DRUGS

and

DRIVING

A study of the need for blood and urine
tests for controlled substances, in addition to breath tests,
in enforcement of Minnesota Statutes 169.121, 169.123,
and related laws concerning driving under the influence
of alcohol or controlled substances.

his study is required by Chapter 225, Minnesota Statutes 1987,
and must be submitted to the appropriate committees
of the Legislature by December 1, 1987.

Minnesota Department of Public Safety
Office of Traffic Safety
October, 1987

EXECUTIVE SUMMARY

This report provides extensive extracts from reviews of the scientific literature on drugs and traffic safety, including summaries of what is known about driving impairment from use of drugs. Special attention is given to similarities and dissimilarities of alcohol and other drugs as to:

1. effects on driving performance,
2. identification of particular drugs and drug use by analysis of body fluids,
3. involvement of drug use in traffic crashes, and
4. lack of knowledge concerning extent of drug use (other than alcohol) by drivers and impediments to gaining that knowledge.

Information is provided describing enforcement, testing and evidentiary procedures when a violation of chapter 169.121, subd 1 (b) or (c) is alleged (driving while under the influence of a controlled substance or a combination of alcohol and a controlled substance.)

Breath testing is specific to identifying both the presence and degree of impairment due to alcohol, but has no value in identifying other drugs, except as a negative screening to rule out alcohol as a cause of suspected impaired driving.

Requiring blood or urine testing in all driving-under-the-influence cases would be counter-productive because it would divert both police and laboratory resources and reduce the total amount of enforcement of all DWI laws without enhancing drugged driving enforcement. If blood or urine tests were conducted in all 40,000 annual DWI arrests, the additional cost would be $8,000,000.

The Department of Public Safety recommends that present drug test policies in traffic law enforcement not be changed. This current system provides that drug tests be conducted when there is probable cause to arrest for driving under the influence of a controlled substance but alcohol concentration tests (usually breath) indicate low or no alcohol involvement.

DRUGS AND DRIVING

A study of the need for blood or urine tests for controlled substances, in addition to breath tests, in enforcement of Minnesota Statutes, sections 169.121, 169.123 and related laws concerning driving while under the influence of alcohol or controlled substances.

Introduction

Chapter 225, Minnesota Statutes 1987, amends section 169.123, subdivision 2a, to clarify the circumstances under which tests of a person's blood or urine may be required in addition to a breath test when driving impairment by a controlled substance is alleged.

At hearings of bills on this subject in the 1987 Session of the Minnesota Legislature, some testimony questioned whether enforcement and testing practices tended to obscure the role of drugs and thus to overstate alcohol involvement in driving offenses and accidents resulting from driver impairment.

As one committee member put it, "You mean drugs are giving booze a bad name?"

In floor action on the bill, the following section was added:

> Sec. 3. (STUDY OF NEED FOR ADDITIONAL TESTING FOR CONTROLLED SUBSTANCES.)
>
> The commissioner of public safety shall study the need for requiring persons suspected of driving under the influence, and persons involved in motor vehicle accidents, to submit to blood or urine tests for controlled substances, in addition to breath tests. The commissioner must report the results of the study to the appropriate committees of the legislature by December 1, 1987. The study must evaluate whether requiring testing for controlled substances would:
>
> 1) improve the accuracy of statistics kept by the department on the number of accidents and driving under the influence cases that involve controlled substances; and
>
> 2) increase the likelihood of convicting persons driving

under the influence of controlled substances. (End quote, Chap. 225, 1987)

This report is provided in response to that legislative requirement. The Department of Public Safety shares a concern that public policy and law enforcement in the area of drunken or other drugged driving is based on the best information available, both as to the scope of the problem and the means of meeting it.

In 1978 Congress required the U.S. Department of Transportation to conduct a similar study of "marijuana and drug use by motor vehicle operators". In 1980 the National Highway Traffic Safety Administration (NHTSA) responded by publishing A Report to Congress:

Marijuana, other Drugs and Their Relation to Highway Safety.

This report, based largely on a study, "Drugs and Highway Safety," Joscelyn, Donelson, Jones, McNair and Rerschmann, University of Michigan, Ann Arbor, 1980, prepared for the U.S. Department of Transportation, provided a comprehensive review of what is known about the issue of drugs and driving, including research on the incidence of drug involvement in driving, the degree to which driving may be impaired by various usage levels of different drugs, and the involvement of drug-using drivers in accidents. In 1985 NHTSA published The Incidence of Driving Under the Influence of Drugs 1985: An Update of the State of Knowledge, reviewing research conducted since the 1980 report to Congress.

This report to the Minnesota Legislature draws heavily on those NHTSA publications because they are an excellent description of the issue and offer a framework for consideration of it. Before providing Minnesota data and considering Minnesota enforcement and testing practices and policies, this paper will provide substantial extracts from these national studies and other information sources.

WHAT DO WE KNOW AND WHAT DO WE THINK WE KNOW ABOUT DRUGS AND DRIVING?

From the introduction to "A Report to Congress: Marijuana, other Drugs and Their Relation to Highway Safety 1980:

> For the purposes of this report, the existence of a drug and driving problem has been presumed. However, the nature and magnitude of the problem are not known. The belief that drugs other than alcohol alone may contribute to the traffic crash risk stems from three pieces of information. First, many drugs have the potential to impair driving skills. Second, many people who drive use such drugs. Third, alcohol, which is a drug that impairs driving skills and which is widely used by the driving population, has been shown to increase the risk of traffic crashes. In fact, it is the alcohol-crash problem that has sensitized people to the potential for other drugs to also be a traffic crash risk.

From "Drugs and Highway Safety" Joscelyn et al, 1980:

> **THE ALCOHOL AND HIGHWAY SAFETY EXPERIENCE: RELATION TO DRUGS AND DRIVING**
>
> No report on the relationship between drugs other than alcohol alone and highway safety can neglect mention of the alcohol-crash problem--its definition and approaches taken to reduce losses from alcohol-related crashes. Not only are other drugs often used in combination with alcohol, but the alcohol and highway safety experience has greatly influenced both research on other drugs and societal responses to the perceived drug and driving problem.
>
> Alcohol is one of many drugs, but unique in a chemical sense and in its use. Unlike most modern psychoactive drugs, the discovery of alcohol, its use, and (probably) its misuse lie beyond historical reach. Both praised and reviled, the effects of alcohol consumption predate modern transportation; patterns of drinking behavior were not superimposed on driving, but vice versa. The advent of the private automobile simply added driving performance to alcohol's potential to impair human behavior. The same cannot be said for most other drugs.
>
> Basic attitudes toward alcohol still influence societal responses to the drinking-driving problem. The alcohol-crash problem has, therefore, a social psychological dimension that extends beyond the scope and practice of highway safety per se (Cisin 1963). This dimension is shared, perhaps, by problems with some controlled substances, whose "recreational" use may have adverse consequences for traffic safety. Therapeutic drugs have another dimension--their accepted use for treatment of medical conditions. Nevertheless, the alcohol and highway safety experience represents a background against which all other drugs are scrutinized.

Reviews of alcohol and highway safety have documented the history and present state of knowledge about the alcohol-crash problem (Goldberg and Havard 1968; U.S. Department of Transportation 1968; Perrine 1974; Organization for Economic Co-operation and Development 1978; Jones and Joscelyn 1979; U.S. Government Accounting Office 1979). Other reviews have critically evaluated studies of the effects of alcohol on human performance related to driving (Wallgren and Barry 1970; Perrine 1973; Levine, Greenbaum, and Notkin 1973; Perrine 1974). It is not the purpose of this section to summarize the present state of knowledge of the alcohol-crash problem. Rather, the intention is to discuss key elements of the alcohol and highway safety experience in relation to drugs and driving. The following subsection briefly outlines the history of alcohol and highway safety. A subsequent subsection discusses its implications for drugs and driving.

THE PERCEPTION OF AN ALCOHOL-CRASH PROBLEM AND RESEARCH TO DETERMINE ITS MAGNITUDE

Given the social climate of the early 1900s, it is hardly surprising that alcohol immediately became suspect as a factor in traffic crashes. Observations of alcohol's role in highway mishaps were forthcoming as early as 1904 (The Quarterly Journal of Inebriety 1904). By the 1930s, amid increasing concern over the magnitude of the drinking driving problem, the scientific study of the problem was defined and advocated (Heise 1934). Basically, two approaches to define the alcohol-crash problem, experimentation and epidemiology, were supported by a third: measurement of the **amount** of alcohol in the body. This was consistent with the fact that the mere presence of a substance in the body is necessary but not sufficient evidence of its effect.

A proven and useful variable, **blood alcohol concentration** (BAC), describes the amount of alcohol contained in a given volume of blood. Early technical advances in analytical chemistry supplied numerous qualitative and quantitative chemical tests for alcohol. Armed with this methodology, researchers proceeded (1) to establish the overinvolvement of alcohol in traffic crashes compared to samples of nonaccident driving populations; and (2) to correlate the **effects** of alcohol on measures of human performance related to driving and its **concentration** in body fluids. The development of chemical tests of alcohol in breath as an accurate estimate of BAC, increases the ease with which data on the alcohol-crash problem accumulated.

EFFORTS TO DEAL WITH THE ALCOHOL-CRASH PROBLEM

As evidence emerged that alcohol was a highway safety problem, countermeasures were developed and implemented. Laws were passed prohibiting alcohol-impaired driving. As chemical tests to measure alcohol levels in the body became more widely available and, importantly, as information correlating the effects of alcohol with its levels in the body was scientifically established, test results were accepted in criminal trials as evidence of impairment. More recently statutes have been passed that make it illegal per se to operate a motor vehicle with a concentration of alcohol in the body above a certain amount.

At the same time, education and information efforts were undertaken to establish a public knowledge base about alcohol and highway safety. This was done to deter people from driving unsafely and to create public support for actions against those who drove while impaired. Sanctions against those convicted of alcohol-impaired driving included the traditional sanctions of fine and imprisonment, driver license suspension and revocation, and referral to health and education programs. The last approach has been characterized as the health/legal approach.

The development of countermeasures and responses to the alcohol-impaired driver has been primarily a state and local effort. Since 1966 the federal government, through the efforts of National Highway Traffic Safety Administration (NHTSA) and National Institute on Alcohol Abuse and Alcoholism (NIAAA), has played a significant role in both stimulating and supporting state efforts. The federal role continues today.

Despite the federal, state, and local efforts, alcohol continues to be a major highway safety program. Its nature and magnitude can be estimated but is not fully defined. Approximately forty to fifty-five percent of the drivers involved in fatal crashes have alcohol concentrations in excess of .10% w/v-the legal limit for alcohol-impaired driving in most states. Comparable figures for personal injury and property damage crashes are nine to thirteen percent and five percent, respectively. Such data in the past have been inaccurately generalized to statements that fifty percent of traffic crashes are caused by alcohol. Such statements are not true, but alcohol is clearly a significant highway safety problem.

The magnitude of the alcohol problem can be estimated and a foundation has been established for actions to reduce the alcohol-crash risk because extensive study of the problem has occurred over many years. Despite the present advanced state of the knowledge about alcohol and highway safety, it remains a highway safety problem. Our knowledge about drugs and driving is much less. The alcohol and highway safety experience demonstrates that

alcohol and drugs other than alcohol are major societal problems. The problems are long-term in nature and will require an equally long-term view to address them. These and other highway safety problems are best perceived and addressed in a broad public health context.

IMPLICATIONS OF THE ALCOHOL-HIGHWAY SAFETY EXPERIENCE FOR RESEARCH AND OTHER ACTIVITY CONCERNING OTHER DRUGS

The incomplete, skeletal outline of the alcohol-highway safety experience presented above hardly does justice to the large body of available information. Nevertheless, it does provide some basis for comparing alcohol and other drugs. These comparisions have strong implications for the conduct of research on drugs and driving and the development of countermeasure programs.

The 1926 Uniform Vehicle Code listed "narcotic drugs" and "habitual users of narcotic drugs" under its model statute dealing with driving under the influence of intoxicating liquor. In 1944, the Code was revised to include persons driving under the influence of nonnarcotic drugs, including therapeutic drugs legally used (National Committee on Uniform Traffic Laws and Ordinances 1972, p. 613). But prior to 1960, little interest in possible highway safety problems due to other drugs was expressed. Three trends in the use of psychoactive drugs probably account for the (relatively) recent and growing concern over other drugs and highway safety.

1. the continued development and widespread use of novel psychoactive drugs for the medical treatment of physiological and psychological conditions;

2. the tremendous increase in the nonmedical use of drugs (including the misuse and abuse of licit, therapeutic agents and the illicit use of other chemical substances such as marijuana and PCP); and

3. the combined use of alcohol and other psychoactive drugs, both licit and illicit.

The known effects of these drugs combined with their widespread use in a mobile, car-loving society are prima facie evidence that a drug and driving problem exists. But whereas the alcohol-crash problem has been known and studied for over half a century, drugs and driving as a recognized area of highway safety is comparatively new and underdeveloped. Its cadre of full-time investigators is few in number and spread thin over research covering literally hundreds of drugs. Unlike the well-funded, coordinated efforts devoted to alcohol, research on other drugs is fragmentary, often cursory, independent, widely scattered, and mostly

experimental, and the results of research projects are rarely comparable. Though much has now been published, little is known about the nature and extent of the drug and driving problem.

One researcher ascribed the "prolonged infancy" of drug and driving research to the large number of drugs to be considered and to the need for technological innovations in toxicology and bicochemistry (Smart 1977). Recent developments in drug analysis and the identification of limited sets of drugs of interest (Willette 1977; Joscelyn and Donelson 1980) address these constraints. But differences among alcohol and other drugs should temper expectations of sudden maturity in research on drugs and driving.

Table 2-2 compares alcohol with "other drugs" in terms of their chemistry, pharmacology, use, and availability. Dissimilarities have implications for the kind of highway safety risk indicators that are developed as well as for possible preventive measures that are applied. For example, alcohol's physical and chemical properties permit its detection and quantitation in body fluids by relatively simple, inexpensive tests. The content of alcohol in breath is proportional to its concentration in blood, and noninvasive techniques are used to identify persons driving under the influence. Analysis for other drugs, which are more complex structurally and less volatile, requires specimens of blood for meaningful judgment about possible drug effects--physiological, psychological, or behavioral. Relationships between concentrations in the blood and effects are much more complex for drugs other than alcohol; threshold concentrations of drugs that impair driving performance have not been determined other than for alcohol. Even for alcohol, relatively high concentrations are required before the statement that **all** drivers are impaired can be made. Toxicologic results indicating polydrug use are even more difficult to interpret, since a quantitative understanding of combined drug effects is lacking. **In summary, the ability to detect and quantitate drugs in body fluids exceeds our present knowledge of what these measurements mean.**

TABLE 2-2

COMPARISONS BETWEEN ALCOHOL AND OTHER DRUGS

Alcohol	Characteristic	Other Drugs
Single chemical entity	CHEMISTRY	Numerous, diverse chemical entities, some substances (e.g., marijuana, opium) are complex natural products. There are many different classes of drugs.
Small, simple molecule		The chemical structure of most other drugs is complex.
A general depressant that may have both excitatory and inhibitory effects (biphasic action). The effects are dose and time dependent.	PHARMACODYNAMICS (effect of a substance on the body)	Most drugs have more selective action than do general depressants. There are a wide range of effects: depression, stimulation, analgesia, hallucination, antianxiety action, etc. Also dose and time dependent.
Tolerance and dependence		Tolerance and dependence are seen for some drugs or classes of drugs. Some drugs shown enhanced potency with chronic use.
It is absorbed rapidly, distributed like total body water (at equilibrium), enters metabolism of the body (energy source), and is excreted in the urine and breath	PHARMACOKINETICS (effect of the body on a substance)	Pharmacokinetics of other drugs is much more complex. Great variations from drug to drug in the rates of absorption, distribution, metabolism, and excretion. Most drugs are present in the body in both active and nonactive forms. Other drugs are metabolized primarily in the liver. Compounds with pharmacologic activity can be produced from the parent drug (active metabolites). Most drugs (or their metabolites) are excreted in the urine or bile. Due to low volatility, almost all other drugs are not found in the breath in significant amounts.

TABLE 2-2

COMPARISONS BETWEEN ALCOHOL AND OTHER DRUGS

Alcohol	Characteristic	Other Drugs
The most common use is recreational (e.g., social drinking), but other patterns exist, including alcoholism.	USE OR EXPOSURE in the general or driving population	Patterns of use for drugs include: recreational (e.g., marijuana, cocaine), therapeutic, illicit use or misuse of therapeutic drugs, and self-medication.
Its use is widespread with general acceptance of alcohol use but not of abuse. The frequency and quantity of use varies from heavy drinking to infrequent consumption. Only about 30% of the general population abstains from alcohol use. Available through relatively loosely controlled retail outlets (like an "over-the-counter" drug) with age limits for purchase.	AVAILABILITY	Almost all drugs are much less-widely used than alcohol. The therapeutic use of drugs, but not their nonmedical use, is sanctioned by law. Patterns of drug use are not well defined for most drugs. Federal and state governments regulate production, marketing, and availability of controlled substances, as well as most other drugs. Licit drug distribution is through the health-care system (primarily through physicians and pharmacists) while illicit drug sales are through "street marketing" (e.g., marijuana).
Alcohol users reflect the total population (in terms of age, socio-economic level, etc.).	USER POPULATION	The characteristics of the drug user population varies according to the drug and its legal status.
There are relatively simple tests available to detect and quantitate the amount of alcohol in breath, blood, urine, and other body substances. Alcohol, which is present in relatively large amounts, can be analyzed using portable breath-testing instruments.	CHEMICAL TESTS on body fluids or breath	Analysis is relatively complex for almost all controlled substances. Instrumentation is expensive and nonportable. Presently, blood specimens are required to determine amount of drug present in the body. Only minute quantities of these psychoactive drugs are required to produce measurable effects.

Differences between alcohol and other drugs extend to their availability, use, and legal status. Alcohol is freely available and used to some extent by over sixty percent of the U.S. population. No other single drug--with the exception of caffeine, a noncontrolled substance-is used by as great a proportion of the

population. Nevertheless, the level of use of controlled substances in general may approach that for alcohol (e.g., Brecher 1972). Unfortunately, as noted elsewhere (Institute of Medicine 1979; U.S. Department of Health, Education, and Welfare 1979), comprehensive data on the use of controlled drugs--medical and nonmedical--is not available and accurate estimates are rarely, if ever, possible. In contrast to that for alcohol, the production, marketing, and distribution of other drugs are more tightly regulated. Some substances, such as marijuana, are simply prohibited, except for use in research conducted according to federal regulations. The more complex and formal delivery systems for drugs other than alcohol appear to offer more intervention points for countermeasure action (e.g., scheduling or rescheduling substances) than presently feasible for alcohol use.

One element of the alcohol and highway experience cannot be overemphasized: **blood alcohol concentration** (BAC). As an objective measure of alcohol presence and effect, BAC has enabled epidemiologic research to demonstrate a strong association between alcohol and traffic crashes; the higher a person's BAC, the more likely a traffic crash will occur. BAC has also enabled experimental research to establish relationships between the amount of alcohol consumed and likely impairment of driving behavior.

BAC equivalents do not now exist for any other drug. Research aimed at developing BAC equivalents for some other drugs (behavioral, pharmacokinetic studies) is ongoing; however, present knowledge about the relationship between concentrations of drugs (other than alcohol) in body fluids and their effects on behavior holds little hope for quick development of BAC equivalents. Today, for example, interpretation of drug concentrations in body fluids is at best an art and at worst impossible. Because measurement of BAC has been so important to alcohol and highway safety, research and countermeasures developed for alcohol may not be appropriate for other drugs. Nevertheless, many drug countermeasures, both proposed and implemented, are patterned after approaches used to deal with the alcohol-crash problem.

SUMMARY

The relationship between drug use by drivers and problems in highway safety has not been defined. The state of knowledge about drugs and driving is limited, despite numerous reports that drugs can impair driving skills and may increase the likelihood of traffic crashes. Although available evidence does not establish that drugs other than alcohol are priority concerns in highway safety, present information does warrant further inquiry.

Research to define the drug and driving problem is complicated by many factors, among them the therapeutic use of most drugs and the

trend toward multiple drug use. Both experimental and epidemiologic research are required to define the problem. In particular, studies comparing the prevalence of drug use among accident- and nonaccident-driving populations are needed to describe the association between drugs and traffic crashes.

Countermeasure approaches to reduce highway safety problems due to drug use by drivers correspond to those for alcohol. Development of countermeasures for other drugs is constrained by the lack of information on the kind of drugs or the groups of drivers that should be targets of action programs.

Research and development of methods to support efforts both to study and to deal with the drug and driving problem are also required, including:

- valid and reliable behavioral methods to measure the effects of drugs on skills related to driving, and to detect drug-impaired drivers;

- sensitive analytic methods to measure the presence and amount of drugs in body fluids; and

- methods to support specific countermeasures aimed at the drug and driving problem.

The most studied drug and driving problem--the alcohol-crash problem-influences approaches to research and countermeasures for other drugs. The alcohol and highway safety experience provides a perspective for viewing the drug and driving problem, but difference between alcohol and other drugs indicate that all elements of that experience may not be applicable to drugs. The pivotal role of blood alcohol concentration (BAC) alone suggests that some approaches to dealing with the alcohol-crash problem cannot be used effectively for many other drugs.

From "A Report to Congress: Marijuana, Other Drugs and Their Relation to Highway Safety" 1980:

THE FREQUENCY OF DRUG USE BY DRIVERS AND ITS RELATION TO HIGHWAY SAFETY

The present focus of research on drugs and driving is to determine the frequency of drug use among drivers and its consequences for highway safety. Two approaches, experimentation and epidemiology, have been used to study the drug and driving problem. Within each of these general approaches are many methods to obtain data linking drug use and highway safety problems.

This chapter summarizes the present state of knowledge and presents recent findings along with a critique of past research.

THE STATE OF KNOWLEDGE

Briefly stated, the **extent** to which drugs contribute to problems in highway safety is unknown. Despite an ever expanding body of literature, the state of knowledge of drugs and driving remains limited. Reviewers of research linking drugs and highway safety (Perrine 1975; Joscelyn and Maickel 1977a; Willette 1977; Organization for Economic cooperation and Development 1978; Seppala, Linnoila, and Mattila 1979; Joscelyn, Jones, Maickel, and Donelson 1979; Nichols 1971) have generally concluded that definitive studies are lacking. Nevertheless, the available evidence indicates that some drugs at certain dosages can impair driving skills, that certain drugs may increase the likelihood of traffic crashes, and therefore further inquiry is warranted.

Research and police investigations have documented drug involvement in specific crashes and have led to the conclusion that drug-impaired driving has been a causative factor in some crashes. Drivers are regularly-but relatively infrequently-detected, arrested, prosecuted, and convicted for drug-impaired driving. These specific instances lend credence to the belief that a drug and driving problem exists. Unfortunately, the magnitude of the drug and driving risk is unknown, and it must be established before drugs and driving can be justifiably termed a highway safety problem and a priority for its resolution established. The evidence to date has not established that drugs other than alcohol should have high priority among highway safety concerns.

RESEARCH FINDINGS: EPIDEMIOLOGY

Epidemiology in drugs and highway safety attempts to determine whether the use of drugs increases the likelihood of a traffic crash. One aim of epidemiologic research is to identify which drugs and which drivers should be targets for countermeasure action.

Epidemiologic studies of drug use among drivers include:

- the chemical analysis of drivers' body fluids (blood) for the presence and amount of drugs;
- questionnaires that obtain self-reported data from drivers about their use of drugs; and
- examination of driving records of those who use drugs.

Studies that do not include the analysis of drugs in body fluids are not considered valid and reliable indicators of the drug and driving problem. Because it is not possible to positively identify that drugs were present, results of these studies do not provide an adequate basis for defining the relationship between drugs and highway safety.

In addition to research studies, some police agencies and offices of medical examiners or coroners compile data on traffic cases involving drugs. Because all eligible cases are not reported or because a single local area is represented, these findings do not support general statements about drugs and driving. Nevertheless, we must place a certain degree of reliance on them because of the lack of valid information on drug use among drivers.

Definitive studies would be those which compare the incidence of drug use among accident-involved drivers with a suitable companion group of non-accident-involved drivers. Without this comparison, findings of drug use among drivers involved in crashes or arrested for impaired driving cannot be interpreted to indicate the danger posed by drugs. Studies using suitable control groups have not been done to date, because of the Department of Transportation's desire to reduce inconvenience to the public (e.g., trip delay, being asked to give volunteer body fluid samples). However, after conducting a number of workshops attended by experts from both the public and private sector, DOT is convinced that there is no viable alternative to roadside surveys.

MARIJUANA

Until recently, the lack of chemical tests to detect marijuana use limited marijuana and driving studies to indirect approaches. A questionnaire study in Canada found that about one-fourth of 246 students, at least once in the preceding year, drove after using marijuana (Smart 1974). However, the length of time between using marijuana and driving was not determined. In the United States, a similar proportion of students reported driving after marijuana use (Mortimer 1976).

Information obtained through interviewing friends and relatives of drivers judged responsible for a fatal accident led Sterling-Smith and Graham (1976) to conclude that 43 out of the 267 drivers were under the influence of marijuana. Since the data were obtained by interviews, the only conclusion that can be drawn is that the people interviewed believed that the drivers had used marijuana. It is not possible to determine without an analysis of the blood, which was not available at the time, whether in fact the drivers had been under the influence of marijuana just prior to the accident. This study, widely cited in the popular literature, is among those which indicate a potential marijuana problem.

However, the percentage of marijuana-involved accidents reported in this study cannot be accepted as a valid indicator of the extent of marijuana involvement in fatal accidents.

The development of chemical tests for presence of marijuana has led to more direct evidence linking marijuana and highway safety. Teale et al. (1977) reported that blood specimens from 6 of 66 car and motorcycle drivers contained cannabinoids (chemicals derived from marijuana). Reeve (1979) reported on chemical tests for delta-9 tetrahydrocannabinol (THC), an active agent in marijuana, in blood specimens from 1,792 California drivers who were arrested for impaired driving. Of these, 285 (16%) tested positive for THC. This cannot be interpreted to mean that any or all of these drivers were impaired by marijuana. Only 45 of those 285 (2.5% of the 1,792 total) tested positive for THC alone; the remaining 240 also tested positive for alcohol, with 100 having greater than 0.10% w/v BAC, the legal limit of impairment. Finally, the largest percentage of specimens positive for THC were from drivers aged forty to sixty-one years, a pattern contrary to usage among age groups determined by numerous questionnaire-based surveys.

Information on the frequency of marijuana use by drivers and its contribution to traffic crashes is as yet sketchy. Preliminary research has produced limited data that have been widely quoted to mean that 16% of traffic crashes involve marijuana as a contributing factor. It is believed that more realistic estimates take into account: (1) the combined use of marijuana and legally impairing levels of alcohol, and (2) the uncertain meaning of low levels of marijuana constituents in blood. At present, the presence of detectable amounts of marijuana constituents after observable behavioral effects have ceased precludes definite interpretation of analytical results in terms of driver impairment.

SEDATIVES AND HYPONOTICS, INCLUDING ANTIANXIETY AGENTS

Sedative-hypnotic drugs include barbiturates and nonbarbiturates. Those antianxiety agents which have similar effects are primarily represented by benzodiazepines, diazepam (Valium (R)), chlordiazepoxide (Librium (R)). Most studies are reported by forensic laboratories investigating cases of traffic deaths or impaired driving. For example, White et al. (1979) found that 358 (29.6%) of 1,819 impaired drivers suspected by the police of being impaired, but who had less than the legal limit for alcohol, had these drugs in their bodies. In a group of drivers arrested for driving under the influence of drugs (DUID), Garriott and Latman (1976) reported that 97 of 135 drivers had used one or more drugs other than alcohol alone; almost all positive finds were sedative-hypnotic or antianxiety agents. A lower incidence of these drugs has been found in fatally injured drivers. Garriott

et al. (1977) described twenty-three instances in which drugs or drugs with alcohol were detected in a sample of 127 cases. Diazepam was found 13 times, sedative-hypnotics 6 times.

OTHER DRUGS

The frequency of use of other drugs has not been as widely studied. For example, Lundberg, White, and Hoffman (1979) studied cases in which blood samples were taken from drivers stopped for problem driving. They found that analyses were not usually done for morphine and other narcotics, cocaine, amphetamines, and antidepressants. The reported incidence of these drugs (e.g., Garriott and Latman 1979) probably do not represent an accurate estimate since most screening methods employed have not been sensitive enough to detect the small amounts of these drugs present in blood. In 1978, however, White et al. (1979) found 125 (6.9%) of blood specimens positive for phencyclindine (PCP, commonly called "angel dust", a dissociative anesthetic) and 51 (2.8%) positive for morphine, in a sample of 1,819 impaired drivers with less than 0.10% w/v BAC. The results of epidemiologic research done to date indicate that the involvement of these lesser used drugs in traffic crashes may be an order of magnitude (i.e., a ten to one difference) less than that of alcohol. In any case, the meaning of percentages of use as indicated above is impossible to determine, since comparable groups of drivers from the general driving population were not included in the studies.

CRITIQUE

The conclusions that can be drawn from past epidemiologic research studies have been limited by methodological problems and other important constraints, including:

* nonrepresentative groups of drivers studies, with invalid comparisons between accident-involved and general driving populations;

* methods to detect and measure drugs in blood were inadequate or unavailable.

Another major constraint has been imposed by the interpretation of the Federal Reports Act of 1942 regarding the conduct of public roadside surveys of drug use by drivers. In roadside surveys, the voluntary participation of motorists is solicited, with assurances that the strictest confidentiality will be maintained regarding any data obtained as a result. Without such studies, the highway safety implications of drug use by crash-involved or arrested drivers will remain unclear, because it is not possible to determine if the drug is overrepresented in the crash or arrest population.

Questionnaire studies of drug use in driving-age populations and other indicators of drug use (e.g., sales of psychoactive prescription drugs) suggest that drug use is widespread, but not necessarily in conjunction with driving. In some instances, of course, the appropriate use of drugs may significantly reduce the impairment caused by the condition for which the drug was taken. The scarcity of other information has led to reliance on experimental research for estimates of drug use and driving risks.

RESEARCH FINDINGS: EXPERIMENTATION

The basic purpose of experimental research is to assess the potential increase in the likelihood of traffic crashes due to drugs. Approaches used to measure drug effects include driving in actual vehicles, driving vehicle simulators, and special laboratory tests or test batteries. The study of drug effects on measures of driving performance and related skills has produced a large but widely dispersed volume of literature. Despite the many reports, information relating drug effects and performance on laboratory tests of driving behavior to traffic crashes is quite limited. The reasons for this include the large number of drugs to be studied, the wide range of methods used to measure behavior, low levels of funding, and the comparatively few research groups available to conduct needed studies.

MARIJUANA

Experimental research on marijuana has used a number of methods to measure driving performance and related skills. A study under actual road conditions showed the effects of marijuana adversely affect driving performance, though some subjects performed better (Klonoff 1974). Hansteen et al. (1976) used tests on a closed driving course to compare the effect of alcohol and marijuana. The higher of two doses of marijuana resulted in poorer car handling, as measured objectively, while observers in the test car rated the subject's performance similar to placebo conditions. Studies with driving simulators (Crancer et al. 1979; Rafaelsen et al. 1973; Moskowitz, Hulbert, and McGlothlin 1976; Ellingstad, McFarling and Struckman, 1973) showed that marijuana degraded performance on some, but not all variables measured. For example Moskowitz et al. (1976) found no significant effect of marijuana on twenty-five performance measures related to car control, such as steering wheel reversals, brake and accelerator pad usage, as well as tracking; however, dose-related increases in subjects' reaction times were observed in subsidiary visual search and recognition tasks. Other laboratory studies, using specific mental, psychomotor, and sensory tests, e.g., time sense, reaction time, perceptual-motor coordination, and auditory signal detection, have

also shown impairment by marijuana, depending on dose and type of task (Jones 1977). Some researchers have reported that marijuana appears to decrease the level of risk that a driver is willing to take (Dott 1972), but it is not known if this compensation would be negated by possible impairment of other driving tasks. The combined effects of alcohol and marijuana results in greater impairment than with either drug alone in some laboratory tests (Burford, French, and LeBlanc 1974; Chesher et al. 1976).

Experimental research, taken as a whole, indicates that certain dose levels of marijuana can impair tracking and perceptual functions involved in driving (Moskowitz, 1976). Perception and other complex mental functions appear more affected than simple motor or sensory tasks that demand little processing of information. The few studies involving actual car handling on closed courses support the implications of laboratory tests that marijuana use by drivers, especially in high doses, can increase the likelihood of traffic crashes. However, whether the differences found in a laboratory are large enough to have impact in an actual driving situation is unknown.

SEDATIVES AND HYPNOTICS, INCLUDING ANTIANXIETY AGENTS

Numerous laboratory studies of sedative-hypnotic and antianxiety agents have been reported. The effects of barbiturates and other sedative-hypnotics are similar to alcohol - for example, impaired thinking, lack of emotional control aggressive behavior, loss of motor coordination, drowsiness, and decreased eye movement (Sharma 1976). Residual effects similar to "hangovers" have been observed (Borland and Nicholson 1975). Depressants can add to the impairing effects of alcohol (Institute of Medicine 1979, pp. 20-31).

Less obvious impairment of psychomotor skills is produced by antianxiety agents (Seppala, Linnoila, and Mattila 1979, p. 392). Kleinknecht and Donaldson (1975) reviewed twenty-three studies of the effects of diazepam on groups of tests that relate to driving performance. In tests of simple reflexive responding, no impairment was noted; however, on tests of vigilance, choice reaction time, and motor coordination, some indications of impaired performance were reported. The combined effects of the drugs and alcohol may be of greater concern, since antianxiety drugs can further decrease performance impaired by alcohol (Moskowitz and Burns 1977; Palva and Linnoila 1978).

The chronic or repeated use of some antianxiety and sedative-hypnotic agents, especially diazepam, chlordiazepoxide, and flurazepam (Dalmane (R)), leads to accumulation of other druglike agents in the body called active metabolites. Their concentrations and effect can exceed those of the parent drugs. Both cumulative and "hangover" effects of these drugs are attributed to

their active metabolites (e.g., Clarke and Nicholson 1978). Alcohol consumed following use of these drugs may enhance the effects of the metabolites (Seppala, Linnoila, and Mattila 1979).

As often noted in literature reviews, however, the use of different test procedures, drug doses, and drug regimens (e.g., acute versus chronic administration) has led to a diversity in findings and has reduced comparability among studies. Nevertheless, in general, these depressant drugs can and do impair skills associated with driving such as vigilance, motor speed, tracking, and simple and choice reaction times.

OTHER DRUGS

Very little driving-related research has been done on other controlled substances. Gordon (1976) reviewed the influence of narcotic drugs on highway safety and concluded that the available evidence indicates that "the use of narcotics in and of itself does not present a hazard or exist as a significant factor in automobile driving" (p. 6). For example, propoxyphene (Darvon (R)) alone in therapeutic doses did not impair driving-related skills (Kiplinger, Sokol, and Rodda 1974). However acute effects of narcotics could present a traffic safety hazard (Seppala, Linnoila, and Mattila 1979). Impairing effects of combining strong analgesics or narcotics with alcohol can be presumed.

Given to non-abusers, clinical dosage levels of amphetamines - whose primary effects are stimulation - have been found to improve performance slightly in driving-related skills, especially under conditions of fatigue (Hurst 1976). Most concern over the use of stimulants by drivers stems not from their positive effects but possible indirect consequences, such as sudden unconsciousness once the stimulants' effects subside. This is a clear risk for long-distance truck drivers who reportedly use "pep pills" (Wyckoff 1979).

Drugs of abuse have received very little attention in the literature. Phencyclindine (PCP) produces an acute, confusional state with low to moderate doses, one that would certainly impair driving ability (Sioris and Krenzelok 1978). Gross impairment of perceptual performance by hallucinogens, such as LSD and psilocybin, is well known. What is not known is how many users of these drugs attempt to drive while under their influence.

Other psychoactive drugs that are not controlled substances have been studied for their effects on driving performance, for example, antidepressants, antipsychotics (major tranquilizers), antihistamines, and outpatient anesthetics. While a discussion of their effects is beyond the scope of this report, drugs in these and other classes of licit, therapeutic agents have the potential

to impair driving (Seppala, Linnoila, and Mattila 1979; Joscelyn et al. 1979).

CRITIQUE

Criticism of past experimental studies of drug effect on driving performance and related skills have identified three problem areas:

* Methods employed to test the effects of drugs do not adequately represent the range or combination of skills required in actual driving performance; standardized test procedures are needed.

* Research designs of experiments intended to demonstrate drug effects on driving-related skills have been weak; in particular, concentrations of drugs in body fluids associated with impairment have not been measured.

* Laboratory studies lack realism, limiting extrapolation to actual driving impairments. To date, test subjects have been representative of users of drugs in the general driving population.

Furthermore, proper concern for human subjects constrains the kinds of experimental research which can be done in this area. For example, restrictions on the dosage level and frequency of dosage, as set by medical review boards, limits study of the effects of some therapeutic drugs, such as antianxiety agents, in that portion of the driving population which uses these drugs. It should be noted that, in some instances, permissible experimental dosages allowed are less than those normally taken.

SUMMARY

Research to define the nature and magnitude of the drug and driving problem has produced some information on the frequency of drug use among drivers and its possible consequences for highway safety. The present state of knowledge, however, is limited. Experimental studies have shown that marijuana, other controlled substances, and other therapeutic drugs at certain dose levels have adverse effects on skills and other measures associated with driving performance. Epidemiologic research has demonstrated that some drivers involved in fatal crashes or arrested for impaired driving have taken psychoactive drugs. The use of more than one drug, in addition to alcohol, is often found in these driving populations. The lack of adequate comparison samples makes it impossible to draw scientifically valid conclusions about the likelihood of traffic crashes given drug use.

Past research has not fully answered basic questions concerning the specific adverse effects of drugs on skills related to driving performance, and has only begun to define the relations between drug use by drivers and traffic crashes. Regarding the first (which is an experimental question), the selection of subjects not representative of the driving population using the drugs under study, and the lack of adequate behavior tests of driving performance, decrease the relevance of experimental studies. As to the second (which is an epidemiologic question), the absence of surveys that compare the frequency of drug incidence in accident and nonaccident drivers prevents the meaningful interpretation of studies that only report drug use by drivers involved in crashes or arrested for impaired driving.

The evidence of date indicates that some drugs can impair human behavior and skills related to driving and that drugs may increase the likelihood of traffic crashes. Such information suggests that driving under the influence of some drugs increases the likelihood of traffic crashes. Nevertheless, given present information, the influence of some drugs on crash risk can not be specified. However, the involvement of drugs in traffic crashes resulting in death, injury, and property damage appears to be considerably less than that of alcohol. Based on available data, the percentage of drug-involved crashes is in the range of 1% to 15%, including cases of combined alcohol and drug use. This finding clearly warrants further, careful inquiry to define the nature and magnitude of the drug and driving problem. Research has established that many drugs widely used by the driving-age population have the potential to impair driving at commonly used dosage levels. Drugs or grups of drugs of interest for continued highway safety research include:

* analgesics and antipyretics
* anesthetics
* antianxiety agents
* antidepressants
* antihistamines
* antinauseants
* antipsychotic agents
* antivertigo agents
* appetite suppressants
* cardiovascular drugs
* hallucinogens
* marijuana and other illicit substances
* psychostimulants
* sedative-hypnotics

(End of quotation from "A Report to Congress. . ." 1980)

MORE RECENT RESEARCH AND REVIEWS

Since the 1980 studies from which the above extracts were drawn, other research into drug involvement in impaired driving has been published and reviewed.

"The Incidence of Driving Under the Influence of Drugs, 1985: An Update of the State of Knowledge" was published by NHTSA, specifically supplementing the earlier reports. This update is presented in its entirety as Appendix A to this paper.

An International Symposium on Marijuana, Cocaine and Traffic Safety was held in July, 1986, sponsored by the journal "Alcohol, Drugs and Driving, Abstracts and Reviews" published by the Alcohol Information Service of the Neuropsychiatric Institute, University of California, Los Angeles. The papers dealing with marijuana were published in that journal, Volume 2, Numbers 3-4, July-December, 1986. Papers on cocaine and other stimulants were published in Volume 3, Number 1. The Preface to the Symposium Proceedings is reprinted below, followed by one paper from that symposium which is of particular interest to this report, "Sobriety Tests for the Presence of Drugs", Marcelline Burns, 1986.

PREFACE

An International Symposium on Marijuana, Cocaine and Traffic Safety was held July 9 to 11, 1986 in Santa Monica, California. The Symposium was sponsored by this Journal in cooperation with the UCLA Alcohol Information Service and the UCLA Neuropsychiatric Institute, with grant support from the Anheuser-Busch Companies.

The presence of cocaine and/or marijuana in drivers involved in accidents, or arrested for impaired driving, has been reported with increasing frequency in the last decade. The purpose of this Symposium was to assess whether these drugs represent a substantial danger to traffic safety and to clarify avenues for future research endeavors. The papers discussing marijuana are presented in this issue; the papers on cocaine and other stimulants will be presented in the following issue.

The data dealing with marijuana range widely. They describe certain of the characteristics of young people, who are the most frequent users of marijuana; the frequency with which marijuana is found in accident victims; the problems in obtaining, analyzing and interpreting body fluid samples; the experimental analysis of marijuana effects (including on-road and driving simulator studies); the combined effects of marijuana with alcohol as well as the complications induced by chronic use of the drug. An important discussion topic dealt with the fact that the alcohol level in breath or blood samples correlates well with the levels at the central nervous system sites of action and with behavioral impairment. However, with most other drugs, including marijuana, there is little correlation between the degree of behavioral impairment and blood, urine or breath levels of the substance. As a result, epidemiological research on the relationship between drug levels and accident rates becomes extremely difficult. This problem, of course, does not prevent experimental studies in which administered drug dose levels exhibit excellent correlation with behavioral impairment effects. If it is accepted that marijuana does impair driving and increase accident rates, then the lack of correlation between body specimen levels and impairment suggests that public policy approaches to dealing with the problem will have to differ from those for alcohol, where the prime drinking and driving countermeasure has been a reliance on police enforcement of a maximum acceptable BAC level for driving. Hopefully, these papers will provide a review of the current status of this problem and serve to identify the issues that still remain to be resolved.

Herbert Moskowitz

Sobriety Tests for the Presence of Drugs

Marcelline Burns

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The Scope of the DUID Problem

Because attempts to precisely assess the extent of driving-under-the-influence-of-drugs (DUID) generally are thwarted by limited epidemiological data, related information sometimes becomes the basis for rather widely varying estimates of the problem. In the City of Los Angeles this kind of "best" estimate places the number of drivers under the influence of drugs (or an alcohol-drug combination) at one-in-five of all impaired driver arrestees. This particular figure, which is based principally on the experience and impressions of traffic officers, has gained considerable credibility in local circles.

Another estimate can be drawn from a study of traffic fatalities in California. In the analyses of blood samples from 440 fatally injured young males, there were 630 separate detections of alcohol and other drugs (Williams et al., 1985). Drugs other than alcohol accounted for 322, or 51% of the detected substances. Although these fatality data overstate by some unknown amount the extent of drug use within the general driving population, they still serve as one kind of index of the problem.

Other estimates of DUID drivers in Los Angeles can be derived from arrest records from the Los Angeles Police Department (LAPD) (personal communication, LAPD Central Traffic Division). At a recent sobriety checkpoint in a suburban community, 85 impaired drivers were arrested over a five hour period. Fourteen percent of the arrestees exhibited symptoms of drug influence and were booked on DUID charges.

In contrast, arrest records from regular enforcement activities over a recent one-week period show that 5% of the drivers arrested for DUI were determined to be under the influence of drugs. The marked difference between sobriety checkpoint data (14% DUID) and regular traffic arrests (5% DUID) reflects, at least in part, the presence of officers with special drug recognition training at the sobriety checkpoint. Regular traffic arrests are made by patrol officers who are unlikely to have had special training.

In spite of the discrepancies in estimates, it is safe to conclude that Los Angeles has a DUID problem of considerable magnitude. Is it unique to Los Angeles? Possibly. Drug use may be more prevalant in Southern California than in other areas. Population characteristics and lifestyles permit, if they do not actually encourage, the non-medical use of drugs within various segments of the community. Also, proximity to the Mexican border and a shift in drug traffic from the East to the West Coast essentially guarantee the availability of illicit substances.

It would be risky to assume that the number of drug-impaired drivers on the streets and freeways of Los Angeles is typical of other cities or of the nation as a whole. However, the extent of the problem has led to an aggressive response by local law enforcement, including the development of sobriety test procedures for drugs.

DUID Enforcement and Prosecution: Issues

Whatever the state of information (or lack of information) at this point in time, police agencies and courts confront daily responsibilities which originate with drug-impaired drivers. Traffic officers in general have little immediate access to the very limited information about roadside tests for drugs. Not surprisingly, in the absence of other information they tend to rely heavily on their alcohol enforcement training. Similarly, prosecutors are likely to be better prepared for handling alcohol cases than for drug cases. The inevitable result is that DUID arrest and court procedures frequently are incomplete and inappropriate.

The commonly held assumption that an analysis of body fluids will provide critical evidence of impairment by drugs illustrates the misapplication of lessons learned in DUI (alcohol) enforcement. The expectation for a chemical test "number" can be traced to procedures for arresting and prosecuting alcohol-impaired drivers.

At the time of a DUI arrest, the arresting officer routinely obtains a blood, breath, or urine test for analysis. In court he reports the defendant's DUI behavior, including driving errors and performance of field sobriety tests (FSTs), and the results of the chemical test are submitted as corroborating evidence. If the driver refused all tests, his refusal can be commented upon as reflecting consciousness of guilt.

Because of the correlation between amount of alcohol and degree of impairment, law enforcement and the courts have been well served by reports of blood alcohol concentration (BAC). Over time, the operational definition of "impairment" has become "BAC," and presumptive or *per se* limits have become law.

The assumption that chemical tests will serve an equally important role in DUID enforcement and prosecution, once the appropriate "numbers" are established for body fluid levels, requires careful scrutiny. Instead of a single substance, "drugs" encompass many misused and abused substances with widely differing properties. Instead of a relatively simple molecule which can be traced and measured in body fluids, there are drug categories with distinct effects. In contrast to the correlation of peak BAC and peak impairment, the relationship between drug level and performance frequently is unknown or unpredictable. Further, interpretations are complicated by the effects of pharmacologically active metabolites, by the potential for performance enhancement by certain drugs at certain doses, and by issues of individual sensitivity and tolerance.

Alcohol does not provide an acceptable model for other drugs. It is unlikely either that meaningful "numbers" will be forthcoming for most drugs, or that efforts to establish presumptive or *per se* levels will be productive.

Behavioral Tests: Issues

Since chemical tests do not reliably reflect the extent of impairment by drugs, other sources of evidence must be relied upon by police and courts. If, as appears likely, more weight is to be given to behavioral symptoms, then it is critical that roadside tests be reliable and sensitive measures. At the present time, however, there are no FSTs specifically for drugs. With only a few exceptions, neither research nor law enforcement has given attention to the problem of drug recognition in the field.

If sobriety tests for drugs are to play an important role, an initial examination of the objective of roadside testing is in order. Exactly what kind of evidence does an officer in the field or a prosecutor in court require? The question seems straightforward, and the following criteria for tests of drug impairment were excerpted from a single document (Donelson et al., 1980):

- behavioral tests which correlate with "safe" driving
- behavioral tests which measure "critical components" of driving performance
- behavioral tests which measure "impaired driving"
- tests related to driving (such as standing steadiness and reaction time) with performance correlated with a criterion BAC (.10%)
- behavioral tests which measure critical aspects of driving, as validated with actual driving

These examples share the point of view that sobriety tests for drugs should have a demonstrated relationship to driving. Although it appears reasonable, it is a very difficult requirement. Just the constraints on time, equipment, and environment at roadside severely limit the tests which even can be considered as candidate FSTs. Further, the requirement mandates that the essential components of the driving task, or conversely a critical lack of skills, be defined. Since there is no clearcut consensus concerning the definition itself, it is uncertain how the selection of FSTs by such a standard could proceed. Further, whether this particular requirement for sobriety tests actually is necessary is open to question.

Note that standing steadiness and reaction time were cited as examples of tests related to driving. The connection is not apparent since neither a steady stance nor simple movement time is essential to the safe operation of a motor vehicle. The point of interest, however, is that their non-relatedness to driving does not exclude them as sobriety tests. In fact, the National Highway Traffic Safety Administration (NHTSA) Standardized Three-Test Battery for DUI includes tests of balance and coordination which were selected, not because they measure driving skills, but because they reliably indicate the presence of alcohol, beginning at moderate BACs.

If it can be agreed that the primary objective of sobriety testing is the demonstration of impairment, the requirement that a test directly examine driving is unnecessary. The objective will be met if a test is a reliable indicator of the presence of an impairing substance. To require that it also measure critical driving skills, or be validated by actual driving is unduly restrictive.

Difficult and complicating issues remain. Which drugs and drug categories are impairing? In what manner and to what extent? To the extent that those questions remain unanswered, DUID enforcement operates in uncertainty. The questions must be addressed, and the selection and validation process for tests to be used at roadside is a related, major undertaking.

Behavioral Tests: Selection

The drug scene changes continually. New drugs gain in favor while others temporarily become prohibitively expensive or drop out of favor for unknown reasons. Users ingest dangerously large amounts and unexpected combinations. An attempt to develop drug-specific FSTs would be a formidable undertaking. A more feasible goal may be to identify the symptoms which are associated with the presence of a particular drug category (e.g., stimulants, depressants, hallucinogens) and with certain currently popular drugs which present unique symptoms (e.g., phencyclidine).

Controlled laboratory study of the effects of widely misused substances would provide much-needed information. But dangerous drugs, high doses and drug-drug combinations, which may be common among users, place human subjects at risk and are not acceptable in the laboratory. Phencyclidine, designer drugs, extremely high doses of prescription drugs, and other "street drugs" contribute to the severely impaired driver population, but to propose to study those substances with human subjects raises ethical and legal questions. In the face of these difficulties, how are behavioral tests of their effects to be validated?

A possible and potentially important study could be undertaken with the records of DUID arrestees booked into a large city jail. Although arrest reports vary widely in quality and detail, depending on the agency and the officer, they include at minimum the probable cause for arrest, i.e., the driving cues which led to the stop and/or the behavioral cues which led the officer to suspect the involvement of drugs. They may also report the suspect's admission of drug use (a surprisingly common behavior), chemical test results, and in some cases, the findings from an examination by the jail physician. In LAPD arrests, records of drug evaluations provide much more extensive information about the individual's behavior, performance, and physical condition.

This large body of information lends itself to a difficult but potentially fruitful analysis in terms of specific symptoms associated with specific drug categories. By definition, however, a field study of this kind is a moderately long-term effort, and the police and the courts currently confront the DUID problem on a daily basis. For the immediate future, is there an alternative to simply generalizing from established DUI procedures?

DUID Enforcement: A Model

The LAPD Drug Recognition Expert (DRE) program, which encompasses a system of training, certification, and utilization, is instructive as an example of one agency's response to a current, real-world problem. As drug use escalated during the past decade, LAPD traffic officers recognized that increasingly they were encountering impaired drivers who were not under the influence of alcohol. Low or zero BACs and other symptoms inconsistent with alcohol could not support DUI arrests. There was an immediate, pressing need to establish specific, effective procedures for these cases, beginning with the officer's activities at roadside and extending through booking into the prosecution phase. A drug recognition program evolved within the department.

Although the methods continue to be scrutinized in an ongoing effort to improve them, the program legitimately can be viewed as a model in the sense that it is operational. At the present time, Drug Recognition Experts (DREs) routinely evaluate arrestees whose impairment symptoms are inconsistent with alcohol.

Training a DRE begins with 40 hours of lecture, films, and workshops at the LAPD training academy. Instruction by police officers is augmented with lectures by physicians and drug and traffic researchers. The course of study is difficult and a substantial number of enrollees fail to complete this initial portion of the training.

The second training phase occurs in the field where trainees conduct drug evaluations of DUID suspects. The time required to complete this phase is indeterminate since the trainee must satisfactorily conduct, under the supervision of a Senior DRE, an evaluation for each of the major drug categories. The opportunity to perform the required evaluations obviously is dependent on the drug choices of the individuals who come through the system in a given period of time.

Finally, the officer's eligibility for certification as a DRE is decided by a committee of instructors and Senior DREs, based on a review of his (or her) classroom and field performance. In the event a certified DRE fails to maintain and use his drug recognition skills acceptably, the committee exercises their option of de-certification.

The hallmark of the DRE approach is that symptoms are observed, and interpreted in a systematic manner. At minimum, the following are recorded on a standard Drug Evaluation Report form:

Appearance, manner, attitude

Behavioral test performance (FSTs, i.e., the three test battery standardized for alcohol plus additional behavioral tests)

Vital signs (blood pressure, pulse rate, body temperature)

Eye signs (nystagmus, strabismus, dilation/constriction, speed of response)

Physical signs of ingestion (marks, debris, residue)

The symptoms are interpreted as a whole and in terms of what is known about the effects of stimulants, depressants, hallucinogens, solvents, or other drugs and categories. The DRE's determination rests not on a single cue but on a pattern of symptoms which uniquely identifies a single drug, a drug category, or a combination of substances. The information obtained in this standardized evaluation plays a major role in the prosecution of DUID cases in Los Angeles courts.

The DRE methods were evaluated in a laboratory study (Anderson, 1985) and in a field study (Compton, 1986, in press). In the laboratory setting, participants were administered a placebo, secobarbital or one of two dose levels of diazepam, marijuana, or amphetamine, i.e., eight different treatments. DREs correctly identified placebo subjects 95% of the time, but their ratings of "intoxication" were dependent on the drug and dose level. At one extreme, 95% of the participants who received secobartital were judged intoxicated. At the other extreme, a low dose of amphetamine produced recognizable symptoms of intoxication in only 17.5% of the cases. Symptoms of a high dose of marijuana were readily recognized (72.5%) whereas recognition accuracy fell with a low dose (32.5%).

Obviously, the dimensions of the recognition problem are markedly different in an arrest situation. Officers encounter suspects who have ingested any one of a variety of licit and illicit drugs, who have taken amounts in excess of common usage, and who are under the influence of several substances simultaneously.

With high doses the symptoms may be so marked that identification is less difficult than in a laboratory study. On the other hand, recognition becomes extremely difficult when several substances are present. The symptoms of one drug often mask the less apparent symptoms of another with the result that only the dominant drug can be recognized. Even more difficult, drugs with opposing actions (e.g., a depressant and a stimulant in combination) may produce paradoxical symptoms. Nonetheless, the field evaluation data confirm that trained officers recognize the presence of a drug or drugs with a high level of accuracy. The program is a promising approach which merits continued development and study.

FSTs for Drugs: 1986

The alcohol model does not suffice for drugs. Although DUI enforcement and prosecution procedures frequently are extended to the DUID suspect, generally for lack of other methods, they are likely to be neither accurate nor effective.

Sobriety tests for drugs are a much needed tool. Research to develop and standardize a battery of field sobriety tests for drugs can begin by building on and modifying what is known about FSTs for alcohol, but it will proceed successfully only in full awareness of the marked differences between the DUI and DUID problems.

REFERENCES

Anderson, T.E. (1985). Laboratory evaluation of the Los Angeles Police Department's drugged driver detection procedures. *Research Notes*, Office of Driver & Pedestrian Research, NHTSA. Washington, DC: U.S. Dept. of Transportation.

Burns, M. (In Press). The behavioral pharmacology of CNS depressants. *Proceedings, International Symposium on Driving Under the Influence of Alcohol and/or Drugs.* Quantico, VA: Federal Bureau of Investigation. March 24, 1986.

Compton, R.P. (In Press). Field Evaluation of the Los Angeles Police Department Drug Detection Program. *NHTSA Staff Technical Report.* Washington, DC: U.S. Department of Transportation.

Donelson, A.C., Marks, M.E., Jones, R.K., & Joscelyn, K.B. (1980). *Drug Research Methodology. Volume 1: The Alcohol-Highway Safety Experience and Its Applicability to Other Drugs.* DOT HS-7-01530, Final Report, NHTSA. Washington, DC: U.S. Dept. of Transportation.

Studdard, R.C. (1983). Testing the impaired driver: The Los Angeles Police Department approach. *Abstracts & Reviews in Alcohol & Driving, 4*(3), 22-24.

Watson, D., & Studdard, D. (In Press). Gaze nystagmus and psychophysical testing. *Proceedings, International Symposium on Driving under the Influence of Alcohol and/or Drugs.* Quantico, VA: Federal Bureau of Investigation. March 24, 1986.

Williams, A.F., Peat, M.A., Crouch, D.J., Wells, J.K., & Finkle, B.S. (1985). Drugs in fatally injured young male drivers. *Public Health Reports, 100*(1), 19-25.

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In October, 1983 the National Institute on Drug Abuse sponsored a conference on drugs and driving and established a consensus panel, representing the disciplines of clinical pharmacology, analytical and forensic toxicology, law, and forensic medicine. Individual members of that panel are identified in the report published in the Journal of the American Medical Association, November 8, 1985 as "Consensus Report -- Drug Concentrations and Driving Impairment". That report is reproduced below:

Reprinted from the JAMA• Journal of the American Medical Association
November 8, 1985, Volume 254

Consensus Report

Drug Concentrations and Driving Impairment

Consensus Development Panel

• Most drugs that affect the central nervous system have the potential to impair driving ability. For many years, alcohol (ethanol) has been the drug of greatest concern, since it is, by far, the most frequently recognized cause of drug-impaired driving. Yet as more therapeutic agents, such as benzodiazepines, are introduced and widely used, and as social use of unsanctioned drugs such as *cannabis* (marijuana) increases, attention must be directed toward other drugs.

The National Institute on Drug Abuse sponsored a conference on drugs and driving in Durham, NC, in October 1983. The objective was to reach a consensus on several key issues associated with the current state of knowledge about the relationship between body fluid concentrations of drugs and their pharmacologically active metabolites and degree of driving impairment. It was also of interest to ascertain whether a sufficient body of knowledge exists for an expert to form an opinion, which will meet the applicable standards of proof for legal proceedings, that a person's driving ability was impaired based on body fluid concentrations of a drug. The consensus panel, representing the disciplines of clinical pharmacology, analytical and forensic toxicology, law, and forensic medicine agreed on answers to the following questions:

1. Is ethanol a good model for other drugs?
2. What drugs might have a potential for impairing a driver?
3. How is driving impairment measured?
4. What is known about correlations between driving impairment and drug concentrations?
5. Could "per se" concentrations be established for drugs other than alcohol?
6. Can impairment be established from body fluid concentrations?

From the Research Technology Branch, National Institute on Drug Abuse, Rockville, Md

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Panel's Conclusions

As the use and abuse of psychoactive drugs escalate in the US population and improvements in chemical analysis techniques continue to lower the detectable concentrations, expert witnesses are more and more frequently faced with the need to provide expert opinions concerning the possible impairment of driving ability based on body fluid concentrations of such drugs. This requires access to a body of knowledge on the measurement of driving ability, the chemical analyses of body fluids, and particularly the correlation and interpretation of those measurements. Such a body of knowledge is not yet sufficient for dealing with drugs such as marijuana, sedative-hypnotics, antihistamines, and benzodiazepines. Sensitivity to the complex issues relating to these measurements and their interpretation is of prime importance to both the forensic expert and the legislative bodies concerned with the effect of drug use on traffic safety. Further research should be given high priority and designed to dovetail with legislative initiatives.

In order to establish that use of a drug results in impairment of driving skills and to justify a testing program to respond to this hazard, certain facts must be available. (1) The drug can be demonstrated in laboratory studies to produce a dose-related impairment of skills associated either with driving or with related psychomotor functions. (2) Concentrations of the drug and/or its metabolites in body fluids can be accurately and quantitatively measured and related to the degree of impairment produced. (3) Such impairment is confirmed by actual highway experience. (4) Simple behavioral tests, such as can be done at the roadside by police officers with modest training, can indicate the presence of such impairment to the satisfaction of courts. (5) A range of concentrations of the drug can be incorporated in laws relating to impaired driving as ipso facto evidence.

These criteria have been met for ethanol. It is not certain that they can be met for other drugs that are now of concern to highway safety.

The development of methods for testing the effects of ethanol on driving skills and relating these to body fluid concentrations took many years. It is obvious that a beginning has just been made to develop similar information about other drugs of similar interest. Before establishing meaningful legislation based on cause-and-effect relationships of drugs and driving, further studies are required. Goals for future research efforts should include the following.

- **Experimental subjects should be tested under conditions that resemble real-life driving experiences after they have been exposed to various acute and chronic dosage regimens of a drug, or combination of drugs.**
- **A set of behavioral tests needs to be established, such as might be performed at the roadside, that may augment present roadside sobriety tests and that may indicate the influence of other drugs.**
- **Drugs for which a range of concentrations in body fluids may be defined in which driving would be impaired should be identified.**
- **Valid micromethods for measuring body fluid concentrations of drugs need to be developed. This will not only enable easier acquisition of smaller sample size but will permit replicate tests, an important consideration in minimizing analytical error and the occurrence of outliers.**
- **First priority for such research should be studies with marijuana and benzodiazepines, as these two types of drugs are those most commonly used.**
- **Additional studies are necessary to examine effects on driving behavior when drugs are used in combination with ethanol or other drugs.**

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1. Is Ethanol a Good Model for Other Drugs?—Traditionally, ethanol has been the drug of greatest concern in relation to driving impairment. Ethanol is by far the most frequently documented drug in fatal motor vehicle accidents. Measurements of ethanol in blood have been available for more than a century, and blood concentrations of ethanol have long been studied in the context of driving impairment so that relationships have been established. The concentration of ethanol in breath can be measured noninvasively. In addition to its relatively low toxicity, ethanol has many pharmacokinetic differences from other sedatives: it is both water and lipid soluble, it is distributed in the body water and is not bound to plasma proteins, it produces no long-lived active metabolites, and it equilibrates readily between blood and brain. Thus, ethanol has provided an unusually good model for studying the effects of a drug on driving performance. Other drugs of concern do not share these characteristics and therefore generalizations cannot be made from the ethanol model to other drugs that might impair driving skills.

Our knowledge concerning ethanol is far from complete, and there are areas of concern that warrant further elucidation.

2. What Drugs Might Have a Potential for Impairing a Driver?—New drugs of concern are primarily those with predominant effects on the central nervous system that cause significant alterations in cognition, mood, or psychomotor functions. Among licit drugs, our major concern is with drugs such as benzodiazepines, sedative-hypnotics, other psychotherapeutic agents, stimulants, and some antihistamines. Among illicit drugs, a major concern is with cannabis, cocaine, opiates, and hallucinogens such as lysergic acid, diethylamide, and phencyclidine. Although technically it is now possible to measure all these drugs quantitatively in body fluids, practical considerations limit the number to be tested in an initial screen. There are very few laboratories prepared to identify and quantitate the low concentrations of drugs that are expected to be found in impaired drivers. Epidemiologic evidence from fatally injured driver studies suggests that the most likely drugs to be associated with impaired driving are ethanol, sedative-hypnotics, cannabis, and antihistamines. Also the fact that benzodiazepines are among the most highly prescribed therapeutic drugs make them candidates of interest. Thus, initial screening analyses should test for these drugs.

Ambiguous Effects of Therapeutic Drugs

Although psychoactive drugs are those most commonly thought to cause impaired driving, their mere presence in body fluids cannot be construed as evidence of impairment. It can be speculated that a chronically anxious, preoccupied, and irritable person might be more impaired by the prevailing mental state than that caused by an antianxiety drug if it were used to alleviate these symptoms. In a similar vein, persons with schizophrenia or depression could be more impaired if untreated than if they were appropriately taking antipsychotic or antidepressant medication. Persons with epilepsy are generally not allowed to drive unless they are taking anticonvulsants, even though some of these, such as phenobarbital or carbamazepine, are potentially impairing. In such cases, the adverse effects of the drugs in therapeutically effective concentrations are deemed to pose much less risk than that posed by the disorder they treat. Although not considered here it must also be recognized that some drugs that are not primarily psychotropic may cause sedation and possibly effect driving skills.

3. How Is Driving Impairment Measured?—Operational definitions of impaired driving have been based largely on experience with ethanol. We are not sure that the same types of impairment would be produced by other drugs except perhaps by sedative-hypnotics. We also have no universal definition of acceptable driving behavior. Licensing is usually based on written tests of knowledge of rules of the road and performance in a short driving test. Whether these simple procedures are adequate to ensure that all licensed drivers are capable of safe operation of a motor vehicle is uncertain. Further research is needed to fix the boundaries of acceptable driving skills as well as to determine whether drugs other than ethanol produce characteristic patterns of impaired driving.

Determination of Impaired Driving

Impairment of driving performance is, in the most general sense, a failure to exercise the expected degree of prudence or control to ensure safe operation of the vehicle. Manifestations of such impairment are many: driving at a

speed that is inappropriate to the flow of surrounding traffic, weaving within a lane of traffic or frequent lane changes, following cars too closely, failing to signal major changes of course, failing to observe traffic signs or signals, as well as many others. These are the signs of impairment that, when observed by law enforcement officers, merit investigation. These signs are not specific to effects produced by drugs. They may be associated with distractions of the driver, fatigue, physical illness, symptomatic emotional disorders, and many other non-drug-related causes. Law officers usually employ roadside sobriety tests, which, on the basis of extensive experience, are adequate to support the opinion that some impairment of psychomotor function was the cause of the observed erratic driving behavior. The determination of the concentration of ethanol or other psychoactive drugs in body fluids may be critical to a decision about the true cause of impairment.

Laboratory Studies of Driving Skills

Most studies of the effects of drugs on driving employ various tests of combined cognitive and motor functions presumed to be pertinent to those skills associated with motor vehicle operation. If the tests are made difficult enough, or the doses of drugs being tested are high enough, it is generally possible to show impairment for any psychoactive drug. Most such tests are novel to the person being tested. Even though subjects may have been given enough practice to learn the test to some acceptable criterion, it is not the same situation as with a potentially overlearned behavior such as driving. Thus, it is difficult to translate the results of such testing to actual driving ability.

Tests using driving simulators are probably more appropriate. Many simulators are now available that mimic to a remarkably good degree the actual conditions of driving. A few studies have used the actual driving situation, either on devised courses or in actual traffic, but devised courses are not easily found and driving in actual traffic under the experimental influence of a drug is not socially acceptable. When tests are done under controlled conditions, subjects are usually studied when they are well rested. They are hardly comparable with drivers who may have been awake for 16 hours and who are preoccupied with the events of the preceding day. Thus, extrapolations from experimental studies are of limited value in applicability and validity.

4. What Is Known About Correlations Between Driving Impairment and Drug Concentrations?—Except for ethanol, determinations of drug concentrations in body fluids are at present of limited value for establishing driving impairment. Adequate information on correlations of body fluid concentration of drugs with measurements of behavioral impairment are rare. Data currently available indicate that wide ranges of drug concentrations may be present at equal levels of impairment; also, evidence of impairment is often lacking in some subjects at drug concentrations that are associated with impairment in others. Many factors contribute to these variations: differences in body weight and composition in relation to dose; genetic and environmental influences that affect rates of drug metabolism and elimination; the phenomenon of hysteresis, in which drug effects are greater as blood concentrations are rising than at the same concentrations when they are failing; the degree of prior exposure to the drug in question or other drugs that can lead to tolerance or cross-tolerance to the effects of the drug; and the presence of other drugs that may lead to pharmacodynamic or pharmacokinetic interactions. The major value of such determinations is to suggest that demonstrated clinical impairment of function is probably related to the presence of the drug in the body fluid, in the absence of other reasonable explanations. Conversely, impairment of function without the presence, in significant amounts, of a drug that might be expected to produce impairment would strongly suggest some cause, unrelated to drug use.

5. Could "Per Se" Concentrations Be Established for Other Drugs?—A simple solution to the problem of interpreting the relationship of body fluid concentrations to driving impairment would be to take an arbitrary approach. Such approaches have been taken in regard to ethanol, where certain blood concentrations, which differ from one jurisdiction to another, have been legislatively defined as per se evidence of impairment. One difficulty is that the blood concentration-impairment relation is more complex with other drugs than it is with the relatively simple drug ethanol. Conservatively, a per se drug concentration might be selected that could be expected to produce impairment in virtually all cases. The problem with this approach would be that many drivers impaired at lower concentrations would not be caught in this net. On the other hand, if a minimum concentration is chosen, below which impaired driving is unlikely in virtually all cases, the system might net too many unimpaired drivers. If both minimal and maximal concentrations could be defined, the intermediate gray area would still have to be resolved by clinical evidence of impairment. Thus, relatively little would be gained by a per se approach based on arbitrary data. In many cases, it may only be possible to use concentrations to establish legal presumptions. A further difficulty with a per se approach is the unrealistic burden it places on a laboratory measurement. It has a potential of deciding guilt or innocence solely on the basis of a single laboratory measurement. Such a potential should be avoided since unexplained outliers, administrative errors, or other factors can lead to a miscarriage of justice.

6. Can Impairment Be Established From Body Fluid Concentrations?—A great need exists for more research relating body fluid concentrations of drugs to impairments of mood, cognition, or psychomotor functions in the context of driving ability. Studies done thus far relate mainly to functions that can only be presumed to be pertinent to driving performance. Use of driving simulators may be more appropriate, but actual driving of vehicles over some test course is probably the best model. Relatively few such facilities are available. Another problem is that virtually all studies use only single doses of a single drug. The effects on single doses of drugs are often quite different from those that follow a chronic dosage regimen. Yet drugs involved in motor vehicle accidents have often been taken chronically and frequently in combinations of two

or more drugs. Obstacles to doing research in subjects exposed to chronic regimens of multiple drugs are formidable but not impossible to overcome. Timing of body fluid sampling for determination of time course/concentrations should be planned with careful consideration of the pharmacokinetics of the drug and its psychoactive metabolites. Specimens should generally be taken as close as possible to the actual performance of tests. Even the most meticulous experimental procedures may not be entirely pertinent to the real-life situation, but it is to be expected that they would assist greatly in the interpretation of body fluid concentrations in relation to impaired driving.

Difficulties in Interpretation

At present we cannot define critical body fluid concentrations above which all would be impaired and below which all would lack impairment. For reasons already discussed and many others, the presumed gaussian distribution curve relating impaired driving ability at a given drug concentration against numbers of individuals is probably broad, flat, and diffuse for most drugs. Furthermore, there are problems of interpreting drug concentration in patients undergoing chronic drug therapy. Again, attempting to mimic the ethanol model poses a dilemma. Nonetheless, measurement of blood concentrations of drug has value in establishing a possible cause of impaired driving. In this regard, such determinations would be analogous to the function of other clinical laboratory tests; that is, they do not establish the diagnosis by themselves, but taken in conjunction with clinical observations and circumstantial evidence, they can help either to support or exclude a diagnosis of impairment due to a specific drug.

Difficulties in Obtaining Blood Specimens

Practical considerations make determining blood concentrations of drugs more difficult under field conditions than determining ethanol concentrations, which can be measured with a great degree of accuracy with a noninvasive breath test that is administered quickly and easily. To obtain blood specimens in the field requires consideration of logistical and technical complexities. Withdrawal of blood requires qualified, licensed personnel. These personnel are available in hospitals and clinical laboratories, but many hospitals do not allow such procedures unless the subject has been admitted to the emergency room. Medical technologists can be available to law enforcement agencies on an "on call" basis. The expense for this would be less than that for admission to an emergency room, but to be effective, qualified personnel must be available to the arresting officer on a continuous basis. Any delay will generally result in finding different drug concentrations than those that existed at the time of the offense. The problem of delay in acquiring a blood specimen and estimating an earlier blood concentration is not unique to measuring drugs. The same problem exists with blood ethanol measurement. Moreover, most drugs follow a blood concentration-time course profile obeying first-order kinetics and are subject to a host of confounding variables.

Determinations in Urine

Testing of drugs or drug metabolites in urine is only of qualitative value in indicating some prior exposure to specified drugs. Inferences regarding the presence or systemic concentration of the drug at the time of driving or impairment from drug use are generally unwarranted. The presence of an illicit substance in urine that may indicate prior illegal action can, however, add a dimension to probable cause of observed driving performance.

Members of the Consensus Development Panel were Robert V Blanke, PhD, Richmond, Va; Yale H. Caplan, PhD, Baltimore; R Thomas Chamberlain, PhD, JD, Memphis; Kurt M. Dubowski, PhD, Oklahoma City; Bryan S. Finkle, PhD, San Francisco; Robert B. Forney, PhD, Indianapolis; Richard L. Hawks, PhD, Rockville, Md; Leo E. Hollister, MD, Palo Alto, Calif; Peter I. Jatlow, MD, New Haven, Conn; Roger P. Maickel, PhD, West Lafayette, Ind; Arthur J. McBay, PhD, Chapel Hill, NC. Other participants included Michael Walsh, PhD, National Institute on Drug Abuse; Ted Anderson, Department of Transportation.

The conference was sponsored by the National Institute on Drug Abuse, Research Technology Branch, Richard L. Hawks, chief.

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MINNESOTA EXPERIENCE, POLICIES AND PRACTICES IN TESTING FOR DRUGS IN ENFORCEMENT OF TRAFFIC LAWS

In 1986 the number of blood or urine tests for drugs in driving cases performed by the Forensic Science Laboratory, Bureau of Criminal Apprehension, totalled 494. This is an increase of 150% over the 199 such tests in 1981.

How much of this increase is the result of an increase in drug use by drivers and how much reflects more vigorous and sophisticated police enforcement of all driving-while-impaired law is unknown.

The following description of typical DWI arrest procedure may be helpful in considering the relative roles of alcohol, and drugs other than alcohol, in impaired driving cases.

Certain conditions must be met before an arrest can be made or tests required. A police officer must have probable cause to believe that a person is driving, operating or in physical control of a motor vehicle in violation of the DWI law, including driving under the influence of alcohol or a controlled substance, or a combination.

The officer's probable cause is most often the observation of erratic driving, the appearance or behavior of a driver stopped for some other violation or accident, or some other articulable reason for suspecting DWI.

When an officer makes a DWI arrest it is likely that alcohol is the primary suspect, if for no other reason than the 4,000 to one ratio of drunken driving convictions to drugged driving convictions.

Because breath testing is the most efficient, quickest, least costly and least intrusive test for alcohol impairment, it is the test most often chosen by police officers. The breath test, however, is of no use in detecting drugs other than alcohol, except as a means of ruling out alcohol as the cause of the impaired driving. Since the erratic driving may have resulted from one of scores of medical conditions, including illegal drug use, the police officer may well chose to get the driver medical attention and at the same time require a blood or urine sample for drug testing. There have been Minnesota

cases, for example, in which a person suspected of drunken driving turned out to be a previously undiagnosed diabetic.

In light of current popular attention to problems of illegal drug use, it is understandable that there should be calls for routine drug testing when an impaired driver is arrested. Leaving aside, for the moment, the fact that blood or urine testing identifies only the presence of a drug other than alcohol, rather than measuring a degree of impairment, there are many factors to be considered before changing the present system.

This report considers those issues and makes recommendations.

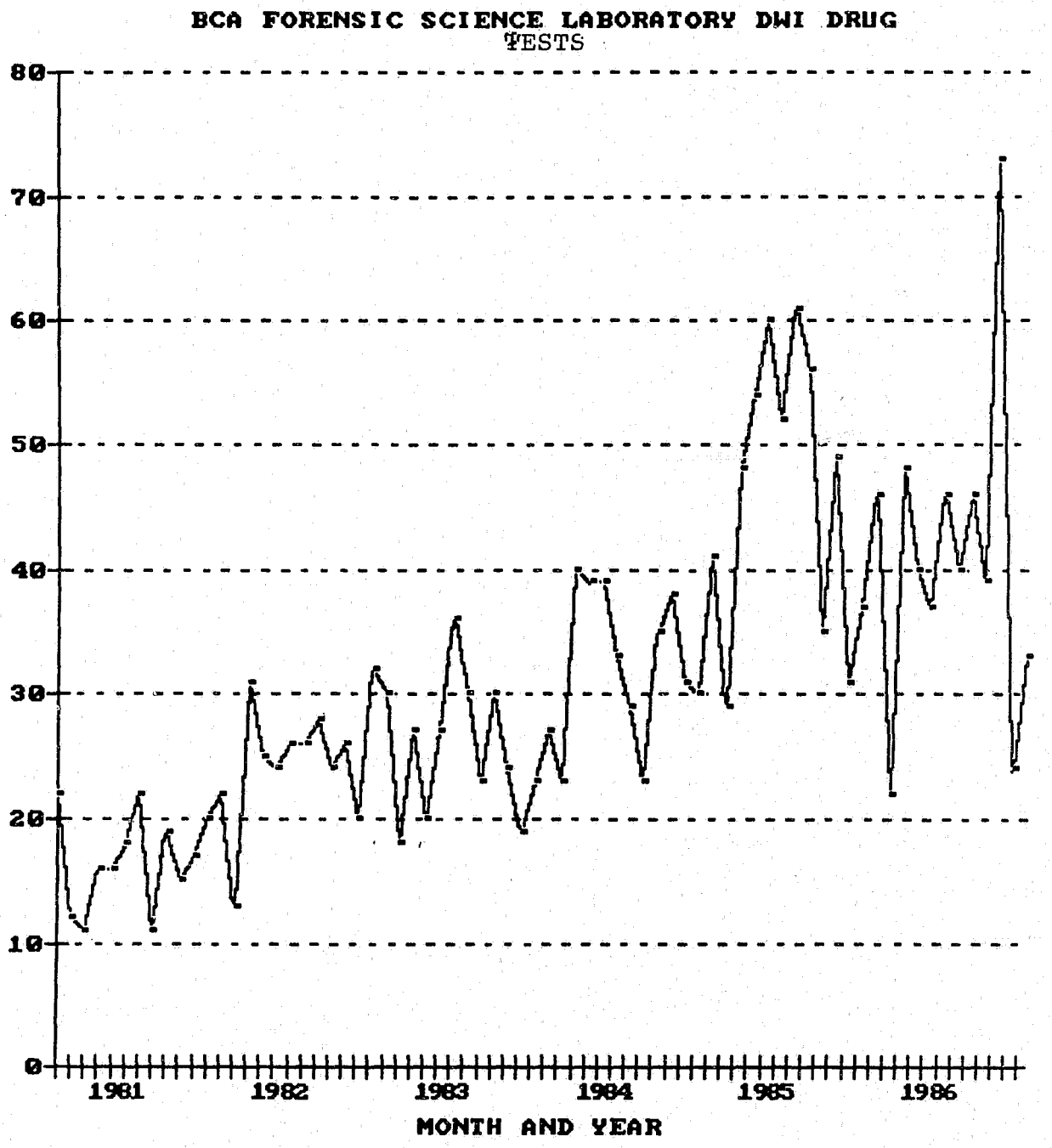
Present enforcement and testing practices result in a breath test for nearly all suspected DWI drivers. If the result of the breath test indicates alcohol impairment the driver is charged with that offense and no other tests are routinely required. For second test of blood or urine to be required, there must be "probable cause to believe there is impairment by a controlled substance that is not subject to testing by a breath test." In other words there must be a reason to suspect drugs. That reason might be the presence of drugs themselves in the vehicle or on the person of the suspect, the odor of marijuana smoke, the behavior of the person or physical signs of drug use.

An example of a situation in which a second test of blood or urine is required would be one in which the original bad driving gave strong suspicion of DWI and ample probable cause for the arrest, but a breath test showed either negative or very low alcohol concentration, and there were indications of drug involvement.

Such cases do arise, but a much more frequent situation is one in which both drinking and other drugs have been involved, but enough alcohol has been consumed that the breath test shows an alcohol concentration high enough to sustain that charge alone. Circumstances of the arrest may make the officer feel that a charge of driving under the influence of a combination of alcohol and a controlled substance is warranted and appropriate. If there is evidence of the drug involvement the officer can make that charge with or without a test to determine the presence in the body of the controlled substance. In fact, the prosecutor, court or jury may find that erratic driving along with the smell of marijuana in the car or on the driver, or presence of marijuana

crumbs or ashes, is better evidence of the impaired driving charge than the mere finding of THC metabolites in the blood or urine which could be found even several days after smoking marijuana.

The forensic science laboratory of the Minnesota Bureau of Criminal Apprehension, a division of the Department of Public Safety, has the responsibility for operation and integrity of DWI tests, including breath, blood and urine tests for alcohol and controlled or other substances. The number of blood and urine tests has more than doubled since 1981 as shown in the graph below:


BCA FORENSIC SCIENCE LABORATORY DWI DRUG TESTS
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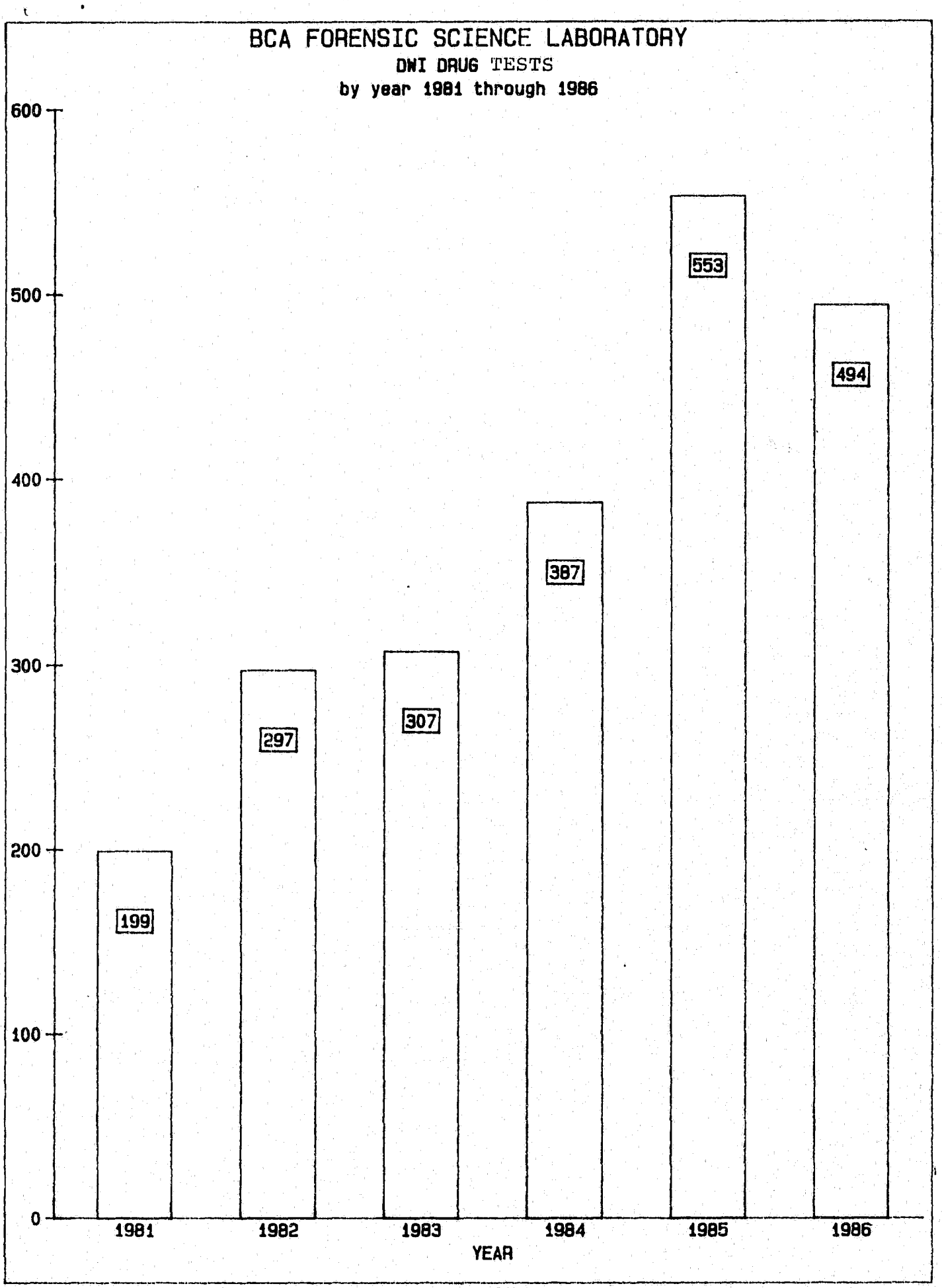
70
60
50
40
30
20
10
0
1981
1982
1983
1984
1985
1986
MONTH AND YEAR


BCA FORENSIC SCIENCE LABORATORY
DWI DRUG TESTS
by year 1981 through 1986
600
500
400
300
200
100
0
199
297
307
387
553
494
1981
1982
1983
1984
1985
1986
YEAR

The tables below provide information to allow some comparison between

a. Minnesota BCA tests for the presence of suspected drugs and

b. tests for the level of alcohol concentration in drivers suspected of impaired driving.

The Minnesota data are consistent with other findings reported in substantial extracts from various studies and reviews included with this report. The consistencies are with the reported scope of drug involvement with traffic safety, the great dissimilarities between alcohol and other drugs, and with the lack of knowledge allowing us to say, for example, that controlled substances "caused" or "were involved in" a given number or a particular percentage of traffic crashes and driving violations.

The conscientious policy maker who tries to act on facts finds very few hard data to support actions which, on the face of them, sound reasonable, because they are based on mistaken assumptions that drugged driving is similar to drunken driving and that similar control measures are appropriate.

This paper has provided lengthy extracts from respected studies and reviews of the scientific literature because we reach conclusions and make recommendations which are contrary to popular wisdom.

SUMMARY OF TESTS GIVEN IN MINNESOTA TRAFFIC LAW ENFORCEMENT CASES (169.121) 1986

Tests for alcohol	N tests		Average alcohol concen.
Breath	26,752		.16
Blood	3,669		.16
Urine	1,399		.14
Total, all AC tests	31,820		.16
Drug tests in TLE	496		
Positive for drugs	296	(60%)	
Alcohol found in combination with other drugs	206	(42%)	.09

Drugs found

Cannabinoids (marijuana)	230
Cocaine	34
Misc (some not controlled)	26
Amphetamine/Methamphetamine	5
Diazepam	2
Methadone	1
Phencyclidine (PCP)	1

Note: Total of individual drugs will not match total of "positive for drugs" since some samples contained multiple drugs.

The reader should also note that a variety of circumstances lead to a TLE drug test. Not all "under .10 AC" go to drug test, especially if no drug probable cause. Most are charged with either careless driving or DWI with relevant evidence of AC over .05 but under .10.

Important considerations before requiring all suspected impaired drivers, or drivers involved in accidents, to undergo blood or urine tests in addition to breath tests, are cost and feasibility.

The cost of a breath test is estimated to be between $15 and $20.

The cost of a blood or urine alcohol test is estimated to be between $30 and $35 per test.

Breath testing of 27,000 alcohol cases in 1986 cost about $475,000.

Blood testing for alcohol of 3,700 samples cost about $120,000.

Urine testing for alcohol of 1,400 samples cost about $45,000.

To add drug analysis to the 5,100 blood or urine tests for alcohol would have cost $1,000,000 more.

If a blood or urine test had been taken in all 1986 impaired driving cases and a minimum (four frequently found drugs) screening and confirmation test conducted, there would have been added cost of approximately $8,000,000. ($250 X 32,000)

It might be argued that with blood or urine tests, a breath test would be superfluous, with savings offsetting some of the additional cost of testing for drugs. Such a theoretical saving would be illusory since a test for alcohol would add one more drug (alcohol) to those tested for and could add as much as saved.

However, the most persuasive argument against either dropping the breath test for alcohol, or adding tests of blood or urine in all cases in order to identify possible other drug involvement, is the drastic disruption of the drunken driver control program through the great increase in police and lab time for blood or urine tests. Police officer time involved in overlaying blood or urine tests on existing breath test procedure would greatly increase officer down time

during the arrest process and would seriously reduce the number of drinking driver arrests per officer hour available.

Minnesota's system of administrative driver license revocation is credited with much of the state's success in achieving the country's lowest traffic death rate. This system, in turn, rests on the integrity and efficiency of the breath test and the quick availability of breath test results (minutes) as contrasted with results from blood or urine testing (days).

FINDINGS

There is no question that drug-impaired driving is a hazard to traffic safety and must be deterred through law enforcement.

The present system of testing for the presence of drugs when there is probable cause to suspect impaired driving under the influence of a controlled substance and a breath test shows an alcohol concentration of less than .10 is effective and cost efficient.

In response to the specific questions to be addressed, the Department of Public Safety finds that "requiring persons suspected of driving under the influence, and persons involved in motor vehicle accidents, to submit to blood or urine tests for controlled substances, in addition to breath tests" would not "improve the accuracy of statistics kept by the department on the number of accidents and driving under the influence cases that involve controlled substances" and would not "increase the likelihood of convicting persons driving under the influence of controlled substances.

These findings result from the conclusion that such a requirement for blood or urine tests in DWI cases would result in a drastic reduction in DWI arrests because of the overwhelming demands on police and laboratory time.

As total DWI apprehensions decline sharply, so too will those drug cases which are detected from the larger pool of those people who were "driving like a drunk" but showed little or no alcohol when relatively inexpensive breath tests are given.

The most efficient way to enforce laws against drug impaired driving is to give all DWI suspects a breath test so that a negative alcohol result works in

reverse as a screen for potential drugged driving. With a breath test the police officer is alerted sooner to such cases, and more specific investigation of the case for drugs can begin earlier. With the use of portable, preliminary breath tests, the suspicion of drug involvement may begin at the roadside.

T.C.

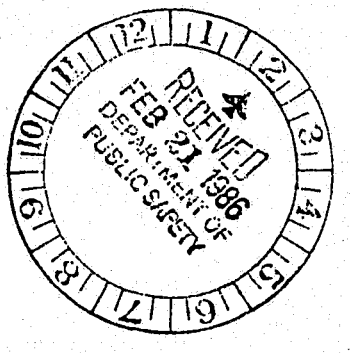
U.S. Department
of Transportation
**National Highway
Traffic Safety
Administration**

APPENDIX A.

"DRUGS AND DRIVING"
Minnesota Department of Public Safety
October, 1987

DOT HS 806 900 **December 1985**
NHTSA Staff Technical Report

The Incidence of Driving Under the Influence of Drugs 1985: An Update of the State of Knowledge



Technical Report Documentation Page

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DOT HS 806 900		

4. Title and Subtitle	5. Report Date
The Incidence of Driving Under the Influence of Drugs 1985: An Update of the State of Knowledge	6. Performing Organization Code: NRD-42
7. Author(s): Richard P. Compton and Theodore E. Anderson	8. Performing Organization Report No.
9. Performing Organization Name and Address: Office of Driver and Pedestrian Research, Research and Development, National Highway Traffic Safety Administration, Washington, D.C. 20590	10. Work Unit No. (TRAIS)
	11. Contract or Grant No.
12. Sponsoring Agency Name and Address: Same	13. Type of Report and Period Covered: NHTSA Staff Technical Report
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

This report reviews recent studies of the incidence of drug use by drivers. Only reports published since a 1980 state of knowledge report were included. The report is divided into three sections covering the incidence of drug use by: (1) fatally injured drivers, (2) injured drivers, and (3) non-accident involved drivers detained by the police.

The studies reviewed indicate which drugs are being used by drivers. The drugs (or drug classes) most frequently detected are (in order of decreasing incidence):

- Marijuana
- Diazepam (Valium(R))
- Cocaine
- Barbiturates (e.g., Secobarbital)
- Methaqualone
- PCP (phencyclidine)

The data reviewed indicate that drugs are detected in 10% to 22% of the accident involved drivers. Drugs (other than alcohol) are detected by themselves in 2% to 15% of the accident involved drivers. The majority of the drug using drivers were found to have high levels of alcohol in combination with the drugs (ranging from 53% to 77%).

The studies reviewed do not allow us to precisely estimate the extent of drug use by drivers. Most of these studies did not use unbiased representative samples and tested for only a limited number of drugs. The simple incidence data currently available is insufficient to determine which specific drugs increase accident risk. This would require data on the extent to which non-accident involved drivers use these drugs. These missing data would allow a determination of the degree to which drivers using drugs are overrepresented in accidents.

17. Key Words	18. Distribution Statement
drugs, drugs and driving, incidence of drugs in accidents, highway safety	Document available to the U.S. public through the National Technical Information Service, Springfield, VA 22101

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Unclassified	Unclassified	31	

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EXECUTIVE SUMMARY

Alcohol is accepted as a major highway safety problem. This came about only after a considerable research effort was undertaken to demonstrate the causal role of alcohol in automobile accidents. Recently, increased concern has been expressed that drugs other than alcohol may also contribute to a significant number of accidents. However, only limited research has been conducted in the drugs and driving area. No empirical evidence yet exists to document the nature and magnitude of the highway safety problem that might be due to drugs.

There have been a number of laboratory studies that have shown that performance on tasks that utilize driving related skills (e.g., divided attention, tracking) is impaired by some of these drugs. Given these results, it might be argued that there is a drug related highway safety problem and that the laboratory data could be used to specify its nature and magnitude. Unfortunately, this is not possible because there is no way to directly relate performance on laboratory tasks to accident risk. In addition, even if a drug has the potential for producing severe impairment, it would not be considered a problem unless there was strong evidence that a significant number of drivers who are driving under the influence are consuming a sufficient quantity of the drug prior to driving.

In order to find out whether any drugs are significant highway safety problems, field research is required that will determine (1) their frequency of occurrence in accident involved drivers, and (2) the extent to which they contribute to the accidents.

In 1980 a drugs and highway safety "state of knowledge" report was published by the NHTSA (Joscelyn, Donelson, Jones, McNair and Ruschmann, 1980) that summarized the data available at that time from accident and police arrest drug incidence studies. The authors concluded that there were insufficient data to define the nature and magnitude of the drug/highway safety problem. Since that time there have been a number of highway-related drug incidence studies carried out by state and local medical examiners, public and private research institutions, and foreign governments. The work reported on in this report reviews these recently published studies to determine whether they contain sufficient data to allow more definitive conclusions regarding which drugs are likely to be highway safety hazards.

This review of the studies published since the 1980 state of knowledge report is divided into three sections, namely: (1) the incidence of drug use by fatally injured drivers, (2) injured drivers, and (3) nonaccident involved drivers detained by the police.

The studies reviewed in this paper tend to report the highest incidence rates for the drugs (or drug classes) listed below (in Table 1).

Table 1

Drugs Found Most Frequently in the Blood of Drivers
(Listed in Order of Decreasing Frequency)

- o Marijuana
- o Tranquilizers
  - diazepam (Valium(R))
  - chlordiazepoxide (Librium(R))
- o Sedative/Hypnotics
  - barbiturates (Seconal(R))
  - methaqualone (Quaalude(R))
- o Hallucinogens
  - phencyclidine (PCP)
- o Stimulants
  - cocaine
  - amphetamines
- o Narcotics
  - codeine
- o Antihistamines
  - diphenhydramine

The incidence rate for the use of drugs other than alcohol, reported in these studies, is summarized in Table 2 (below). Separate estimates are given depending on whether the study samples were fatally injured drivers, injured drivers, or drivers arrested by the police on suspicion of impaired driving. These numbers are not statistically valid estimates of the incidence of drugs in these populations, but represent the best guess one can make based on the available information.

Table 2

Frequency of Drug Incidence in Fatally Injured Drivers, Injured Drivers and Drivers Arrested for Impaired Driving

Driver Type	Incidence
Fatally Injured	10% - 15%
Injured	22%
Arrested Drivers*	14% - 50%

* Note - with BACs below 0.10% w/v

Unfortunately, these data are not representative of drivers in U.S., for a number of reasons. These studies looked at relatively small samples of drivers that were typically not selected in a random or unbiased fashion that would allow generalizations to be made. Also, most of the studies did not screen the drivers for many potentially impairing drugs; they looked only for a limited number of drugs.

The studies of drug use by arrested drivers are particularly difficult to interpret. They generally included only drivers who chose to take a blood (rather than a breath) alcohol test and who had BACs under 0.10% w/v (between 1% - 3% of all drivers arrested by the police). Even with this restriction the drivers were not necessarily selected in an unbiased manner.

It is not possible to say how many of the drivers using drugs were impaired by the drugs, nor whether the use of the drugs contributed to their accidents. The mere presence of drugs in drivers, at any incidence rate, does not necessarily imply that the use of the drug was causally related to the accidents. Only if the drug occurs significantly more frequently in accident involved drivers than it does in nonaccident involved drivers can it be considered a possible causal factor. The greater the overrepresentation of a drug in the accident involved sample, the more likely the drug is a significant highway safety hazard. Only one study reviewed in this report collected any exposure data from nonaccident involved drivers (a foreign study conducted in Finland which had a small sample size and poor blood sampling procedures); thus, they can not be used to establish that drugs other than alcohol are safety problems for drivers.

One important finding is that most of the accident-involved drivers in whom drugs were detected had also consumed alcohol, often in sufficient quantities to produce relatively high BACs (i.e., over 0.10% w/v). For example, the percentage of fatally injured drivers using drugs who also had used alcohol ranged from 54% to 80%, while for injured drivers using drugs approximately 42% had also consumed alcohol.

The frequency with which drivers use drugs in combination with alcohol makes it difficult to determine if the use of drugs increases accident risk. While the dosage of the drug taken may not be sufficient to produce significant driving impairment by itself, the combined effect of the drug and alcohol may increase the impairing effects of the alcohol. This increased impairment may be greater than the sum of the impairing effects of either drug alone.

The critical piece of information necessary for establishing that certain drugs pose significant safety risks, namely the extent to which nonaccident involved drivers use these drugs, is still not available. Without this information it is not possible to meaningfully interpret incidence rates by accident involved drivers.

THE INCIDENCE OF DRIVING UNDER THE INFLUENCE OF DRUGS 1985: AN UPDATE OF THE STATE OF THE KNOWLEDGE

Richard P. Compton & Theodore E. Anderson

INTRODUCTION

Alcohol is accepted as a major highway safety problem. There have been a large number of research studies over the past 30 years designed to examine this problem and determine its magnitude. At this point in time, it is known that alcohol is involved in approximately 50% of all fatal and 20% of all serious injury highway accidents, and that the critical blood alcohol concentration (BAC) associated with an increased accident risk is between 0.08% w/v and 0.10% w/v. Based on this and other information regarding the alcohol problem, programs to reduce alcohol-impaired driving have been developed and are being implemented in States and localities around the country.

Recently, concern regarding drugs other than alcohol has also been increasing. Efforts are underway to educate the public to the dangers of drug abuse. In this context, questions have been raised about whether drugs other than alcohol are a significant highway safety problem. There have been a number of laboratory studies that have shown that performance on tasks that utilize driving related skills (e.g., divided attention, tracking) is impaired by some of these drugs. Given these results, it might be argued that there is a drug related highway safety problem and that the laboratory data could be used to specify its nature and magnitude. Unfortunately, this is not possible for the following reasons:

- For a given driving related task, large differences in the degree of performance decrement are often exhibited between subjects consuming the same drug (and dosage level). Also, the average degree of drug related performance impairment may differ substantially between tasks.

- Perhaps even more important is the fact that there is no agreement as to which of the many driving-related tasks used in the laboratory contain the critical combination of skills necessary to the safe operation of an automobile. Even if this ideal set of performance tasks could be developed, the exact degree of performance impairment that would be required to increase accident risk would be very difficult to determine. Also, the fact that a specific performance impairment results under the artificial and non-life threatening situations necessary in the laboratory, does not mean that this same performance impairment will be evident in the real world. It may be increased or reduced depending on the driver's physical and mental reactions to the specific traffic situations being experienced.

- Finally, laboratory performance data do not provide any indication of how frequently drivers in the real world are consuming drugs that increase accident risk. If a drug has the potential for producing severe impairment of the driving task, but the driving public is not consuming the drug prior to driving, it can be concluded that there is no highway safety problem associated with that particular drug at the present time.

These observations do not mean that laboratory-related data have no utility in assessing the drug related highway safety problem. Drugs that impair driving-related performance in the laboratory can be considered potentially hazardous, whereas drugs that do not precipitate performance impairment can be disregarded. Based on the laboratory research to date, the following drugs (or drug classes) can be classified as potentially hazardous to the driving task:

- Marijuana
- Tranquilizers (e.g., Valium(R))
- Barbiturates (e.g., Seconal(R))
- PCP, LSD, other hallucinogens
- Opiates (e.g., heroin)
- Amphetamines
- Cocaine
- Antihistamines
- Methaqualone (Quaalude(R))

In order to find out whether any of the drugs listed above are indeed significant highway safety problems, field research is required that will determine (1) their frequency of occurrence in accident involved drivers, and (2) the extent to which they contribute to the accidents. This type of research is difficult to carry out for the following reasons:

- Blood samples are required from accident involved drivers within 1-2 hours of the accident. Many of the drugs of interest rapidly disappear from the blood and would not be detected if a longer time period was allowed.

- Blood samples are required from a nonaccident group of drivers so that the frequency of occurrence of the various drugs in this group can be compared with the corresponding frequency in the accident group. If the drug occurs more frequently in the accident drivers, it can be considered a possible causal factor. The greater the overrepresentation of a drug in the accident sample, the more likely the drug is a significant highway safety hazard. Collecting blood samples from a comparable sample of drivers (to the accident group) is a complex and expensive procedure that requires the setting up of safety checkpoints and the cooperation of drivers stopped at these checkpoints.

- The analysis of the blood samples, for a wide range of possible drugs (both an initial screen and a confirmation procedure that specifies dosage level) is very expensive, and requires technical expertise and equipment available in only a few labs around the country. Urine is easier to collect and cheaper to analyze, but it is not a reliable indicator of whether the individual recently consumed the drug, and therefore may be experiencing its effects.

There have been a number of accident investigation studies conducted with the stated purpose of assessing the nature of the drug/highway safety problem. However, most of these studies have focused on determining the incidence of certain drugs only in accident-involved drivers. The corresponding nonaccident control data, required to assess potential causation, were hardly ever collected. This makes it very difficult to interpret the results from these studies. There have also been a number of studies designed to determine the frequency of drug occurrence in drivers arrested for Driving Under the Influence of Drugs (DUID). From an accident causation point of view, these studies are even more difficult to interpret, since DUID drivers included in the study samples were typically not accident-involved drivers.

In 1980 a drugs and highway safety "state of knowledge" report was published by the NHTSA (Joscelyn, Donelson, Jones, McNair and Ruschmann, 1980) that summarized the data available at that time from accident and police arrest drug incidence studies. The authors concluded that there were insufficient data to define the nature and magnitude of the drug/highway safety problem. Since that time there have been a number of highway-related drug incidence studies carried out by state and local medical examiners, public and private research institutions, and foreign governments. The current report that follows will review these studies published since 1980 and determine whether they contain sufficient data to allow more definitive conclusions regarding which drugs are likely to be highway safety hazards.

The following review of the studies published since the 1980 state of knowledge report is divided into three sections, namely: (1) the incidence of drug use by fatally injured drivers, (2) injured drivers, and (3) nonaccident involved drivers detained by the police.

STUDIES OF FATALLY INJURED DRIVERS

None of the studies reviewed in this section collected exposure data from nonaccident involved drivers. Thus, any direct estimation of whether the use of a drug increases accident risk is not possible from these studies. Some of the studies reviewed below have attempted to estimate whether the driver could have been impaired by the drugs they were found to have used. This estimate was typically based upon the concentration of the drug found in their bodies. If the concentration of the drug exceeded the therapeutic or normal dose, or was at a level that has been shown to produce debilitating behavioral effects, the driver was classified as probably impaired. The purpose of this type of analysis is to reduce potentially misleading incidence rates when only trace amounts of a drug are detected.

Two reports have been published from a study that examined the use of alcohol, marijuana, and other drugs in fatally injured drivers killed in single vehicle crashes in North Carolina, during the period of 1978 - 1981 (Owens, McBay & Cook, 1983 and Mason & McBay, 1984). Single vehicle crashes were selected so that driver fault in causing the accident would not be at issue. The specific drugs of interest in the study were: alcohol, marijuana, barbiturates, cocaine, opiates, phencyclidine (PCP), amphetamines and methaqualone. Approximately 850 drivers were fatally injured during the study period, of which 600 (70%) met the study criteria and were included.

The following criteria were used to select cases for the study:

1. The victim was the driver of a vehicle (car or truck) involved in a single-vehicle crash.

2. A suitable specimen containing greater than 5 ml of whole blood or plasma was obtained.

3. The specimen submitted was representative of the blood of the driver at the time of the crash. Either the driver was killed in the crash, or lived for less than one hour after the crash occurred (this was to reduce the effects of either drug metabolism or elimination). The victim must not have received any vigorous medical treatments including medications, surgery or transfusions.

4. Complete documentation was available (toxicology request, medical examiner's report, pathologist's report on any autopsy performed, death certificate, and motor vehicle crash report).

The results showed the incidence of drug use was fairly low. Approximately 14% of the drivers had used any of the drugs tested for in this study. The vast majority of the drivers who had used drugs had also used alcohol (i.e., 80%). The most commonly detected drugs were: THC (8%), methaqualone (found in

6% of 260 cases tested for this drug), and barbiturates (3%). Phencyclidine (PCP), opiates, cocaine and benzoylecgonine, and other volatile substances were detected only rarely (in 2% or less of the drivers).

As might be expected, alcohol was found in 79% of the drivers, with 68% of these drinking drivers having BACs greater than or equal to 0.10% w/v. Of those drivers who had consumed both alcohol and drugs, 77% had BAC's greater than or equal to 0.10% w/v.

The drug concentrations found were usually within or below the accepted therapeutic dosage range. According to the authors, only a small number of drivers (between 2.5% and 8.5%) could have possibly been impaired by drugs and most of these drivers had high BACs. The authors suggest an even smaller number of drivers (2% or less) could have been influenced by drugs alone. Multiple drug use (excluding alcohol) was not common (less than 1%). The authors concluded that alcohol was the only drug for which they tested that appeared to be a significant highway safety problem.

It should be noted that many drugs or drug classes were not screened for in this study. For example, drugs such as some frequently used tranquilizers (like diazepam and chlordiazepoxide), antidepressants, analgesics (e.g., methadone, pentazocine), hallucinogens (such as LSD or mescaline), muscle relaxants (e.g., meprobamate) and antihistamines (e.g., diphenhydramine) were not included. Other studies of fatally injured drivers have reported high incidence rates for some of these other drugs.

Williams, Peat, Crouch, & Finkle (1985) recently reported a study conducted in southern California that documented the drug use of fatally injured young male drivers. The study population consisted of 15-34 year old fatally injured male drivers of motor vehicles who died during selected periods of 1982-1983, in four California counties. Williams et al. state that they selected this special population for study because these individuals have high drug use and high crash rates. They felt this population, above any other, would reveal a high incidence of drug use if such use was significantly related to fatal accident involvement. Of course, the critical issue actually is the extent of overrepresentation of a drug in fatally injured drivers rather than the rate of drug use (which is not necessary related to accident causation).

The study included only victims who died during the crash or within 2 hours of the crash to minimize effects of metabolism and elimination on drug concentrations. During the study period 789 male 15-34 year old drivers died. Of these, 440 (56%) met the study criteria, had sufficient quantities of blood available for analysis, and other necessary information could be obtained. These 440 drivers included 220 automobile drivers and 220 drivers of other vehicles (e.g., motorcycles, pickup trucks, vans, etc.). The blood samples were screened for the presence of 23 drugs or drug groups identified by NHTSA (Joscelyn and Donelson, 1980) as those that might impair driving ability.

Approximately 51% of the drivers were reported to have used drugs other than alcohol. Drugs, when found, were infrequently found alone (in less than 30% of the drivers using drugs), usually occurring in combination with alcohol (and with BACs equal to, or greater than 0.10%). Table 3 (below) shows the percentage of drivers who had used specific drugs who had also consumed alcohol and shows the percentage of those drivers whose BAC was greater than or equal to 0.10%.

Table 3

Percentage of Drivers Using Specific Drugs Also Consuming Alcohol And Percentage of Drivers Using Drugs and Alcohol With BACs $\geq$ 0.10%

Drug Used	(N)	% Using Drug and Alcohol	% Using Drug and Alcohol With BACs $\geq$ 0.10%
Marijuana	(162)	81% (132)	84% (111)
Cocaine	(47)	77% (36)	86% (31)
Other Drug	(113)	70% (79)	81% (64)

The use of multiple drugs was common with 43% of the drivers in the sample having two or more drugs present. Viewed slightly differently, 85% of the drivers consuming drugs used two or more drugs. Alcohol, alone or in combination with drugs was present in 70% of the drivers.

The most common drug category found was cannabinoids (constituents of marijuana) which was detected in 37% of the drivers, followed by cocaine in 11% of the drivers. Diazepam (Valium(R)), phencyclidine (PCP), methamphetamine (stimulant), phenyl-propanolamine and ephedrine (decongestants) were found in 2-4% of the drivers. The fairly high incidence of marijuana, 37% of the drivers, should be interpreted cautiously as it includes drivers in whom only very small quantities of THC were found. At least 40% of these drivers would have been treated as false positives and would not have been counted by other authors, based on the THC levels detected (i.e., concentrations of less than 1 ng/ml in hemolyzed blood).

In a major part of this study, police reports were reviewed to determine driver responsibility for the accident. Comparisons were then made between responsible and nonresponsible drivers in terms of drug presence in order to estimate the role of drugs in accident causation. Williams et al. were trying to determine whether more responsible drivers had used drugs than had nonresponsible drivers. In this analysis, only sex and age were controlled for (all subjects were young males), though other important factors in which the groups may not have been comparable were not controlled (e.g., prior driving record, vehicle factors).

The results showed that drivers who used alcohol alone were more likely to be responsible for their accidents (92%) than were drug-free drivers (71%), and that accident responsibility increased with increasing BACs. However, only 53% of the drivers who used marijuana alone were judged responsible for their accidents (compared to the 71% for the drug-free drivers). The combined use of alcohol and marijuana did not lead to a significant increase in responsibility for accidents (95% judged responsible) over that found for drivers using alcohol alone.

The authors concluded that their analyses indicated that alcohol was significantly related to accident responsibility but that marijuana was not. This analysis was constrained by the small numbers involved (e.g., only 19 drivers had used marijuana alone), and the fact that in the population studied, accident responsibility rates for alcohol alone were greater than 90 percent so that adding marijuana could not have had much of an effect.

A simple descriptive study by Cimbura, Lucas, Bennett, Warren and Simpson (1982) was designed to look at the incidence of drug use by fatally injured drivers in the province of Ontario, Canada during a 1-year period (4/78 - 3/79). A total of 768 driver fatalities were recorded during this time period, and blood and urine samples were collected from 401 drivers who met the study criteria. Excluded were victims who died more than one hour after admission to a hospital and from whom blood and urine specimens were either not available or inadequate. Thus, data were obtained on approximately 52% of the intended study sample.

The blood and urine specimens were screened for a wide range of drugs (at least 90). Psychoactive drugs (e.g., marijuana, diazepam/Valium$^{(R)}$) were found in the blood of 9.5% of the drivers, though the authors report that in many of these cases the concentrations of drugs other than alcohol detected were just trace amounts. The psychoactive drugs detected in the blood most frequently were THC (a metabolite of marijuana) in 3.7% of the drivers and diazepam (Valium$^{(R)}$) in 3%. A number of other drugs were found in less that 2.7% of the drivers.

Psychoactive drugs were rarely found alone (3.7% of the time), typically being used in combination with alcohol. For example, of the 15 drivers who had used marijuana, 53% had BAC levels over 0.10% w/v and almost all had used alcohol (13 out of the 15 or 87%).

The authors of the study report finding drugs, other than alcohol, in 26% of the fatally injured drivers. However, this number is quite misleading for two reasons. First, this study screened for a large number of "drugs" that included such substances as salicylate (aspirin) and acetaminophen (tylenol), which probably do not impair driving ability. Secondly, many of the cases included in the 26% figure involved detection of a drug in urine but not in blood, implying that the drivers had used the drugs in the past but may not have been under the influence at the time of their accident.

In comparison to the drug findings, Cimbura et al. report that alcohol was detected in 57% of the fatally injured drivers. Also, 86% of the drinking drivers had a BAC level in excess of the Canada's statutory limit of 0.08% w/v. Thus, this study found that beyond the incidence of alcohol, only marijuana and diazepam appeared with any significant frequency in the blood of fatally injured drivers, often in combination with alcohol, and typically in fairly low concentrations.

A recent study by Donelson, Cimbura, Bennett & Lucas (1985) documented the incidence of marijuana and alcohol in fatally injured drivers in Ontario, Canada. The study sample was obtained from driver fatalities occurring over a twenty-nine month period (from 3/82 to 7/84), where the death occurred within one hour of the accident. The study sample included 1,169 cases that met the basic eligibility criteria for the study (88% of the total driver fatalities during this time period). The blood samples obtained were tested only for the presence of the two substances, alcohol and marijuana.

Marijuana alone was detected in the blood of only 2% of the drivers tested. Marijuana and alcohol were found in 9% of the drivers. Most of the drivers in whom marijuana and alcohol were detected had BACs over 0.08% w/v (i.e., 69%).

The authors note that the vast majority of the drug-positive cases were male drivers (98% of the marijuana-positive cases were male). Approximately 12% of the male drivers in the sample were marijuana-positive, while only 2% of the females were marijuana-positive. The younger males (14-24 years old) had the highest frequency of drug usage with a 22% marijuana-positive rate.

A study of limited relevance to the situation in the United States was conducted by Krantz and Wannerber (1981) in Sweden. They investigated the incidence of some commonly used tranquilizers and sedatives, including barbiturates (e.g., Secobarbital), benzodiazepines (e.g., Diazepam), meprobamate (e.g., Miltown(R)), methaqualone (Quaalude(R)) and phenothiazines (e.g., Chlorpromazine) in drivers killed in automobile accidents in southern Sweden, during 1977 and 1978. In southern Sweden, autopsies are routinely performed on all persons killed in traffic accidents. Unfortunately, this study included drivers who survived up to ten hours after their accident, which may mean that any drugs they had used were no longer present in the blood in quantities that would be detected.

Of the 122 drivers analyzed, drugs were found in only nine drivers (7.3%). Two of these drivers (1.6%) had also been drinking of alcohol (they had BACs of approximately 0.30% w/v). Benzodiazepines were found in 3.3% of the drivers, and Methaqualone and Meprobamate were each found in 2% of the drivers. In twenty-three percent of the drivers only alcohol was detected.

Thus, the incidence of drugs found in this study was low and as a result provides very little evidence that tranquilizers/sedatives were a potential problem in the fatal accidents studied. However, this study looked at just one drug category and did not include many important drugs that are potential safety hazards (e.g., marijuana, cocaine, etc.).

Wetli (1983) conducted a study of methaqualone-related (Quaalude(R)) deaths in Dade County, Florida during an eleven year period from 1971 through 1981. The Medical Examiner's Office routinely autopsies and performs toxicological tests on deaths involving physical trauma in any form in Dade County. Wetli reports that Methaqualone was detected in 58 cases involving motor vehicle operators during this period. However, the author does not provide any information on the sampling method used, nor does he report any data about the total number of driver fatalities during this period, thus it is not possible to tell what percentage of the fatally injured drivers these 58 cases represent. This study is of little use in estimating the incidence of this drug in fatally injured drivers.

Summary

These few studies of fatally injured drivers report relatively low incidence rates for drugs other than alcohol. The incidence rates for drugs ranged from 9.5% in Ontario (Cimbura et al., 1980) to 13.8% in North Carolina (Mason & McBay, 1984). Fifty-one percent of a special population of high-risk young males in Southern California were found to have used drugs other than alcohol, though this included detections of extremely small quantities (Williams et al., 1985).

Most of the drivers who were found to have used drugs in these studies were also under the influence of alcohol (i.e., with BACs greater than or equal to 0.10% w/v). The percentage of fatally injured drivers using drugs who also had consumed any alcohol was 54% in Ontario, 80% North Carolina, and approximately 77% of young males in Southern California. The frequency with which drivers use drugs in combination with alcohol makes it difficult to determine if the use of drugs increases accident risk.

The mere presence of drugs in fatally injured drivers, at any incidence rate, does not necessarily imply that the use of the drug was causally related to the accidents. Only if the drug occurs significantly more frequently in accident involved drivers than it does in nonaccident involved drivers can it be considered a possible causal factor. The greater the overrepresentation of a drug in the accident involved sample, the more likely the drug is a significant highway safety hazard. None of the studies reviewed in this section collected any exposure data from nonaccident involved drivers, thus they can not be used to establish that drugs other than alcohol are safety problems for drivers.

These studies have looked at relatively small non-representative samples of fatally injured drivers that do not provide a basis for estimating the incidence of drug use by drivers in the U.S. However, certain drugs have been detected with some frequency in these studies and thus are more likely to be possible problems than other drugs; they are: marijuana, tranquilizers and sedatives (diazepam, barbiturates, methaqualone), cocaine, codeine, PCP, and amphetamines.

STUDIES OF INJURED DRIVERS

Joscelyn, et al. (1980), in the 1980 review of the state of knowledge on drugs and highway safety, noted that incidence rate data for injured drivers in the U.S. were virtually non-existant. Only one study of accident involved injured drivers in the U.S. has been conducted since that time. That study, by Terhune and Fell (1982), provides the only available data on American drivers and is reviewed below. A number of studies have recently been conducted in other countries (in Europe, Scandinavia, and New Zealand) that can not be assumed to be representative of American drivers, but may be of interest to the extent that foreign drug use rates reflect American patterns. These foreign studies will also be briefly reviewed in this section.

Only one of the studies reviewed below, that was conducted in Finland, collected exposure data from nonaccident involved drivers that would allow some estimate of increased crash risk as a result of drug use. The Terhune and Fell study of American drivers did include a crash responsibility analysis to determine if drivers who used drugs were more likely to be estimated as responsible for their accidents than were drug free drivers. This type of analysis tries to control for other factors that might be related to accident involvement in order to establish a possible link between drug use and accident risk.

The Terhune and Fell study examined the role of alcohol, marijuana and other drugs in the accidents of 497 injured drivers who were treated at a hospital in Rochester, N.Y., during parts of 1979 and 1980. The authors of this study were unable to obtain a representative sample of injured drivers in this jurisdiction (only one hospital agreed to participate in the study), so the results should be interpreted with caution. Of 1,062 drivers identified as eligible for inclusion in the study, 47% (497) were eventually included. Eligible drivers were lost primarily through not being detected or refusing to participate. Blood samples were screened for the presence of 23 drugs or drug groups identified by NHTSA as potential highway safety hazards (Jones and Donelson, 1980).

The results indicated that approximately 22% of the drivers had used drugs other than alcohol. The drivers were found to have used the following drugs:

Drug	Percent of Drivers
Marijuana	9.5%
Tranquilizers	7.5%
Sedative/hypnotics	2.8%
Cocaine	2.0%
Anti-convulsants	2.0%
Other	Less than 2%

Multiple drug use occurred in about 10.5% of the drivers. Many of the drug users had also consumed alcohol (42% of all the drivers using drugs also had consumed alcohol). For example, over half of the drivers who had used marijuana had also consumed alcohol, 32% of the tranquilizer users and 80% of the cocaine users had also used alcohol. Of all the drivers who had used alcohol, 78% had BACs above 0.10% w/v (no separate breakdown was provided for using drugs).

The THC concentrations detected were mostly quite low, though they did vary widely (from barely detectable traces to fairly high levels of .011 ug/ml). The alcohol and THC concentrations found were not necessarily very representative of the concentrations at the time of the accidents, since up to four hours may have elapsed by the time the blood was drawn.

The responsibility analysis was based on data obtained from police accident reports and driver interviews. Each driver was judged as either responsible or not responsible for his/her accident by two independent coders. Responsibility rates for users of different drugs were then compared to the responsibility rate for drug free drivers. Terhune and Fell assume that the finding of a higher accident responsibility rate for drivers using drugs would imply that the drug use contributed to the accident occurrence. This type of analysis is dependent upon the assumption that the groups being compared do not differ in any other respect than drug use (that might account for the difference in responsibility rates), a very difficult fact to establish.

The accident responsibility analysis resulted in the following estimated responsibility rates for drivers using different drugs:

Drug Group	Responsibility Rate
BAC (over 0.10%) alone	74%
BAC (below 0.10%) alone	54%
Marijuana alone	53%
Drug Free	34%
Tranquilizers alone	22%

These data are consistent with the previous finding that alcohol increases accident risk. The difference between the marijuana or tranquilizer groups and the drug free drivers was not statistically significant. The responsibility rates for alcohol in combination with THC or tranquilizers did not differ significantly from the alcohol-alone group. Thus, this analysis supported the established fact that alcohol remains a serious problem in highway safety. The sample sizes for the other drugs (e.g., marijuana) were too small to allow definitive conclusions to be drawn.

The remainder of this section briefly describes some foreign studies of drug incidence in accident involved drivers. While these studies can not provide direct evidence regarding drug usage rates by American drivers, there is a definite well documented similarity in drug usage patterns (both legal and illegal) throughout the western world.

A preliminary incidence study of alcohol and drug use by accident involved drivers in southern Italy was reported by Ferrara, Castagna and Tedeschi (1980). Details of the methodology used for collecting the sample were not provided in this preliminary report so it is not possible to determine whether the sample used was randomly selected. The study reports on the presence of drugs in the blood and urine of 1,000 injured drivers treated at hospitals in the region of Venezia. All specimens were collected within one hour following the accident.

The blood and urine specimens were screened for a variety of drugs including sedatives and hypnotics, tranquilizers, narcotics, stimulants, and analgesics. Any level of drug detection was considered positive. The results show that approximately 14.7% of the drivers had used drugs (not counting analgesics like aspirin and tylenol(R)).

The most common drug category detected in the blood of these drivers was tranquilizers with 12.7% of the drivers having used this drug. Sedatives and hypnotics were used by 4.2% and stimulants and narcotics were used by less than 1%. These percentages reflect multiple drug use by approximately 3.2% of the drivers. No blood tests were run for marijuana though it was found in the urine of 14% of the drivers (out of only 100 tested for THC). The presence of marijuana in the urine of drivers does not necessarily imply they were under the influence of the drug at the time they were driving (metabolites can remain in the urine for several weeks after use). Of the drivers who used drugs other than alcohol, approximately 64% had also used alcohol.

Honkanen, Ertama, Linnoila, Alah, Lukkari, Karlson, Kiviluto and Puro (1980) conducted a small scale incidence study in Helsinki, Finland in 1977. The study sample was comprised of all injured car drivers who arrived for treatment at any of five hospital emergency rooms for injuries received in automobile accidents within six hours of their accident during April to October of 1977. The authors estimate they obtained approximately 90% of the eligible sample. Serum blood samples and breath alcohol samples were collected from 201 drivers.

Due to this sampling approach, which allowed for the blood and breath samples to be collected up to six hours after the accident occurred, it is possible that many drugs present in the driver's blood at the time of the accident had been metabolized and were no longer detectable at the time the sample was collected. Also, the fact that they were able to obtain breath samples implies that most of these drivers had received very mild injuries.

A control group of 325 nonaccident involved drivers, selected randomly at gas stations (matched to the accident involved drivers by day of week, time of day, and roadway), were also screened for alcohol and drugs. The purpose of including these nonaccident involved drivers in the study was to determine whether the use of drugs was overrepresented in the accident involved group. A finding that certain drugs were overrepresented in the accident involved group would suggest the possibility that the drugs contributed to their accidents.

The blood specimens were screened for about 50 different prescription drugs which included tranquilizers (like diazepam), barbiturates (e.g., secobarbital), amphetamines and narcotic analgesics (e.g., codeine). However, many non-prescription drugs of abuse like marijuana, cocaine and other narcotics were not included in the analytic screen used in this study. The results showed that more injured drivers (5%) had used these drugs than had control drivers (2.5%). Due to the small sample size, however, this difference was not statistically significant. Diazepam was found in 16 of the 18 subjects (89%) in whom drugs were found. Alcohol was found in 15% of the injured drivers and only 1% of the controls. No information on the combined use of drugs and alcohol was reported.

This study is one of the few conducted to date that has at least provided some direct evidence that injured drivers are more likely to have used drugs than are non-injured control drivers. This finding occurred in spite of the long delay in obtaining blood samples from the injured drivers, which undoubtedly resulted in underestimating the percentage of injured drivers using drugs. The extent to which the use of drugs contributed to these drivers' accidents is difficult to determine, especially when one considers that no information was provided regarding the possible role of alcohol (which may have been the prime contributor to the accident occurrence).

A study conducted in Norway by Setekleiv, Wickstrom, Enoksen, Hasvold and Sakshaug (1980) reported on drug use by accident involved drivers treated at a single hospital in the city of Stavanger over a twelve month period in 1978 and 1979. The report states that blood samples were obtained from the drivers as soon after their admission to the hospital "as possible." A total of 41 accident involved drivers were included in this study. The blood specimens were screened for alcohol, benzodiazepines (e.g., diazepam/Valium(R)), acidic and neutral drugs (e.g., barbiturates, methaqualone), and antidepressants and decongestants (e.g., diphenhydramine). Other psychotropic drugs (e.g., marijuana,) narcotic analgesics (e.g., codeine) and stimulants (e.g., PCP, amphetamines) were not included.

Approximately 10% of the injured drivers were found to have used drugs other than alcohol. All of the drivers using drugs had used diazepam (though the levels detected were very low). Almost all of the drivers in whom drugs were detected had also used alcohol (used by 10% of the injured drivers). This study contained such a small sample of injured drivers that no strong conclusions can be drawn from it.

Summary

The one useful study of injured American drivers reported that 22% of the drivers had used drugs other than alcohol (Terhune & Fell, 1982). The comparable alcohol use rate was 25% of the drivers. The most commonly used drugs were marijuana (9.5% of the drivers), tranquilizers (7.5%), sedative/hypnotics (2.8%) and cocaine (2%).

A large percentage of the injured drivers in this study, found to have used drugs, had also consumed alcohol (42%). The combined usage rate of alcohol and drugs found in this study is somewhat lower than that found for fatally injured drivers (which ranged from 50% to 80%).

A responsibility analysis showed that the drivers who had BACs above 0.10% w/v were significantly more likely to be responsible for their accident than were drug free drivers. Small sample sizes precluded conclusions regarding the impairing effects of the other drugs detected fairly frequently (e.g., marijuana).

The foreign studies reviewed above reported drug incidence rates among injured drivers ranging from 5.0% in Finland (Honkanen et al., 1980), 10% in Norway (Setekleiv et al., 1980) to 14.7% in Italy (Ferrara et al., 1980). The most commonly used drugs by the injured drivers were diazepam (Valium(R)), other sedative/hypnotics and tranquilizers.

The Honkanen et al. study represents one of the few investigations that have attempted to compare drug use rates between injured drivers and control drivers. It found that almost twice as many injured drivers had used drugs than had control drivers (suggesting that the use of drugs may have increased the risk of being involved in an accident). However, this study did not look at the combined effects of alcohol and drugs (which may have accounted for some of the increased crash risk) and did not screen for a number of potentially hazardous drugs (e.g., marijuana, cocaine).

STUDIES OF DRIVERS DETAINED BY THE POLICE

This section reviews studies designed to determine the incidence of drugs in drivers believed to be impaired by drugs who were typically not involved in accidents (drivers arrested under "Driving Under the Influence of Drugs (DUI)" laws). Three new studies were conducted in the U.S. since the 1980 drugs and highway safety report was published and will be covered in this section. One additional published article on a large scale project conducted in California (which was reviewed in preliminary form in the previous 1980 drugs and highway safety report) will also be covered. Finally, a number of studies that were conducted overseas will be reviewed briefly.

The typical approach used in these studies is to make use of blood samples drawn at police request from drivers arrested for suspicion of driving under the influence and to screen all or a sample of these specimens for selected drugs. Usually the specimens selected for study are those that have a BAC level below 0.10% w/v. In other words, the drivers selected have a profile that would strongly suggest drug involvement. None of the studies in this section looked for a wide variety of drugs, thus they may not provide an indication of the overall drug use rates for the drivers in their sample.

Valentour, McGee, Edwards and Goza (1980) reported a study by the State of Virginia in which a selection of blood samples taken from drivers charged with DUI were screened for a variety of drugs. The blood samples used in this study were collected over a sixteen month period in 1978 and 1979. The authors report that approximately 7200 blood tests are given in Virginia each year (out of approximately 44,000 arrests). The vast majority of arrested drivers take a breath test rather than blood test. Of those drivers who take a blood test, about 90% have a BAC level of greater than 0.10% w/v. The samples used in this study came from the drivers who had a blood alcohol content below 0.10% w/v (approximately 2% of all arrested drivers). During the study period, 788 samples meeting the criteria were collected and analyzed. No clear statement of which drugs were included in the screening is provided, though the authors do note that some popular drugs were not detectable by the procedures used, including marijuana, LSD, heroin, antidepressants, and antihistamines. The authors do not describe the assay methods used.

The results showed that 16% of the samples analyzed contained one or more drugs. The most frequently found drugs were reported to be the tranquilizers (diazepam and/or nordiazepam, chloriazepoxide), methaqualone, phenobarbital, and phencyclidine (PCP). The authors do not provide any indication of the number or percentage of drivers using the individual drugs. Eighty-four percent of the drug positive samples also contained alcohol in concentrations ranging from 0.01 to 0.09% w/v. The authors report that the probability of a drug being present was inversely related to BAC.

A relatively ambitious study of the use of sedative/hypnotics by drivers arrested for impaired driving in Orange County, California, was reported by White, Clardy, Graves, Kuo, McDonald, Wiersema and Fitzpatrick (1981). This study reports on the drug use rates found in blood samples taken from 8,116 drivers (out of approximately 72,000 drivers arrested for impaired driving, or 11%) during a 6-year period from 1973 to 1978. The authors report that in 1978 approximately 60% of the drivers arrested took a blood test, while the remaining 40% took either breath or urine tests. All the cases included in the study came from drivers who had taken a blood test and who had blood alcohol levels of less than 0.10% w/v (one of the criteria for screening for drugs). Thus, the study sample was not complete and is not representative of arrested drivers nor arrested drivers with BACs below 0.10% w/v. The blood samples were screened for barbiturates (e.g., secobarbital, amobarbital), benzodiazepines (e.g., Valium(R), Librium(R)), methaqualone (Quaalude(R), meprobamate, ethchlorvynol (e.g., Placidyl(R)), and PCP (which was tested for in 1977 only).

The results showed that these tranquilizers and sedative/hypnotic drugs were found annually in 30-50% of the sample tested. The incidence of these drugs was considerably higher in the alcohol negative drivers (approximately 60-70%) than in the drivers with BACs from 0.01 to 0.09% w/v (approximately 20-30%). The usage rate for sedative/hypnotic drugs appeared to show a substantial drop in 1977 and 1978. The authors felt this reflected a shift in drug usage patterns away from drugs detectable by their analytic screen (e.g., toward increased use of drugs like PCP, marijuana, and cocaine that were not detectable).

The most common drugs found in the drivers tested were barbiturates, diazepam and methaqualone. The barbiturates and diazepam were much more likely to be seen in combination with another drug than was methaqualone. Overall, approximately 18% of the drivers were found to have used two or more drugs. Many of the drug positive drivers had also used alcohol (i.e., approximately 40%).

A study conducted in Georgia by McCurdy, Solomons and Holbrook (1981), was designed to assess the range of methaqualone concentration found in the blood of drivers arrested for DUI in order to relate the methaqualone level to deterioration in driving ability. The study sample included only drivers arrested on suspicion of DUI who tested positive for methaqualone (974 cases). The authors did not indicate what percentage of arrested drivers these methaqualone users represented. The study found that the majority (55%) of these drivers had not consumed alcohol or other drugs. Approximately 39% of the methaqualone users had consumed alcohol, while 14% had also taken diazepam, with a smaller percentage (7%) having used a variety of other drugs. The authors reviewed the arresting officer's reports and developed a list of behaviors they felt were indicative of methaqualone impairment (as determined by the methaqualone concentration found in the blood samples).

A report on a study of marijuana use by impaired drivers in California was published recently by Zimmermann, Yeager, Soares, Hollister and Reeve (1983). Preliminary results from this study were reviewed in the Joscelyn et al. report (1980) and only brief comments will be made here. Readers interested in a more thorough review should consult the 1980 report.

Zimmermann et al. indicate that one out of every three drivers stopped by the California Highway Patrol for driving under the influence submit to blood alcohol determination. This results in about 20,000 blood specimens being collected per year, of which greater than 90% have blood alcohol levels above 0.10% w/v. Zimmermann et al. selected a sample of 1792 of these cases, collected from December 1977 to June 1978, for screening for THC.

In their 1983 report they state that these cases were selected at random with an equal number chosen with BAC's above and below 0.10% w/v. However, a previous report on this study indicated that there were 1027 cases selected from the drivers whose BAC level was 0.10% or less and 765 cases whose BAC level was greater than 0.10% w/v. This more detailed report also indicated the month of the incident leading to the specimen collection. The number of specimens per month is not consistent with a random sampling approach. Further, 542 of the cases apparently were accident involved fatally and non-fatally injured drivers. They are not separated out in the analyzes presented in this report (the accident involved and nonaccident involved drivers should have been looked at separately). Thus, these drivers are not representative of impaired drivers or drivers stopped for DUI. and possibly not even those detained drivers who choose to give a blood sample rather than a breath sample.

The results of the analyses performed by Zimmermann et al. indicate that 14.4% of all the specimens analyzed were positive for THC. The drivers who had a BAC of below 0.10% (10% of the sample), had a 23% marijuana positive rate. The percentage of drivers using marijuana increased with driver age (up to age 61), ranging from 13.3% for the drivers 21 years old and under, up to 19% for the drivers 40-61 years old. This finding is at variance with the patterns of usage reported from other sources and raises questions concerning the possibility that this sample was highly unusual. Of the 1,792 samples tested, 252 were positive for THC (14%), while 1507 tested positive for alcohol (84%). Of the drivers who tested positive for THC, approximately 85% had also used alcohol (90% of the total sample had used alcohol).

The interpretation of these findings is complicated by the factors enumerated above (sampling primarily alcohol impaired drivers, non-random selection of cases, unexpected and unexplained usage rates by age of driver, inclusion of fatally and non-fatally injured drivers, etc.). The study does show that some impaired drivers use marijuana, although the magnitude of the marijuana and driving problem can not be estimated from these data. How many of these drivers were impaired by marijuana is unknown. Most of these drivers had used alcohol, and many may have used other drugs (the authors only looked for marijuana).

A study of 254 drivers in New Zealand, who were detained by the police and were suspected to have used drugs, during 1975 - 1979, was reported by Missen, Cleary, Eng, McDonald and Watts (1982). The authors do not indicate how this sample was selected or how the blood samples were obtained. The blood samples taken from the 254 drivers were screened for a large variety of drugs (though some classes of drugs were not included, e.g., marijuana, amphetamines, LSD).

The results showed that 37% of the drivers tested positive for drugs other than alcohol while 63% tested positive for alcohol. The most common drug category detected was the tranquilizers (31%), with diazepam being found in 23% of the drivers. Sedative/hypnotics (10%) were the next most frequently detected drug, followed by anticonvulsants (3%), illicit drugs (3%) and antidepressants (2%). Approximately 50% of the drivers who had used drugs also had used alcohol (with BACs greater than 0.08% w/v).

A study by Peel, Perrigo and Mikhael (1984) reported on the drug use by a small sample of impaired drivers in Ottawa, Canada. The drivers comprising the sample had been detained for driving while impaired and after completing a breath alcohol test were requested to provide a saliva sample for "research purposes." The authors report obtaining 56 samples from 445 drivers suspected of impaired driving during the study period (not specified). This low cooperation rate strongly suggests that this was a biased sample. The saliva samples were tested for the presence of marijuana, benzodiazepines (e.g., Valium(R)), and other base/neutral/acid compounds (e.g., cocaine, amphetamines, LSD).

Drugs other than alcohol were detected in 10 of the 56 cases analyzed (18%). The most common drugs detected were cannabinoids (marijuana) with 11% of the drivers testing positive and diazepam (Valium(R)) with 7%. All of the 56 drivers were shown to have consumed alcohol and the 10 drivers who tested positive for drugs had BACs above 0.14% w/v. These findings should be interpreted cautiously since the finding of drug traces in the saliva of drivers may not be indicative of blood concentration of the drug.

Wilson (1980) reported some data on drug use by drivers suspected of driving while impaired in Queensland, Australia during the period from 1974 to 1979. These drivers had all been tested for breath alcohol and the BAC results did not account for the driver's behavior (typically BACs below 0.08% w/v) so that blood tests for drugs were requested. Thus, these drivers may have had no alcohol or may have had BACs between 0.08% and 0.10%. Certain drugs (e.g., marijuana, LSD) were not included in the screening techniques used.

The sample was comprised of 173 drivers out of which 115 drug positive specimens were detected (66%). The most frequently detected drugs were the benzodiazepines (e.g., Valium(R)) with 38% of the drivers having used these drugs. The next most frequently used drugs were the barbiturates (20% of the drivers), followed by methaqualone (6%). No other drug was found in more than 2% of the drivers. No information about drug concentrations was included in the report, thus it is not possible to estimate how many of these drivers might have been impaired. Also, no data were provided about the frequency with which drugs and alcohol were both found, nor regarding the incidence with which multiple drugs were detected.

SUMMARY

These studies of drug use by impaired drivers detained by the police are particularly difficult to interpret. The drivers dealt with in these studies are a special subsample of the general driving population. Because the study samples are not drawn in a random or unbiased fashion, they are not representative of the general driving public, nor necessarily of drivers who use drugs, or drivers who the police detain for suspicion of drug use. Most drivers detained by the police for suspicion of impaired driving elect to take a breath test rather than a blood test. Of the small number of drivers who do take a blood test, all of these studies found that 90% or more of the drivers had BACs over 0.10% w/v, and thus no tests for other drugs were performed. These study samples came from the remaining 10% or less of the drivers who had low BACs. Such a sample is not representative of any population other than the one from which the data were collected.

While the drivers in these studies came to the attention of the police as a result of committing some illegal driving behavior, one can not assume that the drugs they consumed were necessarily responsible for their deviant driving. Most of the drivers found to have consumed drugs had also consumed alcohol (the percentage of drivers in whom drugs were detected who had also used alcohol ranged from 40% to 100%). Thus, one does not know whether their driving was impaired (drivers not under the influence of alcohol or drugs also commit driving violations), and if it was impaired, whether it was due to the drug or the alcohol they had consumed, or due to the drug enhancing the effects of the alcohol.

One can conclude from these studies that a significant percentage of the drivers the police stop for suspicion of impaired driving, who agree to take a blood test, and whose BAC tests out below 0.10% w/v, have consumed drugs. These studies suggest this percentage ranges from 14% to 50%.

These data are useful in indicating which drugs are likely to be used by drivers suspected of impaired driving by the police. The studies reviewed above appear to indicate that the following drugs or drug categories are the most commonly detected:

- Marijuana
- Tranquilizers (e.g., diazepam/Valium(R))
- Methaqualone (Quaalude(R))
- Barbiturates (e.g., secobarbital)
- Narcotics (e.g., codeine)
- Hallucinogens (e.g., phencyclidine (PCP)

Only a couple of these studies reported data on multiple drug use. These studies indicate that between 18% and 21% of the drivers who had used drugs had taken two or more drugs.

CONCLUSIONS

In the introduction it was stated that in order to determine whether any specific drug was a significant highway safety problem, information was needed to document the extent to which accident involved drivers used the drug and the extent to which the use of the drug contributes to accident risk. The studies reviewed in this report provide information regarding which drugs are being used by drivers and give us some rough idea of the extent of drug use by the drivers. However, since these studies do not report drug incidence for nonaccident involved drivers, they can not be used to determine whether specific drugs, by themselves, or in combination with alcohol, increase accident risk.

The data reviewed indicate that drugs are detected in 10% to 22% of the accident-involved drivers. This range does not probably reflect the true potential drug and highway safety problem. The actual range could be significantly reduced if one considers the finding that drugs, by themselves, occur in only 2% to 15% of the accident-involved drivers. The majority of the drug using drivers (53% to 77%) were found to have high levels of alcohol in combination with the drugs. In these cases, the alcohol may have been primarily responsible for the driver impairment leading to the accident. For the studies reviewed it was not possible to factor out the alcohol effects from the drug effects, or to determine whether there were any combined alcohol and drug effects. When alcohol is not considered, multiple drug use is relatively infrequent in drivers in whom drugs were detected.

The studies reviewed in this paper tend to report the highest drug use incidence rates for the same potentially hazardous drugs. However, since many of these studies only tested for a few drugs (e.g., marijuana) or drug classes (e.g., sedatives and tranquilizers), the repeated reporting of the same drugs may be as much a function of what drugs were looked for, as what the drivers were using. Those drugs (or drug classes) most frequently detected are (in order of decreasing incidence):

- Marijuana
- Diazepam (Valium(R))
- Cocaine
- Barbiturates (e.g., Secobarbital)
- Methaqualone
- PCP (phencyclidine)

In conclusion, it is apparent that the nature and magnitude of the drug and highway safety problem has not been resolved by the recent studies of drug incidence reviewed above. It is important that research be conducted to determine the incidence of drug use in accident and nonaccident involved drivers so that some estimate of the extent to which drugs contribute to the occurrence of accidents can be determined.

REFERENCES

Cimbura, G.; Lucas D.N.; Bennett, R.C.; Warren, R.A. and Simpson, H.M. 1982 "Incidence and Toxicological Aspects of Drugs Detected in 484 Fatally Injured Drivers and Pedestrians in Ontario," Journal of Forensic Sciences, Vol. 27, No. 4, October 1982, pp. 855-867.

Donelson, A.C.; Cimbura, G.; Bennett, R.C. and Lucas, D.M. 1985 "The Ontario Monitoring Project: Canabis and Alcohol Use Among Drivers and Pedestrians Fatally Injured in Motor Vehicle Accidents From March 1982 Through July 1984," Final Report from The Traffic Injury Research Foundation of Canada, 171 Nepean, Ottawa, Ontario, Canada K2P 0B4, January 1985.

Ferrara, S.D.; Castagna, F. and Tedeschi, L. 1980 "Alcohol, Drugs and Road Accidents in Northeast Italy: Preliminary Report," in Alcohol, Drugs and Traffic Safety, Vol. I, Proceedings of the 8th International Conference on ALcohol, Drugs and Traffic Safety, June 15-19, 1980, Stockholm, Sweden, edited by Leonard Goldberg, M.D., Almqvist & Wicksell International, Stockholm, Sweden, 1980, pp. 315-327.

Honkanen, R.: Ertama, L.: Kinnoila, M.; Alah, M.: Lukkari, I.: Karlsson, M.; Kiviluto, O. and Puro, M. 1980 "Role of drugs in traffic accidents," British Medical Journal, Vol. 281, 1980, pp. 1309-1312.

Jack, H.; Hunter, J.R.; Dinan, B.J.; Madsen, S. and Stergachis, A. 1981 "Sedating Drugs and automobile accidents leading to hospitalization," American Journal of Public Health, Vol. 71, No. 12, December 1981, pp. 1399-1400.

Joscelyn, K.B. and Donelson, A.C. 1980 "Drugs Research Methodology. Vol. II. The Identification of Drugs of Interest in Highway Safety." National Highway Traffic Safety Administration, Report No. DOT HS-805-299, U.S. Department of Transportation, Washington, DC 1980.

Joscelyn, K.B.: Donelson, A.C.; Jones, R.K.; McNair, J.W. and Ruschmann, P.A. Drugs and Highway Safety, 1980. National Highway Traffic Safety Administration, Report No. DOT HS-805-461, U.S. Department of Transportation, Washington, DC.

Krantz, P. and Wannerber, O. 1981 "Occurrence of Barbiturate, Benzodiazepine, Meprobamate, Methaqualone and Phenothiazine in Car Occupants Killed in Traffic Accidents in the South of Sweden," Forensic Science International, Vol. 18, 1981, pp. 141-147.

Mason, A.P. and McBay, A.J. 1984 "Ethanol, Marijuana, and Other Drug Use in 600 Drivers Killed in Single-Vehicle Crashes in North Carolina, 1978-1981," Journal of Forensic Sciences, Vol. 29, No.4, October 1984, pp. 987-1026.

MCurdy, H.H.; Solomons, E.T. & Holbrook, J.M. 1981 "Incidence of Methaqualone in Driving-Under-The-Influence (DUI) Cases in the State of Georgia," Journal of Analytical Toxicology, Vol. 5, November/December 1981, pp. 270-274.

Missen, A.W.; Clearly, W.T., Eng, L.; McDonald, K.S. amd Watts, D.T. 1982 "Drugs and Driving," Department of Scientific and Industrial Research Bulliten, DSIR Bulliten N232, New Zealand, 1982, pp. 45-53.

Nakabayashi, K.; Aronson, S.; Siegel, M.: Struner, W. and Aronson, J. 1984 "Traffic Fatalities in Rhode Island: Part II - The Timing of Accidents and the Role of Marital Status, Alcohol and Psychoactive Drugs," Rhode Island Medical Journal, Vol. 67, April 1984, pp. 171-178.

Owens, S.M.; McBay, A.J.; and Cook, C.E. 1983 "The Use of Marijuana, Ethanol, and Other Drugs Among Drivers Killed in Single-Vehicle Crashes," Journal of Forensic Sciences, Vol. 28, No. 2, April 1983, pp. 372-379.

Peel, H.W., Perrigo, B.J., and Mikhael, N.Z. 1984 "Detection of Drugs in Saliva of Impaired Drivers," Journal of Forensic Sciences. JFSCA, Vol. 29, No. 1. Jan. 1984, pp. 185-189.

Setekleiv, J.; Bo, O.; Wickstrom, E.; Enoksen, A.; Hasvold, I. and Sakshaug, K. 1980 "Alcohol and drugs in accident victims -- a one year series from a Norwegian Hospital," Journal of Traffic Medicine, Vol. 8, No. 2, June 1980, pp.26-30.

Terhume, K.W. and Fell, J.C. 1982 "The role of alcohol, marijuana and other drugs in the accidents of injured drivers," NHTSA Technical Report DOT HS-806-181, U.S. Department of Transportation, March 1982.

Valentour, J.C.; McGee, M.P.; Edwards, R.P. and Goza, B.S. 1980 "A Survey of Drug Use Among Impaired Drivers in Virginia," Medico-Legal Bulletin, Vol. 29, No. 5, September/October 1980, pp. 1-7.

Wehr, K. & Maier, R.D. 1980 "Illicit Drugs Among Arrested Drivers in the Border Region of Aix La Chapelle," in Alcohol, Drugs and Traffic Safety, Vol. 1: Proceedings of the 8th International Conference on Alcohol, Drugs and Traffic Safety, June 15-19, 1980, Stockholm, Sweden, edited by Leonard Goldberg, M.D., Almqvist & Wicksell International, Stockholm, 1980, pp. 303-314.

Wetli, C.V. "Changing Patterns of Methaqualone Abuse," 1983 Journal of the American Medical Association, Vo. 249, No. 5, 1983, pp.621-626.

White, J.M.; Clardy, D.O.; Graves, M.H.; Kuo, M.C.; MacDonald, B.J.; Wiersema, S.J. and Fitzpatrick, G. 1981 Clinical Toxicology, Vol. 18, No. 8, 1981, pp. 945-957.

Williams, A.F.; Peat, M.A.; Crouch, J.K.; and Finkle B.S. 1985 "Drugs in Fatally Injured Young Male Drivers," 1985 Public Health Reports, Vol. 100, No.1, January-February 1985, pp. 19-25.

Wilson, D.G. 1980 "Psychoactive Drugs and Driving Impairment," in Alcohol, Drugs and Traffic Safety, Vol. 1: Proceedings of the 8th International Conference on Alcohol, Drugs and Traffic Safety, June 15-19, 1980, Stockholm, Sweden, edited by Leonard Goldberg, M.D., Almqvist & Wicksell International, Stockholm, 1980, pp. 336-339.

Zimmermann, E.G.; Yeager, E.P.; Soares, J.R.; Hollister, L.E. and Reeve, V.C. 1983 "Measurement of Delta-9 - Tetrahydrocannabinol (THC) in Whole Blood Samples from Impaired Motorists," Journal of Forensic Sciences, Vol. 28, No. 4, October 1983, pp.957-962.