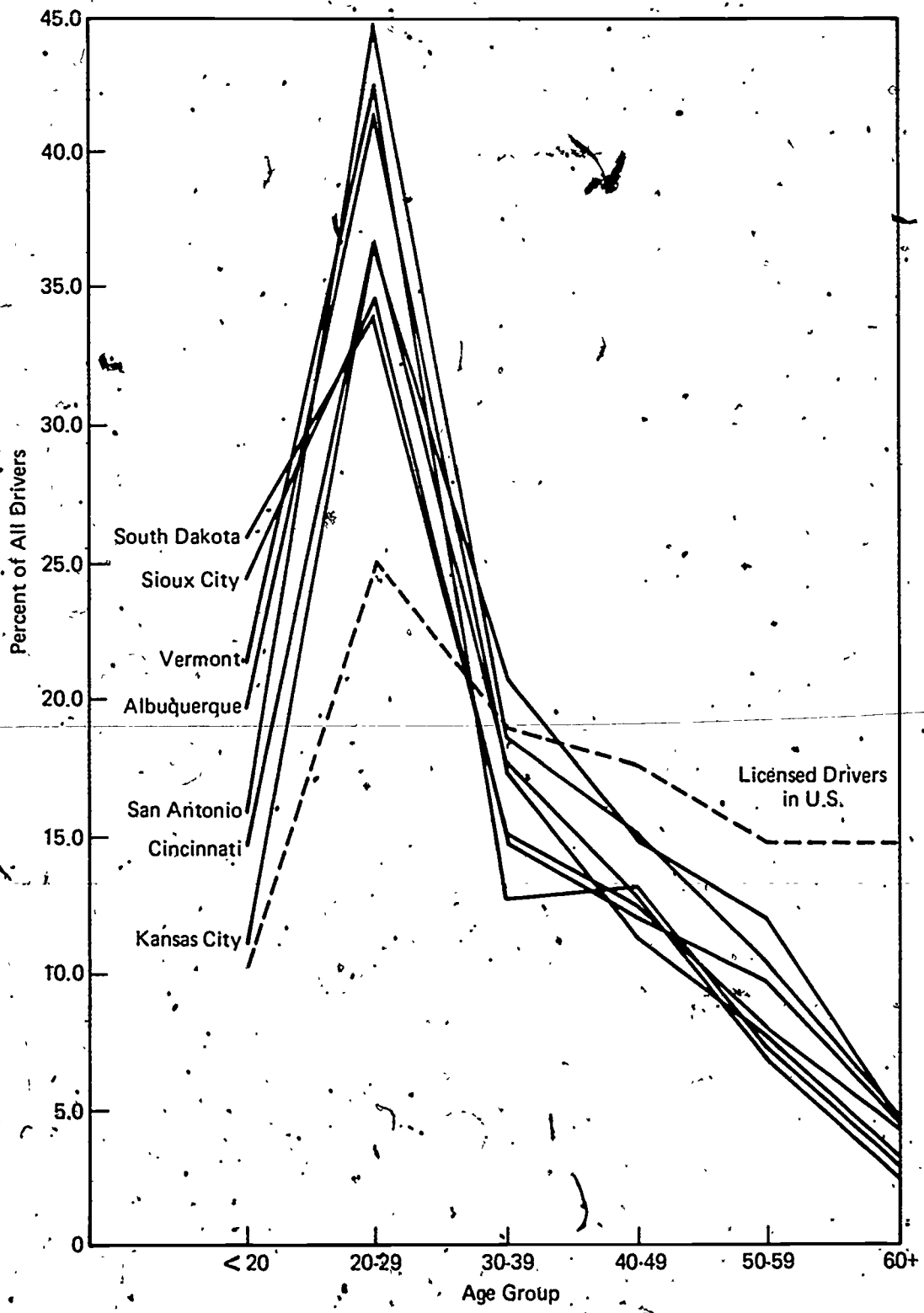


Figure 23. Age Distribution of Drivers Using the Road at Night in Seven Areas in the United States 1971 - 1972 (42)

Reference	Estimated Licensed Drivers in USA (1972)	Vermont	Cincinnati	Sioux City	South Dakota	Kansas City	San Antonio	Albuquerque
Under 20	8.7*	20.9	14.6	24.2	25.9	11.0	15.5	19.3
20 - 29	25.2	42.9	36.5	34.7	34.3	36.9	44.6	41.8
30 - 39	18.2	12.8	18.6	14.8	15.0	20.8	17.5	17.6
40 - 49	17.7	13.2	15.1	12.1	12.5	14.9	11.4	12.2
50 - 59	15.1	7.2	10.4	9.7	8.0	12.0	7.7	6.7
60 & over	15.1	2.9	4.8	4.4	4.3	4.4	3.3	2.4
Total	100.0	99.9	100.0	99.9	100.0	100.0	100.0	100.0
Number	118 Million	522	644	793	814	986	634	863
Proportion of males	55.7	83.7	79.6	80.6	82.1	80.7	86.5	79.4

* All figures except "Number" are in percentages of column total

Figure 24. Age Distribution of Nighttime Drivers Using the Road but Not Involved in Crashes in Seven U.S. Communities 1971-72 (62)

urban areas, such as Cincinnati and Kansas City, and rural areas such as the State of Vermont and the State of South Dakota, they seem to provide convincing evidence that young drivers do indeed drive more in the evenings than would be expected from their numbers in the driver licensed population.

As shown in Figures 23 and 24, the proportion of males among licensed drivers in the U.S. is just under 56% On the other hand, the proportion of males in the nighttime driving population measured at the seven sites summarized in the table varies between 80 and 86 percent. This, of course, is not surprising. The cultural pattern in the United States results in the male driving to nearly all social situations.

The consequences of this exposure pattern are indicated in Figures 25 and 26 which are based on data presented in Figure 27. Presented in these figures are the proportion of fatal crashes for males and females in 1970 as compared to the proportion of males and females in the licensed driver population (41). Two curves are presented for each sex, those crashes that occurred during the day and those that occurred during the night. The figures plotted are the proportion of crash-involved drivers in each age group divided by the proportion of licensed drivers for that age group.

Males under 20 constitute 19.5 percent of the daytime crash population and 8.9 percent of the licensed driver population. Thus, drivers under 20 are found 2.19 times more frequently in the crash group than would be expected from the proportion of the licenses they hold.

As can be seen from these graphs, teenage males and females are over-represented in the crash population for both night and daytime crashes. The extent of that over-representation is approximately equal for day and nighttime crashes. The picture changes quite dramatically, however, for the 20-24-year old group. Here, both males and females experience about the number of daytime crashes that would be expected for their frequency in the licensed population but both are over-represented in nighttime crashes. For the age group 25-34, both males and females are under-represented in daytime crashes, and are represented in nighttime crashes approximately equal to that to be expected from their frequency in the driving population.

From age 35 through 64 both males and females are under-represented in both night and daytime crashes. The elderly, those over 65, appear to be over-represented for both men and women in daytime crashes and for women in nighttime crashes. The over-representation is

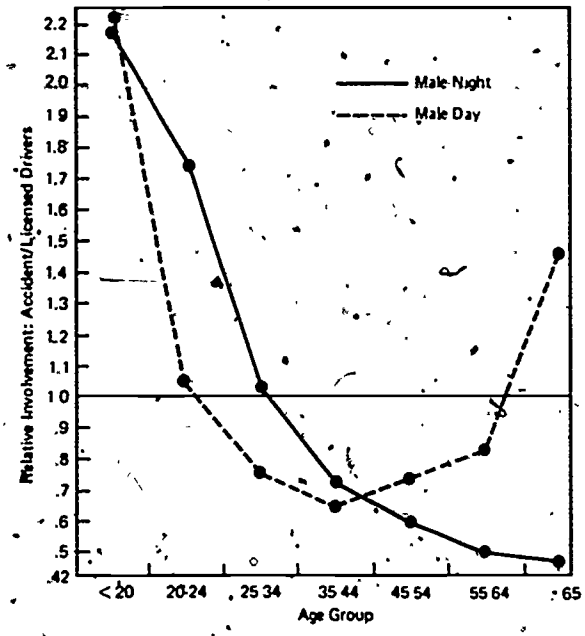


Figure 25. Comparison of Fatal Crash Rates and Number of Licensed Drivers for Various Age Groups (NHTSA National Accident Summary File)

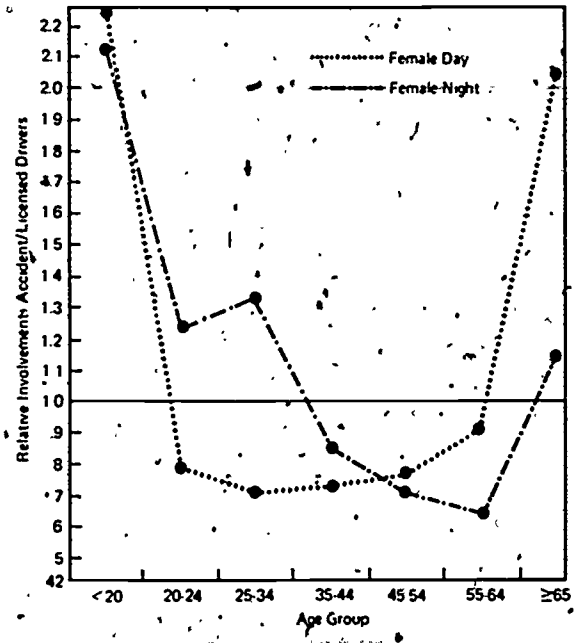


Figure 26. Comparison of Fatal Crash Rates and Number of Licensed Drivers for Various Age Groups (NHTSA National Accident Summary File)

Driver Age	Licensed Drivers in the United States*				Fatal Crashes**							
	Males		Females		Males				Females			
					Day		Night		Day		Night	
	Number in 1,000	% of Total	Number in 1,000	% of Total	Number	%	Number	%	Number	%	Number	%
>20	5,727	8.7	4,557	8.7	2,514	19.5	2,862	19.0	801	19.6	437	18.4
20 - 24	8,720	13.2	7,354	14.1	1,800	13.9	3,731	24.7	453	11.1	412	17.3
25 - 34	13,508	20.5	11,431	21.9	2,020	15.7	3,198	21.2	641	15.6	445	18.7
35 - 44	11,211	17.0	9,473	18.1	1,423	11.0	1,861	12.3	538	13.1	366	15.4
45 - 54	11,048	16.8	9,045	17.3	1,611	12.5	1,531	10.0	536	13.1	291	12.2
55 - 64	8,673	13.2	6,456	12.2	1,427	11.1	1,008	6.7	456	11.1	184	7.7
>65	6,921	10.6	4,071	7.7	2,015	15.6	753	5.0	641	15.6	212	8.9
Unknown	—	—	—	—	97	0.8	157	1.0	31	.8	32	1.3
Total	65,808	100.0	52,386	100.0	12,907	100.0	15,101	100.0	4,097	100.0	2,379	100.0

*Estimate for Total U.S. 1972; NHTSA, U.S. DOT, Nov. 1972

**Data from 33 of 50 States in U.S. in 1970; NHTSA National Crash Data System

Figure 27. Comparison of Fatal Crash Rates With Number of Licensed Drivers for Various Age Groups in the United States

greater for daytime than for nighttime crashes. This may be related to exposure. As noted previously (Figure 23) drivers over 60 are underrepresented during the nighttime hours.

As indicated in Figure 22 the period of highest frequency of alcohol-related crashes occurs just following midnight. Relatively little data are available to contrast the frequency by age group in early evening versus late evening. However, Figure 28 provides some data from the survey in Albuquerque, New Mexico (2). As can be seen, there is some evidence that the 20-24 age group is more frequently found on the road between 1:00 and 3:00 a.m. than between 7:00 and 9:00 p.m. While at the same time, there seems to be a significant decrease through the evening hours in the number of drivers age 30 or above. Drivers under 20 appear to be about equally represented at each hour in the early evening, late evening, and early morning hours.

Thus, the pattern of driving exhibited by young male drivers who do more recreational driving on weekend nights is likely to involve them in alcohol-related crashes quite aside from the extent to which these drivers use alcohol themselves. In this case their involvement is a consequence of the type of driving they do rather than a special sensitivity or lability to alcohol itself. While older drivers may actually drink more, they may do their drinking in circumstances which do not require driving following heavy drinking. For example, older drivers may do more of their drinking in their own homes. Teenagers are generally barred from drinking in their own homes. Dating generally involves visits to dance halls, night clubs and other commercial establishments. Thus, it is to be expected that young drivers may appear to be overinvolved in alcohol-related crashes in relationship to the number of licenses they hold, without necessarily being more sensitive to impairment from alcohol, but rather because of their style of life which involves more driving following drinking.

Age	7-9 p.m.	10-12 p.m.	1-3 a.m.	Estimated Licensed Drivers in U.S. in 1972
15 - 19	17.0	22.4	18.5	8.7
20 - 24	22.1	22.7	31.9	13.6
25 - 29	17.3	16.1	15.6	11.6
Above 30	43.6	38.8	34.0	66.1

Figure 28. Proportion of Drivers in Each Age Group Using the Road but Not in Crashes as a Function of Time of Night in Albuquerque, New Mexico (Figures in percentages of column totals. Total of 863 drivers interviewed) (see p. 51, 2)

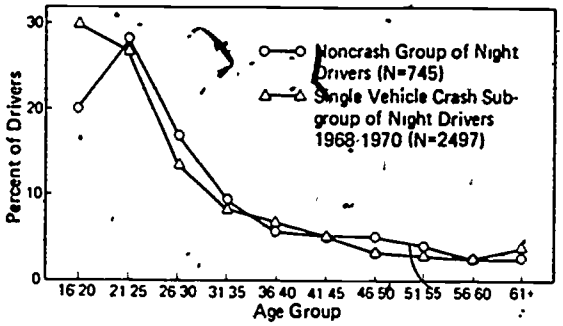


Figure 29: Distribution of Single-Vehicle Crash and Non-Crash Night Drivers by Age Group (15)

The data presented to this point demonstrate that young drivers are over-represented among those drivers using the roadways at night and among those drivers involved in fatal crashes at night. The question arises then whether the over-representation in nighttime crashes is proportional to their over-representation in the population at risk during nighttime driving. Carlson (14, 15) has looked directly at this issue by comparing roadside survey exposure data with the frequency of fatal or severe crashes by age group. These are shown in Figures 29 and 30. These figures present the results of two studies by Carlson of nighttime drivers in Washtenaw County, Michigan. As can be seen in Figure 29, the proportion of single vehicle crash-involved drivers is

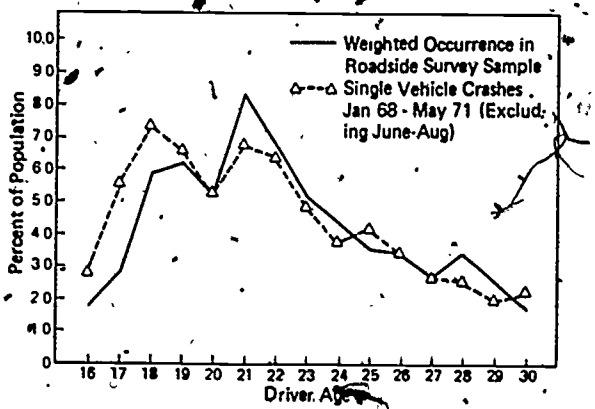
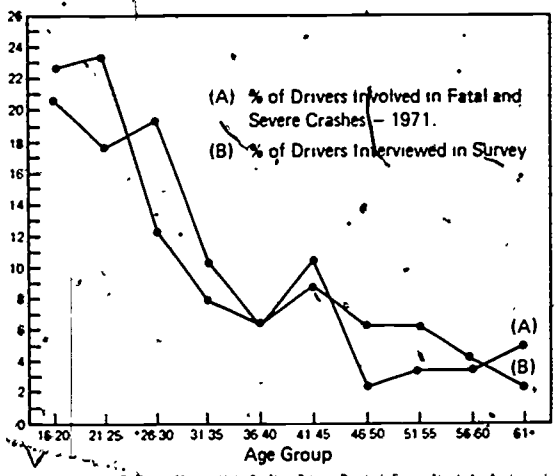


Figure 30. Distributions of Washtenaw County Drivers in Single Vehicle Crashes and in Noncrash Population (14)

almost identical with the proportion of nighttime drivers stopped in their roadside survey for each age group beginning with age 21 and above. Only for drivers from 16-20 do the exposure and crash curves part. In Figure 29 this age group represents 30 percent of the crash population but only 20 percent of the exposed population of night drivers. Another example of a similar curve was presented in a report on the roadside survey conducted by DOT Alcohol Safety Action Project in New Orleans, Louisiana. These data presented in Figure 31 compare the proportion of drivers in each age group stopped in their roadside survey with the percent of drivers by age group involved in fatal and severe crashes for the same year.



Stemmell R, Krause P, Babin M, and Holt G. New Orleans Roadside Survey No. 1 An Analysis of Drinking Drivers. Data Industries, Inc. 1972. Available from the Office of Alcohol Countermeasures, NHTSA, Washington, D.C.

Figure 31. Comparison of the Age Distribution of Drivers on the Road at Night and Drivers in Fatal and Severe Crashes

VII. Comparison of Exposure Estimates for Young Drivers by Three Different Methods

There are two major approaches that have been used to estimate the exposure of drivers. One involves questionnaire data from drivers. These questionnaires attempt to get at the total miles driven by means of a number of different questions which can be cross-referenced and compared to improve the accuracy of the estimates obtained. In general such estimates have tended to indicate that teenagers drive less than older drivers. An example of such data is provided in Figure 32. These data are taken from a study by Walker, et al. (62) in North Carolina.

The second technique is the "Induced Exposure Method" (16). In this procedure the frequency with which drivers in each age group are involved in crashes for which they are judged not responsible is used to estimate their exposure. The assumption being that nonresponsible drivers represent a random sample of the drivers on the road at the times and places of these crashes. A number of investigators have attempted to estimate risks for various driving populations by this method. One of the most detailed of these studies is that by Cerrelli (16). Two graphs from his study are presented in Figures 33 and 34. The first set of graphs compares the relative exposure by age group for males and females for passenger car crashes occurring from 1.00 a.m. to 4.00 a.m. on weekends in urban areas. Exposure index as calculated by Cerrelli involves the percent of innocently involved drivers in each age class over the percent of licensed drivers in that age class. As can be seen, male driver exposure levels are greater than one for all ages below the 35 to 44 age group. Above this level the relative exposure is below one. In drivers over 64, it is approximately one-fifth the exposure which would be predicted from the numbers in this age group in the driving population. The exposure level of male drivers under 20 is approximately one and one-half times the expected level. This climbs to three times expected levels for the 20-24 age group and then falls off again rapidly.

It is interesting to note the difference between male exposure levels and those for female drivers for the same age groups. Female nighttime exposure estimates are (at their highest) about half of what would be expected from their proportion

Sex	Age	Miles Per Week									N	Mean	S.E.
		Under 10	10-50	51-100	101-200	201-300	301-500	501-750	751-1000	Over 1000			
M	25 or less	5%	20%	23%	29%	7%	14%	0%	0%	2%	56	164	24
M	26 - 40	2%	7%	21%	30%	12%	15%	6%	2%	5%	83	264	29
M	41 or more	0%	17%	29%	20%	13%	8%	6%	4%	3%	152	229	21
F	25 or less	8%	44%	24%	15%	7%	0%	2%	0%	0%	58	85	14
F	26 - 40	1%	39%	25%	27%	8%	0%	0%	0%	0%	77	94	10
F	41 or more	12%	42%	20%	18%	7%	1%	0%	0%	0%	86	81	10

Figure 32. Miles Driven Per Week by Age and Sex (62)

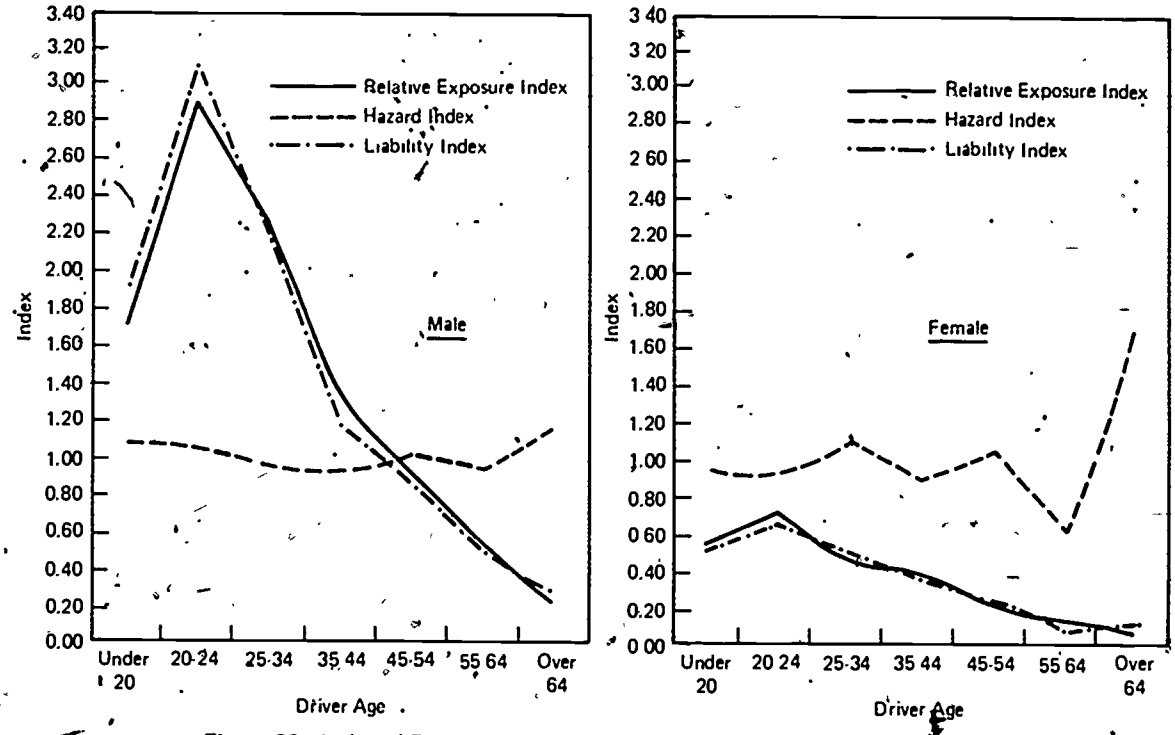


Figure 33. Induced Exposure in Nighttime Driving as a Function of Age (16)

in the population. The second two sets of graphs present data for weekdays from 10.00 a.m. to 1.00 p.m. for urban areas. The difference between the weekday and weekend night graphs for male drivers is striking. The high peak in exposure for the 20-24 age group does not occur. The daytime exposure for the under 20 age group is approximately the same as for the nighttime data, but at all other age periods through age 44 it is less. The exposure level for women is about equal to what would be expected at each age group for their number in the licensed population. Both curves have somewhat U-shaped characters, with increased exposure occurring at younger and older ages for daytime driving.

Figure 35 provides a comparison between exposure estimates calculated by Cerrelli from the data in the National Accident Summary File (41) with roadside survey data from the City of Albuquerque, New Mexico (2). Since the Albuquerque survey data includes both men and women, the proper comparison is with the exposure estimates provided by Cerrelli for passenger cars in urban areas during nighttime, on weekends (16, p. III-55). The Albuquerque roadside survey was conducted in the City of Albuquerque on Friday and Saturday nights between 7.00 p.m. and 3.00 a.m. When the proportion of each age group interviewed in the roadside survey in Albuquerque is divided by the proportion of licensed drivers in the United States for that age group (from Figure 27), the curve shown in Figure 35 is generated. This, in turn, is compared with the Cerrelli curve. As can be seen from these two curves, the Cerrelli exposure estimates run slightly higher at all age levels than do those from the roadside survey data. However, the correspondence between the two curves is striking.

A number of reasons can be advanced for the Cerrelli exposure index curve falling above the roadside survey exposure curve. The induced exposure index is open to the criticism that the nonresponsible population in vehicle crashes is not truly blameless, and therefore not a random sample of drivers exposed to these crashes. To the extent that the nonresponsible drivers are not truly innocent, then the induced exposure index would be expected to be too high. It should be noted that roadside survey data avoid this criticism. The survey population are truly noncontributors, at least at the time measured, to vehicle crashes. Therefore, assuming good sampling procedures, they do represent a random sample of the population using the road at times

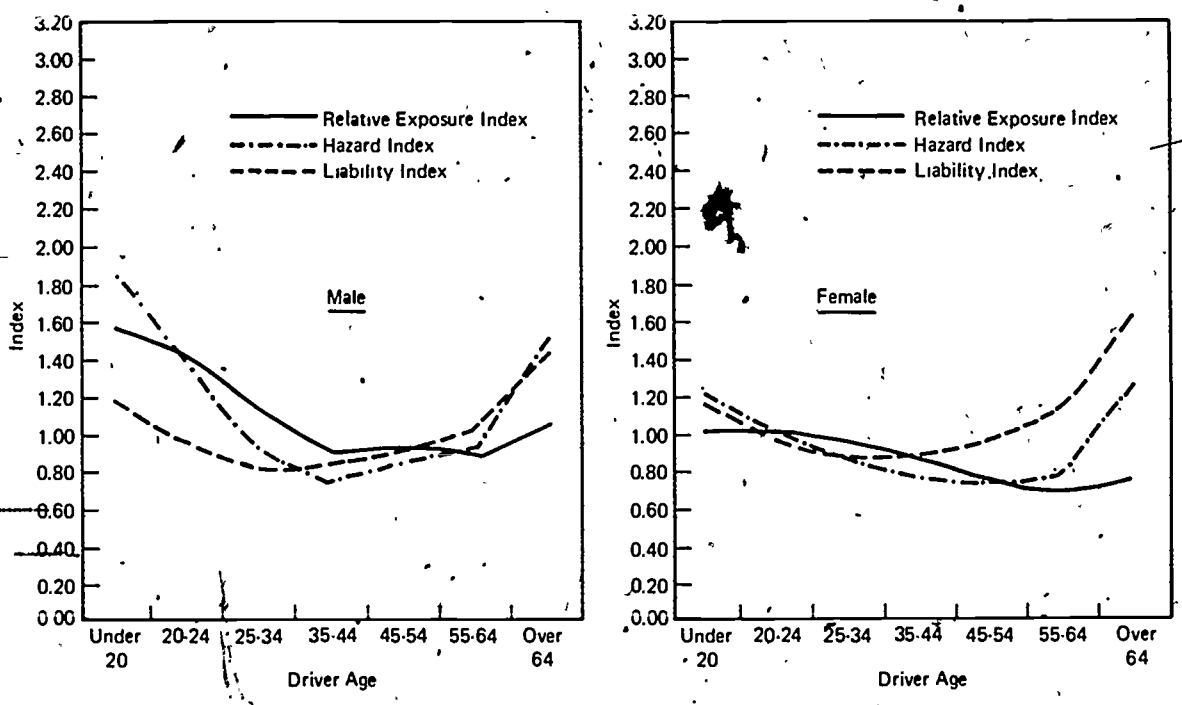


Figure 34. Induced Exposure in Daytime Driving as a Function of Age (16)

and places of crashes. The comparison of these two methods of measuring exposure suggests that the induced exposure method is more realistic than the questionnaire method, but that it does, as would be expected, overestimate the exposure because of the inaccuracies in properly assigning fault (or perhaps because even innocent victims of others contribute to the crashes by failing to take proper evasive action).

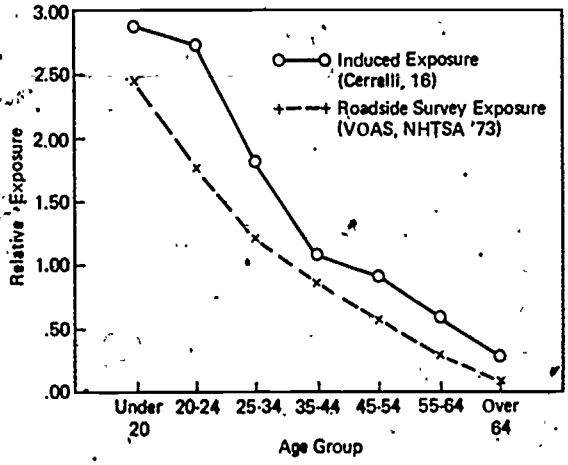


Figure 35. Comparison of Induced Exposure Estimates for Weekend Nighttime Drivers With Roadside Survey Exposure Estimates

Thus, in contrast to questionnaire surveys of the exposure of young drivers, induced exposure studies and roadside surveys indicate that young drivers are more exposed to highway crashes than are older drivers, at least on weekend evenings. However, one feature of this conclusion should be kept in mind. The common understanding of the term exposure is that it refers to conditions *external* to the driver. That is, those factors entering into crashes which relate to the roadway, the traffic, and environmental conditions, and perhaps, to the condition of the vehicle which the individual is using. However, it is possible that the drivers who use the roadways at night differ in significant personal characteristics from those who use the highways in the day. If so, part of this increased exposure is related to personal characteristics, rather than being entirely a function of factors outside the driver.

VIII. Accident Liability Under Alcohol as a Function of Age

A separate issue from the question of exposure just discussed is the issue as to whether given (1) equal driving exposure and (2) equal drug use, the young driver is more likely to become involved in a crash than his older counterpart. No data are available with which to equate driving exposure and drug consumption for drugs other than alcohol. However, there are data available on the relative liability to alcohol as a function of age.

The relative probability of crash involvement as a function of age and BAC level is presented in Figure 36 with data taken from the Borkenstein Grand Rapids Study (66). In it are analyzed the data for crash and noncrash involved drivers as a function of age and BAC. When "accident vulnerability" (crash involvement as a function of exposure) is plotted against age, a U-shaped curve results. "Accident vulnerability" in this figure corresponds roughly with Cerrelli's (16) hazard index in Figures 33 and 34. As this set of curves indicates, at zero BAC 18 and 19 year olds appear to have a slightly greater accident vulnerability than those between 20 and 65. In the 70s the driving risk rises slightly again. The presence of alcohol seems to magnify these trends. Even low levels of alcohol betwen .01% and .04% significantly increase the accident vulnerability of the 18 and 19 year olds and those over 70. However, this level of alcohol seems to cause little increase in accident vulnerability for drivers between 20 and 65. At BAC levels between .05% and .09% the 18 and 19 year olds are even more impaired. In this BAC range there is some evidence of slight impairment at all age levels, and increasing impact again for drivers over age 70. Alcohol has a major impact on accident vulnerability at BAC levels above .10%, but once again these levels appear to be related to age, with the greatest effect occurring for younger and older drivers.

These data suggest that when both driving exposure and alcohol consumption are equated, young drivers as well as elderly drivers are more likely than their middle-aged counterparts to become involved in crashes. These data are compelling in their correspondence with our natural expectations. The young driver, being less experienced and being more emotionally labile and therefore being more prone to taking risks, would be expected to have a higher crash rate, with or without alcohol. At the other end of the scale the elderly driver is more likely to have some deterioration in his physical capability and therefore we would expect a higher crash involvement. The use of alcohol exacerbates these trends. Its apparent effect is to accentuate the weaknesses that are already present, so that its largest effect is upon those segments of the driving population whose normal hazard index is highest and least upon those whose sober crash liability is lowest.

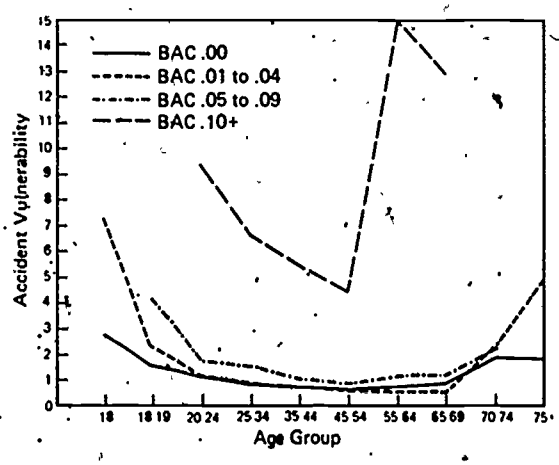


Figure 36. Accident Vulnerability as a Faction of Age and BAC in Men (36)

We must however, be cautious in making such interpretations of these data. Too little is known about the direct effect of alcohol on individuals at either end of this scale. For example, whether alcohol has a greater effect on the young driver because he lacks experience in driving or because he lacks experience in drinking or both has not been determined. There is, however, some information on this issue growing out of the same Grand Rapids Study, Hurst (28) has calculated the relationship between drinking experience and accident liability. These data are presented in Figure 37. In addition to the breath test, Borkenstein and his co-workers were able to collect a small amount of information on the drinking and driving habits of the individuals participating in the survey. From these data it is possible to construct "dose-response" curves for the relative probability of crash involvement at each BAC for individuals who reported that they drank "yearly or less frequently," "monthly," "three times a week," or "daily." As can be seen from the figure, the relative probability of involvement in a crash rises much more steeply for individuals who report they do less drinking. Thus, at a BAC of .06%, the individual who reports he drinks "yearly or less" has a six times higher risk of crash

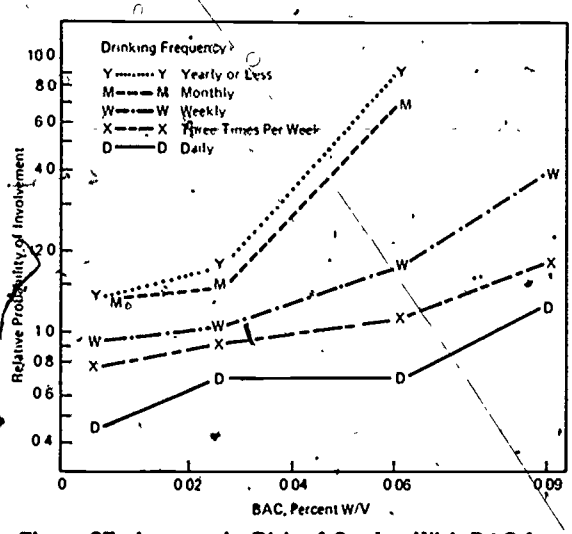


Figure 37. Increase in Risk of Crashes With BAC for Individuals Who Report Differing Drinking Frequencies

involvement than at zero BAC, while the daily drinker at .06% BAC has barely doubled his risk level at zero BAC.

Thus, there appears to be the expected relationship between the amount of experience with alcohol and the probability that a given level of alcohol will result in sufficient impairment to produce a crash. It is probable that teenage drivers consume alcohol somewhat less frequently and in lesser amounts than older individuals. Studies of drinking patterns in the United States indicate that drinking normally begins around age 17 or 18 and that the quantity consumed increases until a maximum is reached at an age between 30 and 40. A part of the explanation, therefore, for increased liability of young drivers to crashes at a given BAC level may be their lack of experience with alcohol.

It is important to keep in mind that there may be many other risk factors confounded with the reported drinking frequency. As indicated in Figure 37, daily drinkers have *less risk at zero BAC* than do yearly drinkers. This must be due to socioeconomic and other factors related to exposure. It is probable that a portion of this effect is due to age, with the less frequent drinkers being represented at both ends of the age continuum, where as indicated in Figure 36 there is an increase in crash vulnerability even at zero BAC. However, the extent of the difference between self-reported drinking frequencies tends to increase as the BAC increases. Thus, the difference in risk between the yearly drinker and the daily drinker is much greater at .06% than at .03% or at zero BAC. It would be expected to be greater still at .09% except that there were too few yearly or monthly drinkers at this BAC level in the Grand Rapids Study. Thus, as Hurst (28) points out, at higher BAC levels the relative probabilities of crash involvement given in Figure 37 are not as high as would be true if drivers with low drinking frequencies were present at these high BAC's. Since yearly or monthly drivers rarely obtain BAC's above .06%, their relative risk does not enter into the overall risk curve at BAC's above this level.

IX. Drinking Patterns and Age in Relation to Crashes

The basic drinking pattern of drivers has generally been considered to be very significant in crash involvement. Alcoholics or problem drinkers are believed to be greatly over-represented in the crash population, not only because they reach higher BAC's, but also because they are on the road more frequently at these high BAC levels. Evidence for the role of alcoholism and problem drinking in the production of highway crashes is based on data from three sources. 1) the relatively high blood alcohol concentrations in crash involved drivers and the relative infrequency with which such BAC's are found in drivers not involved in crashes, 2) the studies of the driving history of arrested drinking drivers and of drivers involved in alcohol-related crashes who have shown a high frequency of previous involvement in alcohol-related traffic and criminal arrests; and 3) the studies of the driving records of diagnosed alcoholics which have indicated a higher crash involvement for this group than for the average driver.

Among noncrash-involved drivers, the proportion of individuals at BAC's of .10% and above is very small, generally running from one to four percent. The proportion of drivers at higher levels is even less frequent. For example, only two nonaccident-involved drivers in a thousand were found by Borkenstein to have BAC's as high as .15%. On the other hand, drivers arrested for driving while intoxicated offenses in the United States normally have an average BAC of approximately .21%. Thus, these individuals represent extremely deviant cases of drinking. Birrell (7) in Australia and Borkenstein (9) in the United States made a study of the typical levels of BAC reached by individuals in social drinking situations. Both of these investigators found that BAC levels of the majority of individuals in the situations they studied were below .08%. Thus, the very high levels found in drivers responsible for fatal crashes and in drivers arrested for drinking-driving offenses are suggestive of a drinking abnormality.

A second line of evidence indicating that problem drinking plays a significant role in alcohol-related crashes comes from studies of the driving records of individuals involved in fatal crashes and of arrested drinking drivers. Several studies have agreed in finding evidence of alcohol involvement in the background of drivers responsible for alcohol-related crashes. Smart and Schmidt (55) in 1967 found that excessive drinkers were three times more prevalent among drivers in alcohol-involved accidents as among those in non-alcohol related crashes. Brown, et al. (10) found that 15 out of 25 drivers killed in traffic crashes could be diagnosed as alcoholics based on interviews with friends and family members. Selzer and Weiss (53) in a similar study found that of 32 responsible drivers in fatal crashes whose BAC's were known, 18 had BAC's above .15% and 17 of these 18 were alcoholics, based on the information they gathered from close relatives of the drivers. Waller (61) in 1967 studied the driving, criminal and social records of drivers responsible for serious crashes and found that approximately two-thirds of these were previously known to social agencies because of an alcohol-related problem.

Studies of convicted drinking drivers show similar results to those of accident-involved drinking drivers. Smith (54) studied a random sample of 100 arrested drinking drivers in Michigan. Based on an interview and a review of criminal, driving, and state hospital records, he concluded that 74% of the convicted drinking drivers demonstrated multiple symptoms of problem oriented drinking.

Waller (61) found that 81% of his group of arrested drunk drivers were known to social agencies because of a problem related to alcohol.

The third indication that problem drinking is related to crash involvement is provided by studies of the driving records of alcoholics. Filkins, et al. (24) found that 27% of a group of 1,247 hospitalized alcoholics had driving convictions on their records. This compared to less than one percent of a random sample of all Michigan licensed drivers. Selzer, et al. (52) studied 50 alcoholic male drivers in comparison to 50 emotionally ill, but nonalcoholic male drivers, admitted to a treatment facility. He found that the alcoholics had approximately twice as many accidents as the nonalcoholic controls. Crancer and Quiring (19) compared 140 chronic alcoholics with nearly 700,000 licensed drivers of the same age and sex distribution in the State of Washington. They found that the alcoholics had significantly more accidents than the control group and were 7.6 times more likely to have arrests for drunken driving on their record. Schmidt and Smart (49) also reported an increased frequency of accidents and nearly nine times the normal number of drunken or impaired driving convictions in a group of alcoholics. Goldberg (27) studied the background history of drinking-driving offenders in Sweden. He found that, of the individuals convicted of drunk driving offenses, 45% could be labeled as alcoholic addicts, alcoholic abusers, or excessive drinkers. This compared to only 8.8% of the total Swedish population in the same category. Selzer (51) in a study in 1963 in Michigan of drunk driving offenders diagnosed 78% of the convicted drivers as alcoholics, probable alcoholics, or prealcoholics.

These studies have led to the belief that problem drinking, and not alcoholism, is a major factor in alcohol-related crashes. Alcoholism, however, is a disease which is primarily diagnosed among the middle-aged. On the other hand, the majority of alcohol-related crashes involve drivers under 30 years of age. This apparent conflict appears to be primarily a matter of definition. Definition of the term "alcoholism" has been a particularly difficult one. Keller (29) has presented a good discussion of the various definitions of this term. Typically, the traditional pattern of alcoholism has not been identified in young individuals. Figure 38 gives the average age for

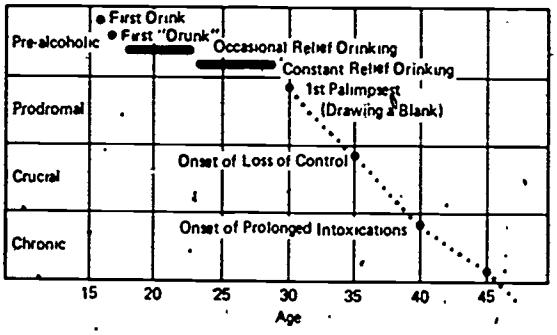


Figure 38. Phases of Alcohol Addiction

the onset of the various stages of alcoholism defined by Jellinek based on a study of members of Alcoholics Anonymous by Trice and Wahl (58). The initiation of drinking for most individuals who later become alcoholics begins somewhat earlier than for the average American. At least a decade or more of heavy, symptomatic drinking generally occurs after the initiation of drinking before the occurrence of the first palimpset (blackout) which marks the initial stage of the prodromal phase of alcoholism. For the group interviewed by Triee and Wahl (58), this symptom occurred on an average at age 30. This is well after the age when the peak percentage of involvement in alcohol crashes occurs.

A clear contrast between the age profiles of hospitalized alcoholics and of those involved in crashes is provided by Clark (17) in a recent study in the State of Michigan. The age distribution of five different groups in this study is shown in Figure 39. Clark compared a group of 1,247 hospitalized alcoholics with a random sample of drivers from the driver license files of the State of Michigan. Also included was a group of 276 fatally-injured drivers and a group of 169 arrested drinking drivers. As can be seen in Figure 39, almost none of the hospitalized alcoholics were under age 25 and the modal age was 46 to 55, whereas the age distribution of the driver fatalities showed a peak in the 20 to 25 period and fell off beyond that point. It is of interest to note that the arrested drinking drivers have an age distribution more similar to that of the alcoholics. This probably accounts for the larger proportion of arrested drinking drivers than of crash-involved drivers who show previous deviant drinking behavior (61). The younger average age of crash-involved drivers has led some to argue that alcoholism cannot be such a major

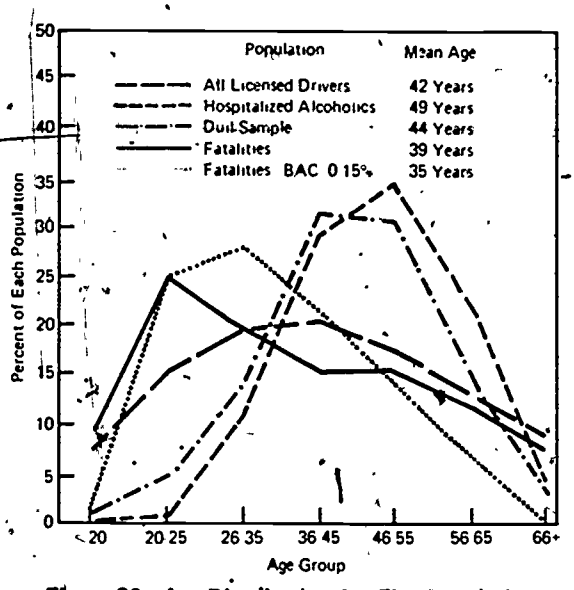


Figure 39. Age Distribution for Five Populations in the State of Michigan (Clark, Hitlab Reports II, 10, 1972) and (53)

feature of the crash problem as has been suggested by investigators such as Waller.

However, youthfulness does not necessarily indicate the absence of a drinking problem. A formal diagnosis of alcoholism tends to be limited primarily to those who actively seek treatment and/or are hospitalized. Because of the process of "denial," individuals with a drinking problem rarely seek assistance or hospitalization until considerable deterioration has occurred in their ability to cope with their drinking problem. Usually pressure must build up from the spouse or employer or because of violations of the law which force the individual to seek treatment. Quite a different age distribution of alcohol problems is presented by a national survey of problem drinking by Cahalan (12). In this survey, indications were sought of problems relating to drinking, such as frequent intoxication, problems with the spouse or relatives, job problems, binge drinking, etc. In this study 21 to 24-year olds showed the largest proportion of individuals with drinking related problems. The frequency of such problems dropped off in the latter half of the 20s and remained level through the 50s. In Figure 40 the age distribution for individuals with an alcohol problem score of seven or more is compared with the age distribution of driver fatalities with a BAC of .05% or greater in the City of Detroit. The similarity of the two curves is striking. Both peak in the age range of 21-24. This suggests that alcohol-related crashes are associated with that period of the drinking history of young men when they are encountering a maximum number of alcohol-related drinking problems. For some individuals this problem period is passed and they return to a more normal drinking pattern in later life. Others continue to experience drinking problems; their drinking becomes more and more symptomatic and ultimately they will be diagnosed as alcoholic. However, this diagnosis is likely to occur much later in life, after the period of maximum exposure to drinking-driving crashes.

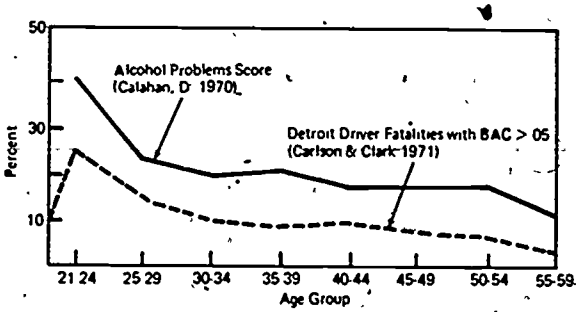


Figure 40. Prevalence of Alcohol-Related Problems and Alcohol-Related Crashes (42)

X. Possible Countermeasures Against Drinking and Driving by Young Drivers

A large number of countermeasures have been proposed and implemented for the problem of drinking and driving by young drivers. However, for the most part these programs have suffered from two major deficiencies. First, the failure to develop a clear model which explains the role which alcohol plays in crash causation frequently results in a failure to develop countermeasures on a logical, systematic basis. Secondly, there has been a general failure to evaluate countermeasure programs with the result that there is little objective information available on which to base new countermeasure efforts.

The need for valid models is well described in the OECD study entitled "Road Safety Campaigns. Design and Evaluation" (63) which devotes a chapter to the discussion of various theories of accident causation. The theories reviewed do not deal with the role of alcohol in crashes and relatively little theoretical work on the way in which alcohol produces crashes has been undertaken. As a result, there is no theoretical framework on the basis of which to develop proposed countermeasure systems. Without such a framework, countermeasures tend to be implemented in a piecemeal fashion based on the apparent "face validity" of the measures, without consideration of the complex nature of the drinking and the driving behavior of young people.

Borkenstein, et al. (9) have pointed to the fact that both driving and drinking satisfy strong basic needs of young people. Both are related to the satisfaction of sexual, status, and other basic personality needs. The availability of an automobile opens special possibilities for young males to meet and be alone with women. Operation of the vehicle permits the male to control the relationship. Thus, for example, it may be quite difficult to persuade the young male to allow the female to drive when he has too much alcohol because, as a driver, he is able to choose the destinations and thereby control the dating situation. It is unlikely that the young lady will drive her date to "lover's lane" or to his apartment. Without a valid model which takes into account the significant needs of the young driver and the role that both drinking and driving play in his life, it is unlikely that we can develop countermeasures which will be fully effective.

One example of an effective countermeasure program which was developed both on the basis of an understanding of the underlying motivation of young drivers and was carefully evaluated was that conducted by Barmack and Payne (5) at Lackland Air Force Base in the United States. The countermeasure program itself was preceded by a detailed study of young airmen who were involved in alcohol-related crashes. This study was able to identify the personality characteristics of the young drivers who were most involved in such crashes. Based on this preliminary study, a countermeasure program was developed designed to change the basic attitude of young males to drinking and driving. The theme of the program was that drunk driving was "sick" (rather than manly) behavior.

This theme, that drunk drivers are sick, was backed by an active mass media education program and by administrative action under which airmen involved in a drinking-driving offense or crash were referred to a psychiatrist and considered for a medical discharge from the service. During the first year of the implementation of this program, crashes by airmen stationed at this base declined dramatically in comparison to a nearby base and to crash levels within the same

state Since this program occurred within a system of military discipline, caution must be exercised in extrapolating these results to young males generally On the other hand, the techniques utilized in the development and implementation of the program provide an illustration of a systematic approach to countermeasure development.

Evaluation of countermeasure programs is a highly technical and difficult problem. Normally, countermeasure programs take place within a milieu of competing influences and it is easy for these extraneous factors to produce changes which confuse or mislead the program evaluator. The previously cited OECD publication on "Road Safety Campaigns: Design and Evaluations" contains a good critical discussion of many of the methodological problems in evaluating countermeasure programs. An outstanding example of effective evaluation of an alcohol countermeasure program was that by Ross (48) of the British Road Safety Act of 1967. A good source of experimental design information appropriate to countermeasure evaluation is the publication by Campbell and Stanley (13).

Some potential countermeasures for drinking and driving by young drivers are described below. For the most part many of these proposals have been fully evaluated and most have yet to be fully implemented.

Limitations on Drinking

Age: One of the most widely applied control procedures is to limit the use of alcohol and/or other drugs by age. This has the advantage that, if it can be enforced, it will remove the proscribed drugs as a problem in all areas of behavior including driving. On the other hand, it is frequently difficult to enforce such laws fully. Young people close to the age limit may be able to use forged identities or the assistance of friends to obtain liquor while still below the legal age limit. Moreover, in countries such as the United States where age limits may vary from one jurisdiction to the next, the presence of a lower age limit in one area may produce additional driving by young people from adjacent areas to this more liberal jurisdiction. This may actually increase the amount of driving following heavy drinking.

Up to the present there has been little useful information on the effectiveness of age limits in reducing involvement by young people in alcohol-related crashes. However, in the United States there has recently been a movement to lower the age at which young people can buy liquor from age 21 to 18. Early reports by police from one state, Michigan, which made such a change, indicated that the number of young people under age 21 involved in crashes in which the policeman judged that the driver had been drinking, had significantly increased. However, such data are suspect, since the police could have been influenced by the implementation of the lower drinking levels themselves, rather than by a real change in the actual drinking driver's behavior. More persuasive were the findings of the roadside surveys conducted by the Alcohol Safety Action Project in Washtenaw County, Michigan, (18) which showed that in comparison to a survey conducted the year prior to the passage of the law, the number of teenage drivers at high BAC levels increased following the implementation of the lower drinking age limit.

As a result of these tentative findings a complete study of this problem has been funded by the U.S. Department of Transportation (21). This study covered thousands of crashes in which young drivers were involved in seven different states. The focus of the study was upon three states, Michigan, Maine, and Vermont, which changed their legal drinking age from 21 to 18 within the last two years. For comparison, two other groups of states were chosen. The first group, consisting of New York and Louisiana, were states which have for many years permitted 18-year olds to drink. The second group, Texas and Pennsylvania, were states which have never permitted 18-year olds to drink. Thus, it was possible to compare the crash experience for drivers in the 18-20 year-old group for states which have never allowed such drivers to drink, for states which have always allowed such drivers to drink, and for states which have recently changed.

When a detailed statistical analysis of the crash involvement of 18-20-year olds before and after the change of laws was made, the study indicates that there was a statistically significant increase in crashes for this age group in Michigan (see Figure 41). Maine also appeared to show an increase. On the other hand, lowering of the

State	Total Crashes 18 - 20	Total Crashes 21 - 45	Had Been Drinking* 18 - 20	Had Been Drinking* 21 - 45	Nighttime Surrogate Measure** (60) 18 - 20	Nighttime Surrogate Measure** (60) 21 - 45
Michigan statewide						
Percent change	5.80	0.81	13.1	2.97	9.99	1.64
Number	684	296	226	184	135	53
Vermont						
Percent change	0.92	0.2	2.73	1.14	1.59	0.75
Number	37	28	8	12	7	8
Main						
Percent change	6.49	-5.07	29.14	5.73	16.42	5.65
Number	158	-621	67	74	44	55

Underlined figures are statistically significant at or beyond the P = .05 level

*Police Notation of "Had Been Drinking" on accident investigation form

**A surrogate measure for alcohol related crashes based on time of day (nighttime) and type of crash (single vehicle) and sex (male)

Figure 41. Percent Change in Alcohol-Related Crashes Following Lowering of the Drinking Age from 21 to 18

drinking age in the State of Vermont had no noticeable impact on youth crash experience.

The most interesting feature of this study is that the scientists who conducted it believe that they have developed a method for predicting whether a given state will or will not show an increase in crashes for young drivers upon reduction of the drinking age. They noted that the State of Vermont which did not show a significant change already had a crash distribution across age groups similar to the State of New York which has always permitted 18-year olds to drink. On the other hand, both Michigan and Maine which did show a change, had an age distribution of alcohol-related crashes among young people which was similar to that of Pennsylvania which has never allowed liquor sales to individuals below age 21. They made the guarded prediction that if Pennsylvania were to lower its drinking age there would be an increase in alcohol-related crashes among teenagers. On the other hand, they predicted that Texas which does have a 21-year old law would not show this change since despite this law, their teenage drinking driving data is similar to New York rather than Pennsylvania.

This study is significant. It provides objective data on what is currently a sensitive and controversial issue. Its results seem to make sense. In those states where teenagers have access to an adjacent state which permits serving alcohol to 18-year olds they develop a pattern of drinking and driving similar to a state which permits 18-year olds to drink, no change should be expected and no change occurs with a reduction in the drinking age. In those states, however, that are somewhat isolated from 18-year old drinking states and which have developed a significantly different pattern of teenage drinking and driving, a change should be expected and does indeed occur.

At best, the total prohibition of teenagers from drinking can only partially deal with this problem since, as indicated in Figure 29, the largest number of nighttime drivers fall in the 21 to 25 age group. No country currently restricts this group from drinking. The application of drinking limits to this age group would meet with major resistance and most likely would not be effective.

Type of Liquor: Age limits on the use of liquor in many of the states in the United States provide for differential treatment of various types of alcoholic beverages. In some states it is possible for young drivers under 21 to purchase beer but not spirits. The effect of such a limitation is unknown in regard to the reduction of

crashes. There is some danger that such laws can mislead the young. Roadside surveys conducted in Vermont (65) indicated that many young drivers believed beer was "safe." Forty-five percent of teenagers believed that they could drink six or more beers and still drive safely. Since a 12-ounce can of beer is equal in alcohol content to a 1-ounce drink of hard liquor, the potential for producing a dangerous level of intoxication is approximately the same.

Amount of Liquor: No major attempt has been made to limit by law the amount of liquor that young people might be able to purchase at one time. The so-called "Dram Shop" laws make the tavern owner or bartender responsible for damages if he serves liquor to someone who is obviously intoxicated if that person is later responsible for an accident. In general, such laws have been ineffective because they are difficult to enforce. It is difficult to prove that the individual was obviously drunk and that the bartender was aware of this. With the development of low cost, inexpensive breath alcohol measuring devices, it is now possible to require that a customer take a breath test prior to purchasing drinks at a bar. Such a law would, of course, encounter major opposition if an attempt were made to enforce it for all drinkers. However, a more limited application to those under 20 as an alternative to a complete prohibition of teenage drinking might be acceptable. While such a procedure would be technically feasible, undoubtedly it would be more difficult to enforce than the current limitations against any sale of liquor to individuals under age 21.

Place of Drinking: Young people tend to frequent certain types of drinking establishments and studies of nighttime drivers have indicated that those drinking in commercial establishments tend to have higher BAC levels than those individuals who drank in their own or other people's homes (15). Stronger controls might be placed over licensing of drinking establishments catering to young people. Such regulations might require that they be located so as to be reachable by public transportation rather than only by private vehicles. Liquor control authorities could also provide additional supervision to ensure that the proprietors are not serving individuals who are under age or those who are obviously intoxicated. Special transportation systems might be provided such as free or low cost taxi service for those who are not fit to drive. However, experience with such driver assistance programs within the Alcohol Safety Action Projects operated by the Department of Transportation in the United States has indicated that they generally are not effective. Drinkers who have traveled to a bar in their own car are unwilling to leave their car behind and be taken home. Those who make use of the taxi service frequently abuse it. They call for the free service to take them to another bar rather than to their home.

Limitations on Driving

It appears that this age group is particularly vulnerable because they are both learning to drive and learning to drink. Thus, this suggests that some benefit might be obtained from separating these two processes. In some countries limitations on teenage drinking have served this purpose at least partially. A similar restriction on teenage driving would, of course, be even more effective in reducing alcohol-related crashes. However, raising the minimum driving age is probably not an acceptable approach to the young driver problem in most industrialized countries because of the requirement for transportation to and from work sites. It has been suggested that with drinking ages being lowered even younger age limits (age 14-15) might be permitted for initiation of driving in order to have greater opportunity for learning driving skills prior to the initiation of drinking. However, as many as 21% of the 14 and 15-year olds admit to using alcoholic beverages (Figure 4). Moreover, the availability of an automobile would probably result in an increase in drinking because of the ability to get away from family restrictions and travel to places where alcohol is served. Thus, the separation of the period of adaptation to alcohol from the period of skill acquisition in driving is probably not practical. To the extent that a society is willing to restrict the mobility of its young people, it can obtain savings in crash losses by delaying the initiation of driving until the individuals are more mature.

Time of Day: The data provided in Figure 26 indicate that young drivers up to the age of 25

were primarily overinvolved in crashes at night time. A limitation in night driving by this group would presumably result in major crash savings. Such a limitation would be difficult to implement since the motor vehicle plays such an important role in the young males social and sexual life. A limitation on night recreational driving would greatly limit his satisfaction of these basic needs. On the other hand, the extension of the driving privilege to teenage drivers is generally justified on the basis of employment rather than recreational driving. It is possible to permit the use of a car by young drivers to get to and from work or in connection with their vocational activities, while at the same time prohibiting its use at nighttime when the probability of involvement in serious crashes is greatest. Such limitations are frequently applied by the courts in the United States to drivers convicted of drunk driving. Enforcement of such restrictions, however, is a major problem for the police. This is particularly true in urban areas since there is such a large volume of traffic on the road and there is no obvious way to know who is driving under such a restriction. To ease the enforcement of such limitations special license plates for vehicles owned by a driver under restriction have been proposed. These might be similar to the learner's tag currently used on vehicles in Britain. Until acceptable means are found which permit the police to enforce such driving restrictions, their usefulness will be limited.

Speed Limitation: Among the dangerous effects of alcohol is its tendency to increase risk taking. Excessive speed is frequently a characteristic of crashes involving young people and studies of fatally injured drivers conducted for the U.S. Department of Transportation by the University of Michigan have indicated that high blood alcohol levels and high speed at the time of impact are correlated in fatal crashes (24). Thus, it appears that a speed limit applied to young drivers might be effective in reducing the number and perhaps the extent of injury resulting from drinking-driving crashes.

Effective enforcement of such a limit would be a serious problem in the implementation of such a countermeasure. This might be done mechanically through a speed governor on the vehicle. The cost of installing, inspecting and maintaining such a device would probably prohibit large scale use. However, for limited application to certain types of offenders this approach might have some benefit.

Vehicle Interlocks: Recently the U.S. Department of Transportation (34) has undertaken a research project directed at the development of an *Alcohol Safety Interlock System (ASIS)*. Such devices are intended to be placed on the vehicle to prevent its ignition by a drunk driver. Currently two basic types of devices are under study. The first of these is a device which measures the psychomotor performance of the driver and permits the starting of the vehicle only if that performance is not significantly impaired. A second procedure is to install a device in the car which makes a measurement of alcohol in the breath and permits the starting of the car only if the driver's blood alcohol concentration is below a preset level. A major concern with both devices is the "false positive" indication which results in a sober driver being prevented from starting his car. Because of the variability of human performance, the performance devices so far developed appear to have too high a frequency of such "false positive" responses. Therefore, current efforts center primarily on the breath test interlock system. Because of the complexity and expense of such systems, it is expected that they will be primarily applicable to individual offenders who purchase or rent these devices as a condition for being permitted to continue to drive. It is not expected that such ASIS devices can be manufactured and placed on all cars at a sufficiently low cost to make them attractive as a general countermeasure.

General Deterrence: Most motorists conform to certain general standards of driving behavior without going through the experience of being penalized for serious infractions of the law. They do this out of a belief in the validity of these rules or out of a fear of the consequences of breaking them. This deterrent effect is dependent upon a number of factors, the most significant being the probability of apprehension. This principle is applicable to the deterrence of young drivers. The primary special factor being the problem presented to the enforcement agency in detecting young drinking drivers. From the data summarized in Figure 39, it appears that the

police are arresting more middle-aged drivers than their involvement in crashes would justify, while arresting fewer young drivers in relationship to their crash involvement. This may result from the higher average BAC levels demonstrated in middle-aged drivers. Enforcement officers need to be trained to detect the young drinking driver. The increasing use of inexpensive roadside breath testing devices may assist police in this activity. These devices can detect relatively lower levels of alcohol than can the police officer who is dependent solely on the behavior of the driver.

Because there is evidence that young drivers become involved in crashes at lower BAC levels (Figure 36), it may also be desirable to have special, lower BAC limits for individuals in this age group. Such a law does exist in the State of New York in the United States. However, no data are available to evaluate the effectiveness of this legislation which provides for a BAC limit of .05% for drivers under the age of 21 in comparison to the BAC limit of .10% for older drivers. Since young drivers appear to be more likely to commit speeding and other driving infractions, a wide use of prearrest breath tests with all drivers stopped at night for moving offenses, together with lower BAC limits for young drivers, would appear to give some promise of apprehending significantly more young drinking drivers. Since there are large numbers of such drivers and since the nighttime drinking and driving activity is an important part of the life style of young male drivers, intensive enforcement will be necessary if the probability of apprehension is to be raised to a high enough level to produce general deterrence.

Specific Deterrence: A second function of the enforcement/judicial system, in addition to deterring the public from committing traffic offenses in the first place, is to mount an effective rehabilitation effort for those actually apprehended. This function can be considered "specific" deterrence directed at the individual offenders themselves. For this group, fines, license revocations and jail sentences have been traditionally viewed as methods of ensuring against repetition of the same offense. Such penalties are probably effective with young drivers who have their drinking well under control and can adjust their behavior to avoid future driving infractions. However, as indicated earlier, problem drinking appears to be a significant factor in the drinking and driving of many young offenders. These problem drinkers have lost control over their drinking to at least some extent. For these individuals it is unlikely that either a general deterrence program or traditional penalties applied once the problem drinkers have been arrested will be effective in preventing recidivism, since their drinking behavior is not fully under their own control. This group requires a special rehabilitation program.

The U.S. Department of Transportation Alcohol Safety Action Projects (ASAPs) (42; Chapter 1) have been aimed at identifying these individuals and ensuring that they get into a rehabilitation activity. Experience to date suggests that, of those arrested drinking drivers coming before the courts in the ASAPs, about one-third are "social drinkers," one-third are "problem drinkers" and a final third are unidentified, falling somewhere in between the first two groups. Special questionnaire and structured interview forms have been developed which permit paraprofessional personnel to identify drinking problems in individuals passing through the courts with reasonably good validity (36). Once identified, these problem drinkers have been motivated to enter one or more rehabilitation programs. A full discussion of the types of schools used and the effectiveness of these treatment programs is contained in the Annual Report of the Alcohol Safety Action Projects (42; Chapter 6). Some of the ASAP programs are both novel and promising. Several programs have demonstrated improved knowledge and attitudes in their graduates. Whether this knowledge and attitude will ultimately be reflected in a lower offense rate by those attending the schools remains to be demonstrated. New rehabilitation programs specifically aimed at young drinking drivers must be developed to fit their special needs.

Mass Media Programs: Safety messages directed at the general driving public have rarely focused on the particular interests and needs of young people. Little information is currently available on the effectiveness of such mass media programs with drivers in general or young drinking drivers. The OECD report on Road Safety Campaigns (63) provides a clear outline for the development of effective mass media programs. The development of the roadside survey technique has provided a new method for designing mass media

campaigns in keeping with the recommendations in the OECD publication. A good example of the use of roadside surveys for the development of a young drinking driver campaign is provided in the report of Worden and Waller (65). To develop their program aimed at young male drivers, they began with a roadside survey which helped them to determine the "target group" (young male drivers) and the critical "target behavior" (heavy beer drinking prior to driving). Through the questionnaires used in the survey they were also able to determine what "appeals" might be made to this target audience (fear of arrest and the increased cost involved in higher insurance rates), and what mass media facilities their target group of young male drivers was most exposed to (drive-in movies, radio and newspapers). With this information, they were able to develop and implement a mass media campaign aimed at young male drivers which was effective in changing their information and attitudes. Roadside surveys also provided a method by which the program could be evaluated. Following the campaign the investigators conducted another survey to determine what changes had occurred in their information and attitude. Thus, the roadside survey technique, by providing access to the specific young drivers at risk in drinking driving crashes, permits both the collection of information on the basis of which to develop improved educational programs and provides a method of collecting data to evaluate the effectiveness of such programs. The Worden and Waller (65) report is a classic example of the use of this technique and provides a model for similar efforts.

Formal Educational Programs: Driver education has become a formal part of the high school educational program for all young Americans. In France a required educational and driver training program must precede the initial application for licenses. Similar educational programs exist throughout most of the western industrialized nations. These programs provide the opportunity to give information on the characteristics of alcohol, its impact upon driving skills, and its relationship to crashes. The effectiveness of driver education in promoting safer driving is much disputed. No evaluation has been made of the effectiveness of the alcohol portion of such educational programs.

Since the use of alcohol, just as the use of the automobile, is a basic part of the whole society, attitudes toward the use of alcohol are developed at an early age—well before the child begins to drink. Consideration needs to be given to including educational material on alcohol and on safety throughout the primary and secondary school program. The U.S. Department of Transportation has funded the development of special materials on drinking and driving to be used in kindergarten through the twelfth grade (1). This approach, which has yet to be evaluated, may help produce improved attitudes toward both the use of alcohol and the automobile among young drivers.

Conclusions

As this brief review of potential countermeasures for young drinking drivers illustrates, there are many possibilities and few demonstrated effective programs. There is every reason to expect that both the number of miles driven and the amount of alcohol and other drugs consumed by young people will increase during the coming years. With increased affluence in western nations young people will do more of the night recreational driving which is highly associated with drinking-driving crashes. It is essential, therefore, that more effort be placed in the development of effective countermeasure programs and that those programs in existence be more effectively evaluated.

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